Dirvotyra ir agrochemija
Soil Science and Agrochemistry
Почвоведение и агрохимия

International calibration of the textural properties of Lithuanian Eutric Albeluvisols

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Transfer functions were developed between the protocols used to analyze soil texture by East European (Katchinski), U. K. and U. S. methods. Ninety-two (0–20 and 20–40 cm depth) samples of Eutric Albeluvisols were collected from 46 long-term field plots of the Kaltinėnai Research Station of the Lithuanian Institute of Agriculture. The soil samples were from five sites. Three sites have been monitored for eight years and are representative of six land management systems on slopes with different soil textures. In addition, two further sites were sampled, which have been monitored for 20 years and are representative of four management systems on 2–5, 5–10 and 10–14° slopes.

The database contains results of the 92 textures obtained by laser-diffraction, USDA and Katschinski methods and provides calibrations and correlations between soil textural classes analyzed using the different protocols. The EXCEL macro *BOOTiFUL* has two stages. Stage 1 involves mathematical interpolation procedures to recalculate sand, silt and clay contents. The equations assume linear transitions in the percentage content between the individual particle size intervals and, therefore, has some errors. However, the strong significant correlation coefficients ($r = 0.833–0.942$) suggest the procedure to offer a valuable calibration approach. The remaining differences may represent variations in laboratory analytical techniques. Thus, Stage 2 uses the least-squares regression equations to convert Katschinski data to comparable values of both the U. K. and U. S. methods, with no significant differences between the three data sets. Consequently, this allows direct cross-reference between East European, U. K. and U. S. textural classifications. However, there is a need to continue the calibration of the textural properties of Lithuanian soils using additional samples with more diverse textures.

Keywords: Soil texture classes, Eutric Albeluvisols, Laser-diffraction, Katschinski method

INTRODUCTION

Several international soil texture classification systems are currently employed to characterize particle sizes, each system operating with different class size intervals. At present, the Soil Survey of England and Wales (SSEW) (renamed the Natural Soil Resources Institute, NSRI) [27] uses a different size boundary between sand and silt size particles to that of the United States Department of Agriculture

(USDA) [29], yet operates the same size boundary between the silt and clay size particles. In contrast, the East European (N. Katschinski) system [13, 33] uses the same size boundary between the sand and silt size particles to that employed by the USDA, yet operates a different size boundary between the silt and clay size particles to both the USDA and SSEW (Table 1).

Differences between textural classification systems can lead to different interpretations when attempting to classify a soil description, which can cause erroneous cross-referencing or data redundancy. Given the widening application of soil texture data for inclusion in pedotransfer functions, it is of paramount importance that East European textural data can be universally employed, so more complex soil physical, chemical and biological properties (such as soil water content, available soil water capacity and permanent wilting point) can be calculated [14, 22, 31]. In addition, transferable soil texture data are of global importance, because they fundamentally affect the dynamic processes of soil organic matter accumulation and interactions to form complexes and micro-aggregates. In turn, this aids our understanding of carbon sequestration, nutrient cycling and the biophysical attributes of land management systems [1, 3, 8].

In the unlikely event that common international standard boundaries are agreed and adhered to in the immediate future, there is a need to develop these transferable texture functions between the analytical protocols used to analyze soil texture, by Katschinski, U. S. and U. K. methods. Using these pedotransfer functions, it is possible to re-evaluate East European soil texture data analyzed by the Katschinski method, to correlate and convert them to international data sets with equivalent soil textural classes analyzed by sieving and laser-diffraction protocols. Previously, Rousseva [21] achieved this using a graphical technique, which was time-consuming, laborious and subjective. The SOVEUR Project, which studied the comparability of international soil analytical methods, stated that no usable procedures were found for converting between the Katschinski and the USDA texture schemes, because they required data for more particle size fractions than routinely considered [2].

Various approaches have been employed to estimate the fractions between particle size intervals. These include graphical and polynominal fits [21], geometric mean and geometric standard deviation of size ranges [24, 25], log-normal models [5, 6], exponential and power law closed-form models [20], empirical models [15], logistic models [26] and both similarity procedures and neural network models [17].

The most detailed and specific of these investigations was that by Nemes et al. [19], who described four different procedures (a loglinear interpolation using the phi-scale, a special asymmetric type of Gompertz curve, a nonparametric spline function and a novel similarity procedure) for interpolation of soil particle-size distributions and evaluated their accuracy for the HYPRES database [30]. They found that the accuracy of the procedures varied with the size intervals between the measured points of particle size distributions. However, Nemes et al. [18] suggested all approaches used for textural recalculation to have limitations, with some being less reliable, and questioned the uncertainty and applicability associated with many standardization methods.

Despite the concerns of Nemes et al. [18], there remains a need to resolve the issue of incompatible soil data sets. Frequent approaches to particle size interpolation procedures have adopted log-linear interpolation routines, involving the phi-scale, because soil texture distributions show approximately lognormal distributions [7, 24]. However, doubt has been cast on the universal applicability of these approaches, as they are deemed inappropriate for many soil texture classes [6, 19].

This paper presents a two-stage procedure, which firstly involves a linear interpolation process. Second-

Table 1. **Particle size classification systems of the fine-earth fraction, used by the United States Department of Agriculture (USDA), by the Soil Survey of England and Wales (SSEW) and by the East European (Katschinski) soil system**

Major textural groups	Individual fractions	Size (µm), USDA	Size (µm), SSEW	Size (µm), Katchinski
Sand	Very Coarse	2000–1000	–	–
	Coarse	1000–500	2000–600	1000–500
	Medium	500–250	600–200	500–250
	Fine	250–100	200–60	250–50
	Very Fine	100–50	–	–
Silt	Coarse	50–20	60–20	50–10
	Medium	–	20–6	10–5
	Fine	20–2	6–2	5–1
Clay		<2	<2	<1

ly, array formulae generated from the least squares method were used to calculate data trend lines. These stages are a means of converting the percentage sand, silt and clay content of East European soil texture data sets to USDA and SSEW size boundaries.

METHODOLOGY

Site description and sample collection. A total of 92 Eutric Albeluvisol samples were collected from topsoil (0–20 cm: Ap, n = 38; Ah, n = 8) and subsoil (Bt, 20–40 cm, n = 46) horizons of 46 long-term experimental field plots on the Kaltinėnai Research Station of the Lithuanian Institute of Agriculture (LIA). Samples were taken from three monitoring sites, representative of six land management systems, on slopes of 7–9, 7–8 and 9–11° gradient (duration 8 years) [12] and from two monitoring sites representative of four management systems, on slopes of 2–5, 5–10 and 10–14° gradient (duration 20 years) [11]. Each sample was then sub-sampled and analysed by the traditional Katschinski technique [16, 32] by the USDA method [10] and by the contemporary Western approach of laser-diffraction [27].

Laser diffraction method. All analyses were based on bulk fine-earth (<2 mm) fraction samples and were subjected to the same textural preparation and analysis procedure, using sieving followed by laser-diffraction analysis [27]. Low Angle Laser Light Scattering (LALLS), using a Malvern Mastersizer Long-bed X with a MSX17 automated sample presentation unit, employs a 5mW CW He–Ne laser with a wavelength of 632.8 nm as a light source. Measurements were taken on two separate lenses whose range overlap (45 mm: 0.1–80 μm, 1000 mm: 4–2000 μm) and once blended enable measurement of particle sizes within the 0.1–2000 μm range.

The removal of organic matter preceded textural analyses and was adapted from the procedure described by Gale and Hoare [9]. Macroscopic traces of organic matter were physically removed from representative sub-samples before treating the latter with hydrogen peroxide (H_2O_2) until the reaction ceased. The soil and hydrogen peroxide mixture was then allowed to evaporate to a thin paste, but not to dryness, before being dampened by the dropwise addition of a standard chemical dispersion solution (40 g of sodium hexa-metaphosphate ($(NaPO_3)_6$) per litre of distilled water) to help particles disaggregate. To ensure complete disaggregation, each soil slurry was then subjected to ultrasonic dispersion in a Malvern MSX17 automated sample presentation unit. For greater precision, the mean of five replicate analyses was measured with a mixed refractive indices presentation setting. A standard range of textural parameters was calculated, which included the percentage content of the sand, silt and clay class sizes.

USDA method. Particle size analysis by the USDA method was based on separation of the mineral part of the soil into various size fractions including gravel and coarser material, but the main procedure was applied to the fine-earth fraction (<2 mm) only. Analyses were performed at the Laboratory of the Agrochemical Research Centre of the Lithuanian Institute of Agriculture (LIA) using the particle-size analysis method of ISRIC FAO [10]. The procedure involves oxidation of organic matter (OM) by hydrogen peroxide (H_2O_2) 30%, removal of carbonates using hydrochloric acid (HCl) 1M (if required), dispersion, separation of fractions, determination of sand fractions by dry sieving and determination of silt and clay fractions by pipette analysis. The procedure for oxidation of OM and carbonate removal was not used because of the low concentrations OM and calcium carbonate in these soil samples.

Katschinski method. Most analyses were performed on fine-earth fraction (<1 mm) soil samples at the laboratory of the Kaltinėnai Research Station (LIA), using the method of N. A. Katschinski [32]. The analysis is similar to the USDA method, however, the washing losses containing dissolved carbonates are ascribed to the <0.001 mm fraction.

Texture conversion protocol. The mathematical process for Stage 1 of the conversion protocol is summarized by the following notation:

$$W_i = \sum_{0}^{j} S_j - \sum_{k=0}^{k=i-1} W_k - \left((B_{S_j} - B_{W_i}) / (B_{S_j} - B_{S_{j-1}}) \right) \times S_j ,$$

where W_i is the ith Western category and S_j is the jth Soviet category and $B_{Wi} < B_{Sj} < B_{Wi+1}$, where B_{Sj} is the upper bound of the jth Soviet category and B_{Wi} is the upper bound of the ith Western category,

so that: USDA data

$$\text{Sand} = \sum_{50}^{2000} W_i \quad \text{Silt} = \sum_{2}^{50} W_i \quad \text{Clay} = \sum_{0}^{2} W_i$$

SSEW data

$$\text{Sand} = \sum_{60}^{2000} W_i \quad \text{Silt} = \sum_{2}^{60} W_i \quad \text{Clay} = \sum_{0}^{2} W_i$$

Stage 2 of the conversion protocol employs the array formulae generated from the least squares method for calculating the data trend line between the recalculated Stage 1 former-Soviet data and the Western data, to further recalculate the percentage sand, silt and clay content of the former-Soviet data. Paired regression was calculated using the 'STAT_ENG for EXCEL version 1.55 Program' [28].

RESULTS AND DISCUSSION

The main problems for converting East European (Katschinski method) soil texture datasets to USDA size boundaries are: 1) different initial fine-earth fraction samples (<2 mm in case of USDA and <1 mm in the case of the Katschinski method), 2) different initial clay fraction size (<2 µm USDA and <1 µm Katschinski), 3) summarizing washing losses due to dissolution of soil carbonates ($CaCO_3$ and $MgCO_3$) in the case of the Katschinski method to sand, silt and clay fractions proportionally or to fractions <1 µm in the case of raw data. However, detailed analyses of soil particle sizes by laser-diffraction method enabled resolution of these problems (Table 2).

Statistical analysis shows significant differences between the 'raw' results of the analytical techniques at each size interval in each classification system (Table 3). Despite all the laboratory analyses being conducted on the same samples, this evidence highlights the challenges faced in comparing soil texture data sets.

Table 3. **T-test values between East European data and both the USDA and SSEW laser diffraction data**

	T-value	T-critical	d. f.
USDA Sand	4.804***	1.974	170
USDA Silt	10.131***	1.973	179
USDA Clay	5.043***	1.977	141
SSEW Sand	5.647***	1.974	166
SSEW Silt	11.558***	1.974	175
SSEW Clay	5.043***	1.977	141

Note: Significance level of P < 0.001 = ***

An international soil texture conversion protocol (*BOOTiFUL*) has been developed to remove differences between the soil textural systems and to allow comparison between analytical protocols. This is a two-stage process. Firstly, a simple mathematical interpolation procedure was employed to recalculate the percentage sand, silt and clay content of the soils received by the Katschinski method to both the U. S. and U. K. classification systems. In doing this, the equations assume linear transitions in the percentage content between the individual particle size intervals and therefore

Table 2. **Results of particle size analysis of one soil sample by laser diffraction method**

Size, µm	Result below %	Size, µm	Result below %	Size, µm	Result below %	Size, µm	Result below %
0.5	1.722	80.0	79.227	500.0	99.380	960.0	99.941
1.0	5.756	100.0	82.600	520.0	99.464	980.0	99.945
2.0	13.717	120.0	85.518	540.0	99.538	1000.0	99.949
3.0	20.503	125.0	86.175	560.0	99.602	1050.0	99.957
4.0	26.381	140.0	87.982	580.0	99.654	1100.0	99.963
5.0	31.445	160.0	90.028	600.0	99.700	1150.0	99.967
6.0	35.732	180.0	91.712	620.0	99.738	1200.0	99.971
7.0	39.456	200.0	93.093	640.0	99.770	1250.0	99.973
8.0	42.775	220.0	94.223	660.0	99.798	1300.0	99.976
9.0	45.718	240.0	95.142	680.0	99.820	1350.0	99.978
10.0	48.294	250.0	95.542	700.0	99.840	1400.0	99.980
15.0	57.055	260.0	95.909	720.0	99.854	1450.0	99.981
20.0	62.003	280.0	96.537	740.0	99.867	1500.0	99.983
25.0	65.216	300.0	97.063	760.0	99.877	1550.0	99.985
30.0	67.499	320.0	97.504	780.0	99.886	1600.0	99.987
35.0	69.258	340.0	97.875	800.0	99.894	1650.0	99.988
40.0	70.728	360.0	98.187	820.0	99.902	1700.0	99.990
45.0	72.026	380.0	98.450	840.0	99.909	1750.0	99.992
50.0	73.212	400.0	98.673	860.0	99.915	1800.0	99.994
55.0	74.323	420.0	98.861	880.0	99.921	1850.0	99.995
60.0	75.380	440.0	99.022	900.0	99.927	1900.0	99.997
62.5	75.890	460.0	99.160	920.0	99.932	1950.0	99.998
63.0	75.991	480.0	99.279	940.0	99.937	2000.0	100.000

Notes. Sample details: Plot trial No. 4, Filed treatment No. IA, Sample No. 71, Depth 0–20 cm; 2. Statistical details: Median = 10.751 µm, Mean = 52.027 µm, Sorting = $2.605^{\sigma 1}$, Skewness = –0.158 SK_1, Kurtosis = 0.831 K_G.

are not without error. However, the recalculation represents the sum of several sub-interval class sizes, and correlation coefficients (r = 0.833–0.942) suggest that the results of the conversion procedure offer a valuable approach to addressing this problem (Table 4).

Table 4. **Correlation coefficients of texture data by the Katschinski method after Stage 1 of the conversion procedure with both USDA and SSEW data (n = 92 soil samples)**

	Sand	Silt	Clay
USDA	r = 0.942***	r = 0.853***	r = 0.862***
SSEW	r = 0.940***	r = 0.833***	r = 0.862***

Note: Significance level of P < 0.001 = ***

Despite the significant correlation after Stage 1 of the conversion process, noticeable differences remained between the absolute values of the converted Katschinski data and those of both the USDA and SSEW data (Table 5), assumed to represent differences between the analytical techniques. For instance, using the USDA and SSEW data and the recalculated Katschinski data to classify soil texture by each of the international soil texture descriptions, it is evident that when the appropriate Katschinski method data classifications are compared to each of the corresponding classifications generated by the laser diffraction technique, very few samples have matching descriptions (USDA – 7.6%; SSEW – 19.6%), irrespective of which descriptive approach is used.

Table 5. **Mean texture data and the percentage coefficient of variation (*in parentheses*) after Stage 1 of the conversion procedure**

	Sand, %	Silt, %	Clay, %
Recalculated to	38.824	37.406	23.770
USDA system	(60.981)	(35.301)	(49.432)
Laser diffraction	23.653	61.695	14.652
USDA system	(76.434)	(21.167)	(37.615)
Recalculated to	37.416	38.814	23.770
SSEW system	(60.660)	(31.711)	(49.432)
Laser diffraction	21.343	64.005	14.652
SSEW system	(80.634)	(19.121)	(37.615)

Stage 2 of the conversion process uses an array of formulae (rectilinear equations) generated from the least squares method of regression analysis used to calculate data trend lines. By utilizing these mathematical relationships between the data sets, the converted Katschinski data have been further recalculated. Statistical analysis shows no significant differences between the results of each analytical technique at each size interval classification system (Table 6), which is further supported by the similarity of the percentage sand, silt and clay content of the samples (Table 7). Stage 2 transformation ensured a remarkable match between all 92 soil textural classes in the textural classification systems (USDA 75.0%; SSEW 72.8%).

Table 6. **T-test values between recalculated Katschinski method data after Stage 2 of the conversion procedure and both the USDA and the SSEW laser diffraction data**

	T-value	T-critical	d. f.
USDA Sand	<0.001 N. S.	1.973	179
USAD Silt	<0.001 N. S.	1.973	178
USAD Clay	<0.001 N. S.	1.973	182
SSEW Sand	<0.001 N. S.	1.973	180
SSEW Silt	<0.001 N. S.	1.974	179
SSEW Clay	<0.001 N. S.	1.973	182

Note: All T-values are non-significant = N. S.

Table 7. **Mean texture data and the percentage coefficient of variation (*in parentheses*) after Stage 2 of the conversion procedure**

	Sand, %	Silt, %	Clay, %
Recalculated to	22.125	62.460	15.415
USDA system	(71.496)	(18.128)	(34.274)
Laser diffraction	23.653	61.695	14.652
USDA system	(76.434)	(21.167)	(37.615)
Recalculated to	21.344	64.004	14.652
SSEW system	(72.586)	(16.693)	(38.189)
Laser diffraction	21.343	64.005	14.652
SSEW system	(80.634)	(19.121)	(37.615)

After Stage 2, the significant similarity between the Katschinski method data set with those of both the U. S. and the U. K. suggests that the *BOOTiFUL* procedure has successfully accomplished the transformation of Katschinski data to equivalent Western counterparts and now allows direct cross-reference between East European data and both the USDA and SSEW classification systems.

Paired regression between raw Katschinski and raw SSEW data shows quite a large spread of actual particle size characteristics of all three textural

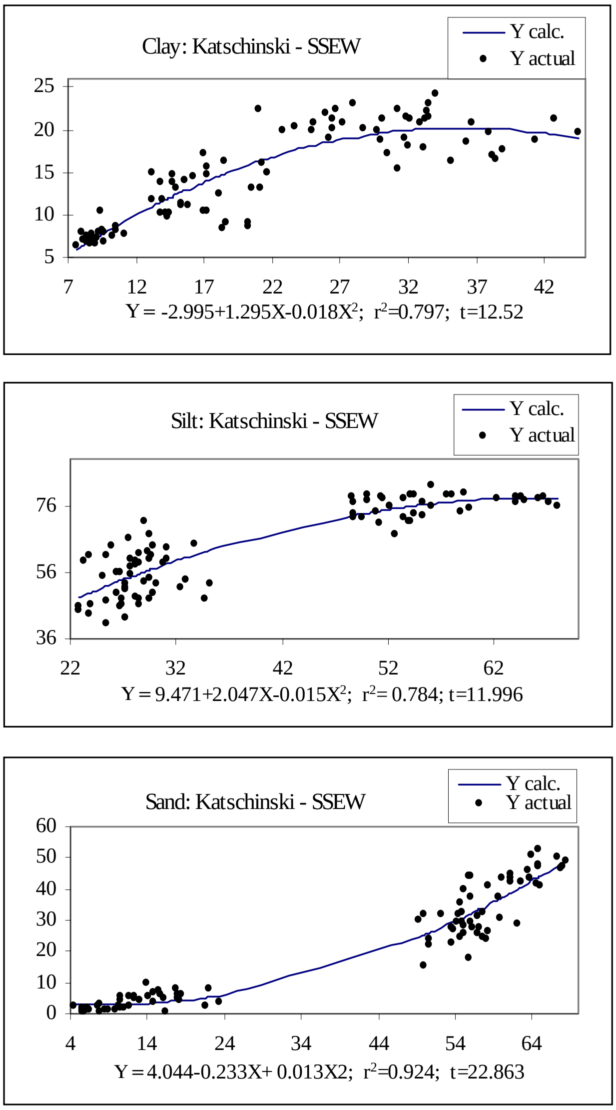

Fig. 1. Paired quadratic regression between raw Katschinski and raw SSEW data (%)

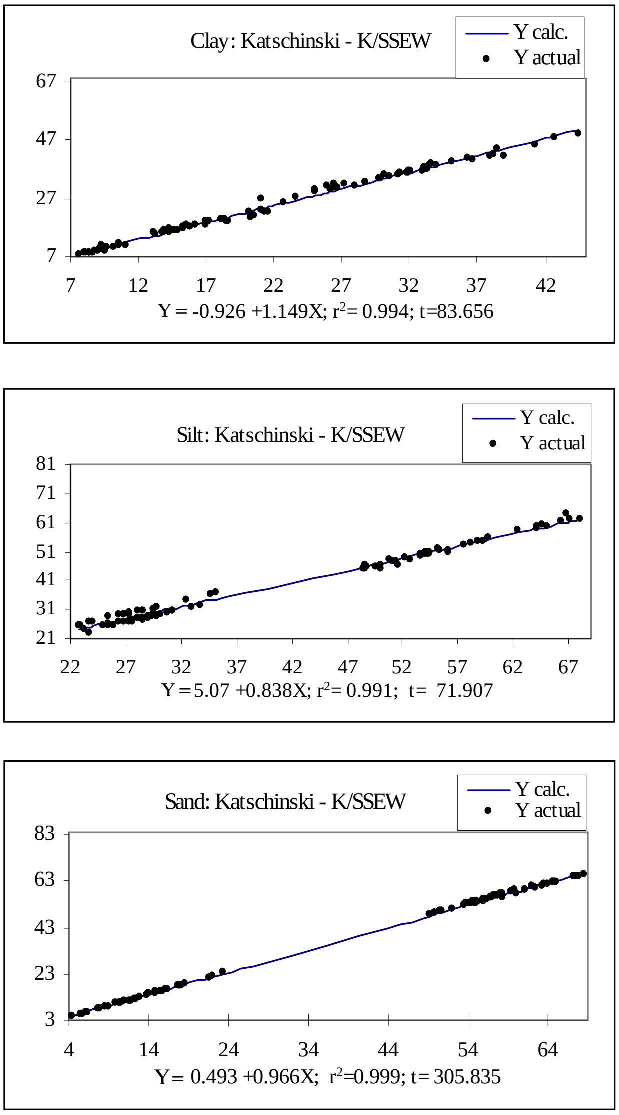

Fig. 2. Paired linear regression between raw Katschinski and converted Katschinski / SSEW data (%)

fractions. However, there was a strong correlation (R^2 = 0.924, 0.784 and 0.797 for sand, silt and clay fractions, respectively) between Katschinski and SSEW laser diffraction results (Fig. 1). The significance level ($P < 0.01$) was highest in the case of paired quadratic regression.

A very strong paired linear regression (Fig. 2) was found between the characteristics of raw Katschinski and converted Katschinski/SSEW data (R^2 = 0.999, 0.991 and 0.994 for sand, silt and clay fractions, respectively).

The uneven distribution of data sets, especially for sand and silt fractions (Figs. 1 and 2), indicates under-representation of some soil textures. Therefore, there is an urgent need to continue the calibration of the textural properties of Lithuanian soils using additional and texturally diverse soil samples.

CONCLUSIONS

1. The successful conversion of Katschinski generated East European data to laser diffraction generated USDA and SSEW data by the *BOOTiFUL* protocol provides the possibility to both adapt all contemporary textural data sets and to harmonize the archive of Katschinski textural data with those of the Western classification systems.

2. Given the nature of this work, it is recognized that the protocol is not without some minor practical and theoretical errors, but it is perceived that these are relatively small. Statistical evidence shows that the recalculation of Katschinski data produces data very similar to those of the USDA and SSEW systems of laser diffraction analysis.

3. There is an urgent need to continue cross-calibration using more and diversely textured soil samples.

ACKNOWLEDGEMENTS

This research forms part of a pilot-project funded by the Leverhulme Trust (F/00630B), to whom all authors gratefully acknowledge financial assistance. The expertise and support of academic, research (especially Jackie Hooley) and technical staff at both establishments is fully appreciated and acknowledged.

Received
6 May 2003

References

1. Barrios E., Buresh R. J., Sprent J. I. Organic matter in soil particle size and density fractions from maize and legume cropping systems // Soil Biology & Biochemistry. 1996. Vol. 28. P. 185–193.
2. Batjes N. H. Soil data derived from SOTER for environmental studies in Central and Eastern Europe, GCP/REP/007/NET Project, FAO & ISRIC Report. 2000. 27 p.
3. Bosatta E., Agren G. I. Theoretical analyses of soil texture effects on organic matter dynamics // Soil Biology & Biochemistry. 1997. Vol. 29. P. 1633–1638.
4. Buchan G. D. Applicability of the simple lognormal model to particle size distribution in soils // Soil Science. 1989. Vol. 147. P. 155–161.
5. Buchan G. D. Comments on 'A unifying quantitative analysis of soil texture: improvement of precision and extension scale' // Soil Science Society of America Journal. 1989. Vol. 53. P. 594.
6. Buchan G. D., Grewal K. S., Robson A. B. Improved models of particle size distribution: an illustration of model comparison techniques // Soil Science Society of America Journal. 1993. Vol. 57. P. 901–908.
7. Campbell G. S. Soil Physics with BASIC // Developments in Soil Science 14. Elsevier, Amsterdam, 1985.
8. Franzluebbers A. J., Haney R. L., Hons F. M., Zuberer D. A. Active fractions of organic matter in soils with different texture // Soil Biology & Biochemistry. 1996. Vol. 28. P. 1367–1372.
9. Gale S. J., Hoare P. G. Quaternary Sediments. London: Belhaven Press, 1991. 323 p.
10. ISRIC FAO. Particle Size Analysis // Procedures for Soil Analysis (Fifth edition). Ed. L. P. Van Reeuwijk. 6700 AJ Wageningen, The Netherlands, 1995. P. 3(1–12).
11. Jankauskas B., Jankauskienė G. Soil conservation and sustainable land-use programme for the hilly-rolling relief // Žemės ūkio mokslai. 2000. Nr. 3. P. 27–33.
12. Jankauskas B., Jankauskienė G. Stacionariniai dirvožemio erozijos tyrimai Žemaičių aukštumoje. 1. Dirvožemis ir jo savybės // Žemdirbystė: mokslo darbai / LŽI, LŽŪU. Akademija. 2003. T. 82. P. 3–19.
13. Katschinski N. A. Die mechanische Bodenanalyse und die Klassifikation der Boden nach ihrer mechanischen Zusammansetzung // Rapports au Sixième Congrès de la Science du Sol. Paris, 1956. P. 321–327.
14. McBratney A. B., Minasny B., Cattle S. R., Vervoort R. W. From pedotransfer functions to soil inference systems // Geoderma. 2002. Vol. 109. P. 41–73.
15. Minasny B., McBratney A. B., Bristow K. L. Comparison of different approaches to the development of pedotransfer functions for water-retention curves // Geoderma. 1999. Vol. 93. P. 225–253.
16. Motuzas A. J., Buivydaitė V., Danilevičius V., Šleinys R. Dirvotyra. Vilnius: Mokslas, 1996. 375 p.
17. Nemes A., Czinkota I., Czinkota G., Tolner L., Kovacs B. An automated system for the quasi-continuous measurement of the particle size distribution // Proceedings of the 17th World Congress of Soil Science. Bangkok, Thailand, 2002. P. 935.
18. Nemes A., Pachepsky Y., Rawls W., Wosten H., Zeiliguer A. Using similarity and neural network approaches to interpolate soil particle size distributions // Proceedings of the 17th World Congress of Soil Science. Bangkok, Thailand, 2002. P. 943.
19. Nemes A., Wosten J. H. M., Lilly A., Oude Voshaar J. H. Evaluation of different procedures to interpolate particle size distributions to achieve compatibility within soil databases // Geoderma. 1999. Vol. 90. P. 187–202.
20. Rousseva S. S. Data transformations between soil texture schemes // European Journal of Soil Science. 1997. Vol. 48. P. 749–758.
21. Rousseva S. S. Studies on the soil erodibility of calcaric Chernozems and cinnamonic forest soils // Ph. D. Thesis. N. Poushkarov Institute of Soil Science and Agrogeology. Academy of Agricultural Sciences. Sofia, 1987 (in Bulgarian).
22. Saxton K. E., Rawls W. J., Romberger J. S., Papendick R. I. Estimating generalized soil-water characteristics from texture // Soil Science Society of America Journal. 1986. Vol. 50(4). P. 1031–1036.
23. Shirazi M. A., Boersma L. A unifying quantitative analysis of soil texture // Soil Science Society of America Journal. 1984. Vol. 48. P. 142–147.
24. Shirazi M. A., Boersma L., Hart J. W. A unifying quantitative analysis of soil texture: improvement of precision, and extension of scale // Soil Science Society of America Journal. 1988. Vol. 52. P. 181–190.
25. Shirazi M. A., Boersma L., Johnson C. B. Particle size distributions: comparing texture systems, adding rock and predicting soil properties // Soil Science Society of America Journal. 2001. Vol. 65. P. 300–310.
26. Skaggs T. H., Arya L. M., Shouse P. J., Mohanty B. P. Estimating particle size distribution from limited soil texture data // Soil Science Society of America Journal. 2001. Vol. 65. P. 1038–1044.
27. Syvitski J. P. M. Principles. Methods and Application of Particle Size Analysis. Cambridge: Cambridge University Press, 1991. 368 p.
28. Tarakanovas P., Raudonius S. Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas ANOVA, STAT, SPLIT-PLOT iš paketo SELEKCIJA ir IRRISTAT. Akademija, 2002. 62 p.
29. USDA NRCS Soil survey laboratory information manual. National Soil Survey Center, Soil Survey Laboratory. Lincoln, Nebraska, 1995. P. 9–25, 222–223.
30. Wosten J. H. M., Lilly A., Nemes A., Le Bas C. Development and use of a database of hydraulic properties of European soils // Geoderma. 1999. Vol. 90. P. 169–185.

31. Wosten J. H. M., Pachepsky Y. A., Rawls W. J. Pedotransfer functions: bridging the gap between available basic soil data and missing soil hydraulic characteristics // Journal of Hydrology. 2001. Vol. 251. P. 123–150.
32. Гречин И. П., Кауричев И. С., Никольский Н. Н., Панов Н. П. и Поддубный Н. Н. Практикум по почвоведению. Москва: Колос, 1964. 423 с.
33. Мичманова А. И., Долгов С. И. Методы механического и микроагрегатного анализа почв // Агрофизические методы исследования почв. Москва: Наука, 1966. С. 5–41.

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TARPTAUTINIS LIETUVOS PASOTINTŲJŲ BALKŠVAŽEMIŲ GRANULIOMETRINĖS SUDĖTIES SAVYBIŲ KALIBRAVIMAS

S a n t r a u k a

Sukurtas dirvožemio granuliometrinės sudėties perskaičiavimo mechanizmas tarp Rytų Europos (Kačinskio), Jungtinių Valstijų žemės ūkio skyriaus (USDA) ir Didžiosios Britanijos (SSEW) taikomų metodų. Tam panaudoti 92 pasotintųjų balkšvažemių mėginiai (iš 0–20 ir 20–40 cm gylio), surinkti iš 46 ilgalaikių Lietuvos žemdirbystės instituto Kaltinėnų bandymų stoties lauko bandymų laukelių. Dirvožemio mėginiai surinkti iš penkių lauko bandymų. Trijuose bandymuose su skirtingos granuliometrinės sudėties dirvožemiu aštuonerius metus tyrinėtos šešeriopos sudėties žemės naudojimo sistemos. Kituose dviejuose bandymuose 2–5, 5–10 ir 10–14° statumo šlaituose 20 metų tyrinėtos keturios skirtingos žemės naudojimo sistemos.

Duomenų bazė turi visų dirvožemio mėginių 92 granuliometrinės sudėties frakcijų duomenis, gautus lazerinės difrakcijos (SSEW), USDA ir Kačinskio metodais, ir įgalina jų kalibravimą bei koreliacijas tarp dirvožemio granuliometrinės sudėties frakcijų, naudojant skirtingais metodais gautus duomenis. Ekselinė *BOOTiFUL* programa turi dvi stadijas. Pirmoji stadija matematinių interpretacijų pagalba perskaičiuoja smėlio, dulkių ir dumblo kiekius. Lygtys numato linijinį perėjimą tarp individualių frakcijų procentinės sudėties, todėl turi nežymius nukrypimus. Tačiau glaudūs patikimi koreliacijos koeficientai (r = 0,833–0,942) rodo vertingą kalibruojamų duomenų suartėjimą. Koreliaciniai ryšiai būtų dar glaudesni dirvožemio granuliometrinės sudėties kalibravimui panaudojus įvairesnius analizuojamus dirvožemius. Likantys skirtumai priskirtini laboratorinėms analizavimo paklaidoms. Antroji stadija naudoja kvadratinės regresijos lygtis Kačinskio metodu gautiems duomenims pervesti į palyginamus SSEW ir USDA metodais gautuosius su liekančiais nepatikimais skirtumais tarp trijų lyginamųjų grupių. Tai įgalina daryti kryžminę nuorodą tarp Rytų Europos, Didžiosios Britanijos ir JAV dirvožemio granuliometrinės sudėties klasifikacijų.

Raktažodžiai: dirvožemio granuliometrinė sudėtis, pasotintieji balkšvažemiai, lazerinė difrakcija, Kačinskio metodas

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МЕЖДУНАРОДНОЕ КАЛИБРОВАНИЕ СВОЙСТВ ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА ДЕРНОВО-ПОДЗОЛИСТЫХ ПОЧВ ЛИТВЫ

Р е з ю м е

Создан механизм пересчета гранулометрического состава почв между методами Восточной Европы (Качинского), Сельскохозяйственного отдела США (USDA) и Великобритании (SSEW). Для этого использованы 92 образца дерново-подзолистых почв, собранные из 46 делянок (глубиной 0–20 и 20–40 см) многолетних полевых опытов на Кальтиненской опытной станции Литовского института земледелия. Образцы почв собраны из пяти полевых опытов. В трех опытах с различным гранулометрическим составом почвы в течение восьми лет исследовались шесть различных систем земледелия. В остальных двух опытах на склонах 2–5, 5–10 и 10–14° в течение двадцати лет исследовались четыре различных системы земледелия.

В составе базы данных находятся результаты 92 фракций гранулометрического состава почв каждого образца, полученные методом лазерной дифракции (SSEW), а также методами USDA и Качинского. База данных позволяет делать калибровку и корреляцию между результатами фракций гранулометрического состава почв, полученными различными методами. Программа *BOOTiFUL* включает две стадии расчетов данных. Математические интерполяции первой стадии позволяют пересчет количеств частиц песка, пыли и глины. Формулами линейного перехода предвиден переход между процентным составом индивидуальных фракций, поэтому допускаются незначительные отклонения. Тесные достоверные коэффициенты корреляций (r = 0,833–0,942) указывают на ценное сближение калибруемых данных. Следующие отклонения предназначены погрешностям лабораторных анализов. Они могут быть сокращены дополнительными анализами почвенных образцов различного гранулометрического состава. Во второй стадии расчета данных используются квадратные уравнения регрессий для перевода данных, полученных методом Качинского, на сравнимые результаты, получаемые методами SSEW и USDA с остающимися недостоверными отклонениями между сравниваемыми группами. Это позволяет делать крестное сравнение между данными классификаций гранулометрического состава почв, полученными методами Восточной Европы, Великобритании и США.

Ключевые слова: гранулометрический состав почвы, дерново-подзолистые почвы, лазерная дифракция, метод Качинского