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Variability of soil properties in an intensively cultivated experimental field

Abstract: The aim of the study was to determine whether long-term intensive cultivation that used variable ploughing and fertilisation technologies and schemes influences the differentiation of soil properties which may impact the results of growing experiments in a relatively small experimental field (0.1 ha). The field under study is located in Wrocław, in an agricultural experimental station that has been operating for more than 60 years. A transformation of rusty gleyic soils (Brunic Gleyic Arenosols) into anthropogenic black earths (Gleyic Phaeozems (Arenic)) was noticed. The content of organic carbon and nitrogen, pH and the content of exchangeable base cations in the plough layer were positively (statistically and spatially) correlated and their increased values were observed in soils with a deeper and darker plough level. The present differentiation of the physical and chemical properties of soils in the experimental field do not result from such primary soil-forming factors as a kind and texture of parent material, topography, moisture regime, or (micro-)climatic conditions, which are not differentiated within the field, but from various intensity of former cultivation on individual sections of the experimental field. The variability coefficient of the crucial soil properties was found to exceed 30%, which might significantly influence the results of micro-plot vegetation experiments.

Keywords: soil properties, soil variability, experimental field, anthropogenic impact

INTRODUCTION

Spatial differentiation and temporal variability of the physical and chemical soil properties in the agricultural and forest areas are analysed routinely, as well as in the contaminated areas that are subject to reclamation (Godwin and Miller 2003, Kabała et al. 2013, Karczewska et al. 2006). These reports include both relatively stable soil properties and dynamic ones that change under the influence of external factors. Relatively stable properties of soil include particle-size distribution and mineralogical composition, whereas properties changeable in time include pH and the content of organic matter and nutrients (Usowicz et al. 2004).

The analyses of soil properties are important for making of an optimum environment for the plant growth and development, as well as for the spatial planning of the crop cultivation structure. They might also be decisive for the exclusion of certain areas from agricultural production and starting their remediation (Turski and Witkowska-Walczak 2004). The change of any environmental factor may lead to a negative or positive transformation of specific soil properties, which is crucial for the course of soil processes and soil quality due to the complex relations between the physical, chemical, and biological parameters of the soil (Chodak et al. 2003).

Omitting the spatial variability of soil properties and its influences for the plant growth might result in unreasonable cultivation practices, such as excessive soil fertilisation and liming, long-term retention of nutrients in forms unavailable for plant, and even decrease in crop yields. The analysis of the spatial differentiation of physico-chemical soil properties provides the bases for precision agriculture that is currently being promoted and implemented in the most economically developed countries (Usowicz et al. 2004).

The rule of the field experiments is to eliminate soil variability that may noticeably affect the statistical significance of the influence of experimental factors on crop yields (Sowiński et al. 2016). The southern part of an experimental station of the Department of Crop Production (a unit of the Wrocław University of Environmental and Life Sciences) is located on the edge of the Dobra River valley, in a plain Pleistocene terrace. Pedological evaluation conducted in the 1950s showed a low spatial differentiation in soil

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morphology and properties, which allowed to assign the whole area to a single bonitation class and one agricultural suitability complex. However, the results of field experiments differ significantly between replications of the same experimental variant (Sowiński et al. 2016).

The aim of the study was to determine whether the long-term intensive cultivation that used variable ploughing and fertilisation technologies and schemes influences the differentiation of soil properties which may impact the results of plant-growing experiments in a relatively small experimental field. The field under investigation has been used for growing experiments for over 60 years.

MATERIALS AND METHODS

The experimental station is located in Pawłowice, a district of Wrocław city. The field designated for growing experiments on sweet sorghum has an area of approx. 0.1 ha. The field surface is flat and levelled. The field was divided into 52 plots of a dimension of 7 x 2.1 m each, arranged in two parallel rows. In the beginning of May, before grain sowing and first rate of fertilisation, two soil pits were excavated to characterise the morphological, physical and chemical differentiations of the soil profiles (located in the southern and northern edges of the experimental field) (Fig.). In order to determine the spatial differentiation of physical and chemical soil properties in the plant rooting zone, samples of the plough layer were collected with the use of soil sampling stick, from each experimental plot separately (5 primary samples per each mixed sample from a plot). After initial soil drying, grounding and sieving through a 2 mm sieve, the following properties were determined in the soil samples collected from all 52 plots (Karczewska and Kabała 2008): particle-size distribution by sieve method (sand fraction) and hydrometer method (silt and clay fractions), after sample dispersion with hexametaphosphate; pH potentiometrically in distilled water and 1 mol·dm^{-3} KCl solution, at soil:solution ratio as 1:2.5; total organic carbon (TOC) by dry combustion with spectrometric determination of emitted CO_2 (CS-Matt Analyzer 5500); the content of exchangeable base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) by ICP-OES method after sample extraction with 1 mol·dm^{-3} ammonium acetate at pH 8.2; total potential acidity – by potentiometrical titration after sample extraction with 1 mol·dm^{-3} ammonium acetate at pH 8.2; the content of plant-available phosphorus and potassium by ICP-OES after Egner-Riehm extraction (with calcium lactate); and plant-available magnesium content by AAS method after Schachtschabel extraction (with 0.01 mol·dm^{-3} $CaCl_2$). The total nitrogen (Nt) content was determined by the Kjeldahl method in the samples from 26 plots in the eastern part of experimental field (Fig.).

RESULTS AND DISCUSSION

Soil morphology and classification

The experimental field is located on the edge of the Dobra River valley, on a Pleistocene fluvial terrace

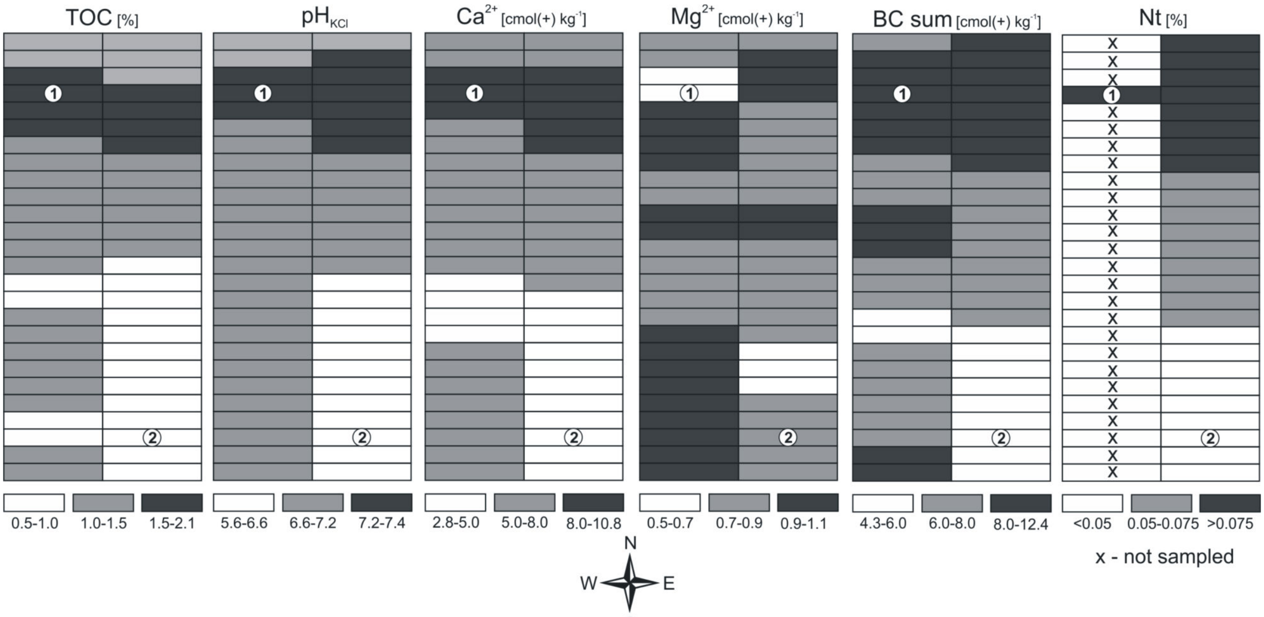

FIGURE. Distribution of soil properties in the experimental field (divided into 52 plots). Location of soil profiles No. 1 and 2 was indicated in circles. Abbreviations are explained in Table 4 rising 4.5–5 m above the Dobra valley. The terrace consists of well-sorted sands and gravely sands, locally underlain by fine-grained (loams, silts) limnic deposits (Kabała et al. 2011). In the course of common soil evaluation (bonitation), the soils of the experimental field were assigned to the podzolic soil type and V bonitation class, which corresponds to the weakest 7th rye and lupine soil complex. According to the current Polish Soil Classification (PSC 2011), these soils correspond in general to rusty soils. However, the soils after a long-term intensive agricultural usage at the experimental research station, in particular deep ploughing and liming, as well as organic and mineral fertilisation, have artificially gained features of black earths.

The soil in profile No. 1 is characterised by sandy texture throughout the profile, has a 28 cm deep plough

TABLE 1. Description of soil profile No. 1 – WRB 2015: Gleyic Phaeozem (Anthric, Arenic, Brunic, Drainic, Raptic); PSC 2011: Czarna ziemia wyługowana (antropogeniczna)

Horizon	Depth (cm)	Description
Ap*	0–28	dark-grey (Munsell moist 10YR 3/2, dry 10YR 5/1); texture: medium sand; structure: granular, medium strong, medium fine; very friable consistence; no redoximorphic features; neutral reaction; abrupt, smooth boundary
Bv	28–45	rusty-brown (10YR 5/6) with darker (10YR 4/6) mottles from deep tillage and mole activity; texture: mixed-grain sand; structure: subangular blocky, weak, fine; very friable consistence; 10% of fine reductimorphic mottles; slightly alkaline reaction; gradual boundary
BCg	45–60	yellow-brown (10YR 6/4); mixed-grain sand; structure: almost single-grain; loose consistence; 25% of fine reductimorphic mottles; slightly alkaline reaction; gradual boundary
Cg	60–75	parent material – alluvial sand of Pleistocene river terrace; yellow (2.5Y 7/3); mixed-grain sand; single-grain; loose consistence; moist; 10% of fine dark rusty (5YR 4/6) soft Fe accumulations; slightly alkaline reaction; gradual boundary
Cmog	75–95	yellow (2.5Y 7/3); mixed-grain sand; single-grain; loose consistence; 20% of fine dark rusty (5YR 4/6 or 7.5YR 4/6) iron nodules ("ironstone"); wet, groundwater and ceramic drains at ca. 85 cm; slightly alkaline reaction; clear, smooth boundary
2Gd	95–120+	underlying parent material; yellowish-grey (2.5Y 8/2); loamy fine sand; massive structure; wet, water-saturated; >50% reductimorphic mottles; slightly alkaline reaction

Explanation table 1 and 2: * designation of soil horizons according to Polish Soils Classification (2011).

TABLE 2. Description of soil profile No. 2. – WRB 2015: Eutric Brunic Gleyic Arenosol (Aric, Drainic, Raptic); PSC 2011: Gleba rdzawa gruntowo-glejowa

Horizon	Depth (cm)	Description
Ap1*	0–15	dark-grey (Munsell moist 10YR 3.5/2, dry 10YR 5/2); texture: medium sand; structure: granular, medium strong, medium fine; very friable consistence; no redoximorphic features; neutral reaction; abrupt, smooth boundary
Ap2	15–32	dark-grey (Munsell moist 10YR 4/3, dry 10YR 5/3); texture: medium sand; structure: granular, medium strong, medium fine; very friable consistence; no redoximorphic features; neutral reaction; abrupt, wavy boundary
ABv	32–50	grey-brown (10YR 5/4); texture: mixed-grain sand; structure: subangular blocky, weak, fine; very friable consistence; few, very fine soft Fe accumulations; slightly acid reaction; abrupt, smooth boundary
Bvg	50–68	yellow-brown (10YR 6/4); texture: mixed-grain sand; structure: weak subangular blocky or almost single-grain; loose consistence; 25% of fine dark-rusty (7.5YR 4/6) Fe mottles or soft accumulations; slightly acid reaction; gradual boundary
Ccog	68–90	parent material – alluvial sand of Pleistocene river terrace; yellow (2.5Y 7/3); mixed-grain sand; single-grain; loose consistence; 25% of fine dark rusty (7.5YR 4/6) Fe mottles and nodules; moist to wet, groundwater and ceramic drains at ca. 75 cm; neutral reaction; clear boundary
2Gd	90–120+	underlying parent material; yellow (2.5Y 7/2); loamy fine sand; massive structure; wet, water-saturated; >50% reductimorphic mottles; neutral reaction

layer of a nearly black colour, with a relatively high TOC content and well-formed although weak granular structure (Table 1). The plough layer is noticeably divided into two sublayers and abrupt lower limit, which clearly cuts it from the subsoil. Plough layer has a neutral reaction, high base saturation (over 90%), and high content of plant-available phosphorus. Well-developed sideric horizon (Bv), with numerous traces of biological activity occurs below the plough layer. The horizon is partly mixed with a more humic material, probably due to occasional deep tillage. Single redoximorphic (gleyic) features are visible below the depth of 45 cm, whereas cemented iron aggregates occur at the depth of approx. 75–95 cm, causing partial hardening of the soil layer. The groundwater level had been artificially lowered by ceramic drainage to the depth of approx. 90 cm. Originally, the soil probably met the criteria for gleyic rusty soils, but, due to a deepening and enrichment of the humus layer it currently meets the criteria for leached black earths (PSC 2011). The international classification FAO-WRB (IUSS working group WRB, 2015) also notices the transition of these soils from Arenosols to the soils with a black, structural and fertile mollic layer, i.e. to the Phaeozems reference group (Łabaz et al. 2014).

Similarly to profile No. 1, the profile No. 2 (Table 2) had sandy texture throughout the profile (Table 3) and a deep plough (humus) layer, 32 cm thick, with another underlying layer with traces of tillage, extending to a depth of ca. 50 cm. It is most likely that the deep ploughing caused mixing of the humus layer with the original rusty Bv horizon, as the Bv layer remained in this soil in residual form only, and, on the other hand, the humus layer has significantly lower TOC and nitrogen content (Table 4), and a lighter colour, compared to soil No 1. Therefore, in spite of a deep Ap horizon, the soil does not meet the criteria for black earths and remains in the group of gleyic rusty soils. Intended mixing (tillage) of the topsoil up to the depth of 50 cm brought it closer to the anthropogenic soils, so-called culturozems (PSC 2011). According to the international FAO-WRB classification, this soil belongs to Brunic Gleyic Arenosols. Further drilling on the entire surface of the experimental field enabled to approximate that leached black earths cover ca. 60% of the area (in the northern and mid-western parts of the field), whereas gleyic rusty soils with a deep plough layer cover approx. 40% of the area (in the south-eastern part of the field).

Spatial differentiation of physical and chemical soil properties

Soils throughout the experimental field are characterised by homogeneous particle-size distribution of the plough layer (Table 3), 2–3% content of clay fraction (<0.002 mm) and 7–11% of silt fraction (0.002–0.05 mm). In all of the plots one texture class was observed – medium sand (USDA), and according to the Polish classification – piasek słabogliniasty średnioziarnisty (PTG 2009).

The soil reaction of the plough layer (Ap) of the experimental field was mostly neutral or slightly alkaline, which was reflected in the mean values $\mathrm{pH}_{\mathrm{H_2O}} = 7.4$ and $\mathrm{pH}_{\mathrm{KCl}} = 6.8$ (Table 5). In spite of low

TABLE 3. Particle-size distribution of soils in two profiles located in the experimental field

Horizon	Depth (cm)	Particle-size distribution in mm (%)										Texture class PTG 2009	Texture class USDA
		>2	2–1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.02	0.02–0.006	0.006–0.002	<0.002		
Profile No. 1 – Gleyic Phaeozem (Anthric, Arenic, Brunic, Drainic, Raptic)													
Ap1	0–15	2	2	13	44	24	4	4	5	2	2	ps	S
Ap2	15–28	1	2	13	40	24	8	3	6	2	2	ps	S
Bv	28–45	0	2	13	41	32	4	1	4	2	1	pl	S
BCg	45–60	0	2	12	42	31	8	2	1	1	1	pl	S
Cg	60–75	1	3	18	42	25	7	1	2	1	1	pl	S
Cmog	75–95	1	4	16	57	15	4	1	1	1	1	pl	S
2G	>95	1	2	12	31	33	7	4	4	3	4	pg	LS
Profile No. 2 – Eutric Brunic Gleyic Arenosol (Aric, Drainic, Raptic)													
Ap1	0–15	1	3	14	42	28	3	4	4	2	2	ps	S
Ap2	15–32	1	3	13	45	27	3	3	3	1	3	ps	S
ABv	35–50	1	4	15	43	28	1	2	4	2	1	pl	S
Bvg	50–68	0	2	21	40	28	5	1	1	1	1	pl	S
Ccog	68–90	0	2	12	61	17	4	1	1	1	1	pl	S
2Gd	>90	0	1	10	33	32	7	4	5	4	4	pg	LS

Explanation: pl – piasek luźny, ps – piasek słabogliniasty, pg – piasek gliniasty; S – sand, LS – loamy sand.

TABLE 4. Physico-chemical properties of soils in two profiles located in the experimental field

Horizon	Depth	dv	TOC	Nt	C:N	pH_{H2O}	pH_{KCl}	Hh	Ca^{2+}	Mg^{2+}	K^+	Na^+	BC	ECEC	BS
	(cm)	$(g\cdot cm^{-3})$	%					$cmol_{(+)}\cdot kg^{-1}$							(%)
Profile No. 1 – Gleyic Phaeozem (Anthric, Arenic, Brunic, Drainic, Raptic)															
Ap1	0–15	1.66	1.64	0.090	18	7.3	6.6	0.6	5.80	0.92	0.33	0.24	7.29	7.89	92.4
Ap2	15–28	1.70	1.26	0.070	18	7.3	6.7	0.6	7.00	1.48	0.35	0.37	9.20	9.80	93.9
Bv	28–45	1.74	0.39	0.028	15	7.8	7.4	0.1	4.80	0.79	0.22	0.23	6.04	6.14	98.4
BCg	45–60	1.70	0.17	0.012	15	7.9	7.2	0.0	2.80	0.63	0.15	0.17	3.75	3.75	100
Cg	60–75	1.77	0.11	n.d.	–	7.9	7.1	0.0	2.20	0.58	0.12	0.16	3.06	3.06	100
Cmog	75–95	1.79	0.06	n.d.	–	7.7	6.8	0.1	1.94	0.58	0.10	0.16	2.78	2.88	96.5
2G	>95	1.85	0.05	n.d.	–	7.6	6.7	0.3	2.80	0.85	0.20	0.18	4.03	4.33	93.1
Profile No. 2 – Eutric Brunic Gleyic Arenosol (Aric, Drainic, Raptic)															
Ap1	0–15	1.52	0.83	0.049	17	7.1	6.4	0.6	4.08	0.80	0.23	0.24	5.35	5.95	89.9
Ap2	15–32	1.71	0.77	0.040	19	7.1	6.4	0.5	4.14	0.69	0.21	0.23	5.27	5.77	91.3
ABv	35–50	1.73	0.18	0.009	20	6.1	4.7	0.8	2.40	0.54	0.16	0.26	3.36	4.16	80.8
Bvg	50–68	1.74	0.10	n.d.	–	6.5	5.3	0.8	1.62	0.43	0.08	0.16	2.29	3.09	74.1
Ccog	68–90	1.82	0.05	n.d.	–	6.9	5.9	0.7	1.58	0.48	0.07	0.16	2.29	2.99	76.6
2Gd	>90	1.85	0.05	n.d.	–	7.5	6.5	0.4	2.10	0.55	0.18	0.17	3.00	3.40	88.2

Explanation: dv – bulk density, TOC – total organic carbon, Nt – total nitrogen, Hh – total potential acidity, BC – sum of base cations, ECEC – effective cation exchange capacity, BS – base saturation.

TABLE 5. Statistical parameters of soil properties in the plough layer of an experimental field

Parameter	pH_{H2O}	pH_{KCl}	Plant-available forms			TOC	Nt	Base cations				BC	BS
			P	K	Mg			Ca^{2+}	Mg^{2+}	K^+	Na^+		
			$mg\cdot kg^{-1}$			(%)		$cmol_{(+)}\cdot kg^{-1}$					(%)
N	52	52	52	52	52	52	27	52	52	52	52	52	52
Minimum	6.6	5.6	127	67	18	0.46	0.008	2.8	0.51	0.21	0.17	3.9	75
Maximum	7.8	7.4	460	166	33	2.09	0.085	10.8	1.00	0.52	0.57	12.4	100
Mean	7.4	6.8	303	94	24	1.16	0.061	6.2	0.77	0.32	0.27	7.6	92
Standard deviation	0.22	0.38	120	21	0.4	0.38	0.022	2.0	0.17	0.06	0.09	2.1	6.1
CV (%)	3	6	40	22	15	34	38	33	22	20	32	28	7

Explanation: TOC – total organic carbon, Nt – total nitrogen, BC – sum of base cations, BS – base saturation, CV – coefficient of variability.

values of pH variability coefficient, the pH was quite clearly spatially differentiated, and allowed for assignment of three different reaction classes according to agronomic guidelines (Fig.). Soils with an alkaline reaction occur in the northern part of the field, whereas slightly acidic soils dominate in the south-eastern part.

Soils in the northern section of the experimental field that meet the criteria for black earths, are noticeably enriched in TOC (maximally up to 2.1%) as compared to the southern part, where the TOC content decreases to approx. 0.5% (Fig.). Strong spatial TOC differentiation is reflected in high values of the variability coefficient, CV = 34% (Table 5). The differentiation in the humus content is important as it is connected with the durability of the granular structure and soil porosity in the arable layer of the soils, which may result in somewhat higher values of water retention capacity of sandy soils (Paluszek 2011).

Nt content in the arable layer was analysed for half of the plots (in the eastern part of an experimental field), and the results show that Nt is differentiated even by 10 times, within the range from 0.008 to 0.085% (Table 5). The spatial differentiation of Nt is extremely regular, arranged into three zones of a decreasing content, from the northern to the southern part of the field (Fig.). In spite of the fluctuations in the TOC and Nt content, the C:N relation fluctuates within a narrow range of 17–21:1.

The content of exchangeable calcium in the plough layer (Ap) is in a very wide range from 2.8 to 10.8 $\mathrm{cmol_{(+)}\ kg^{-1}}$, which is reflected in a high value of the variability coefficient CV = 33% (Table 5). Similarly high differentiation between the minimum and maximum values (0.17–0.57 $\mathrm{cmol_{(+)}\ kg^{-1}}$) and a high value of the variability coefficient (CV = 32%) are noted for exchangeable sodium. The contents of exchangeable magnesium and potassium are statistically less differentiated (CV 20–22%), but the spatial differentiation of abundance classes is very clear (Fig.). The highest content of exchangeable calcium, sodium and potassium was noted in the northern part of the experimental field, whereas the lowest – in the southern (in particular in south-eastern) part. The spatial distribution of exchangeable magnesium is slightly different, because its higher content was found both in the northern and in the south-western parts of the field. The sum of base cations in the soil plough layer is within the range from 4.23 to 12.4 $\mathrm{cmol_{(+)}\cdot kg^{-1}}$, is higher in the northern part of the field than in the southern one, and is related mainly to the content of exchangeable calcium. The variability coefficient for sum of base cations is high, approx. 28% (Table 5), but the fact that CV_{BC} was lower than CV_{Ca} demonstrates the influence of other exchangeable cation, in particular of magnesium.

The analysed soils are characterised by a very high content of plant-available phosphorus (Table 5). The limit value for very high phosphorus content, i.e. 87.2 $\mathrm{mg\ P\cdot kg^{-1}}$ (20 mg P_2O_5/100 g) was exceeded in soils of all the plots, which evidently resulted from intense phosphorus fertilization in the past. The content of plant-available potassium and magnesium usually meet the average content ranges (Table 5). Phosphorus content is statistically more differentiated with the highest CV 40%, whereas the smallest differentiation was observed for magnesium (CV 15%). In general, the highest contents of macroelements were found in the northern section and the lowest ones – in the southern section of the experimental field.

Most of the analysed physical and chemical properties showed higher values in the northern part of the field. This section is considered to be subjected to the stronger anthropogenic transformation of soils, which is exemplified by deeper arable level and higher content of organic matter (Fig.). This finding was proved by statistically significant correlation (at $p<0.05$) between the TOC content and pH_{KCl}, pH_{H2O}, exchangeable calcium, sum of exchangeable cations, and Nt with correlation coefficients (r): 0.68, 0.73, 0.65, 0.66, and 0.73, respectively. The mutual correlation between the indicators of increased soil fertility resulting from the higher level of ploughing, liming, organic and mineral fertilization, as well as their spatial correlation with a stronger morphological transformation of rusty soils into black earths demonstrates that the current spatial differentiation of soil physical and chemical properties is resulted from different intensity of previous usage of particular sections of the field rather than from the primary variability of soil-forming factors (kind and texture of parent material, (micro-)topography, moisture regime, microclimatic conditions which are not differentiated within the field). Spatial differentiation of soil properties in the experimental field doesn't have a randomised but a zonal nature, which might have an influence on the experiment results, even if the experiments are correctly designed, e.g. in randomized replicated blocks. The obtained results support the proposal to periodically change the location of experimental fields (Cassel et al. 2000), which will enable to "equalize" the soil properties throughout the experimental field under "normal" cultivation, which apply the same technology (including ploughing, cultivation of secondary crops, level of organic fertilization and liming, etc.) in the entire field.

CONCLUSIONS

1. Significant spatial (zonal) differentiation of soil properties was found in a small experimental field (0.1 ha).
2. Morphology of the native, gleyic rusty soils (Brunic Gleyic Arenosols) was transformed under the anthropogenic impact to such an extent that the

majority of soils meet the criteria for black earths (Gleyic Phaeozems (Arenic)).

3. The content of organic carbon and nitrogen, pH and the content of exchangeable base cations in the plough layer are spatially correlated and their elevated values were observed in soils with a deeper and darker plough layer (a mollic horizon).
4. The current spatial differentiation of the physical and chemical soil properties in the experimental field did not result from primary soil-forming factors such as the kind and texture of parent material, land (micro-)topography, moisture regime, or (micro-)climate conditions, which are not differentiated throughout the field, but from the different intensity of previous cultivation in the individual sections of the field.

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Przestrzenne zróżnicowanie właściwości gleb w obrębie intensywnie użytkowanego pola doświadczalnego

Streszczenie: Celem pracy było ustalenie, w jakim stopniu zmienność wyników doświadczeń uprawowych na relatywnie małej powierzchni pola doświadczalnego (0,1 ha) może wynikać z długotrwałej intensywnej uprawy, obejmującej różne techniki orki i nawożenia. Pole objęte badaniem jest położone na terenie rolniczej stacji doświadczalnej działającej od ponad 60 lat. W obrębie relatywnie małego pola stwierdzono przekształcenie części gleb rdzawych (oglejonych) w antropogeniczne czarne ziemie mające głęboki, ostro odcinający się poziom orny. Zawartość węgla organicznego i azotu, pH oraz zawartość wymiennych kationów zasadowych w warstwie ornej są ze sobą dodatnio skorelowane (w sensie statystycznym i przestrzennym), a ich podwyższone wartości stwierdzono w glebach o głębszym i ciemniejszym poziomie ornym. Aktualne przestrzenne zróżnicowanie właściwości fizykochemicznych gleb pola doświadczalnego nie wynika z pierwotnych czynników glebotwórczych, takich jak: rodzaj skały macierzystej i jej uziarnienie, topografia, reżim wilgotnościowy, warunki mikroklimatyczne, które nie różnicują się w obrębie pola, ale z odmiennej intensywności zabiegów uprawowych na poszczególnych fragmentach pola w przeszłości. Współczynnik zmienności kluczowych właściwości gleb przekracza 30%, co może mieć istotny wpływ na wyniki mikropoletkowych doświadczeń wegetacyjnych.

Słowa kluczowe: właściwości gleb, zmienność glebowa, pole doświadczalne, wpływ antropogeniczny