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ANALYSIS OF AGRONOMIC CATEGORIES IN DIFFERENT SOIL TEXTURE CLASSIFICATION SYSTEMS

Abstract. Different soil texture classification systems are used in Poland. The system most widely used in agriculture is named after Polish Soil Science Society (PSSS) and is described in the soil classification norm BN-78/9180-11 (BN1978 standard). The last edition of soil classification system and soil texture classes published by PSSS in 2008 (PSSS 2008 classification) is different from BN1978 standard. The aim of this paper is a quantitative and qualitative comparison of the compatibility of agronomic categories created according to the old textural classes (BN1978 standard) and the new textural classes (PSSS 2008 classification). The representative set of soil samples (n=316) for arable mineral soils in Poland were divided into agronomic categories according to these two soil classification systems. The agronomic categories, which comply with soil classification systems PSSS 1978 are widely used in agricultural advisory. The results of the study showed differences in the amount of soil samples classified for the corresponding agronomic category. The study also showed discrepancies in the fine particle (<0.02 mm) and colloidal fraction (<0.002 mm) content in the corresponding categories. The differences may affect the assessment of soil fertility in nutrients(abundance) such as potassium, magnesium and of soil liming needs, as well as appropriate determination of fertiliser doses.

Key words: soil texture classification, soil texture group, agronomic categories

Particle size distribution is a basic factor determining physical and chemical properties of mineral soils. It is also the main criterion in classifying soil texture (Dobrzański 1996; Regulation 2012; Różański 2010). Soil texture has a significant influence on soil characteristics and functions, including water,

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buffer, and sorption properties (Królokowski et al. 1968; Uziak et al. 2005; Walenczak et al. 2009; Wang et al. 2008; Zawadzki 1999). Sorption complex made up of soil colloids is responsible for absorption properties. Soil colloids consist of clay minerals, organic-clay complexes, amorphous minerals, organic matter, iron oxide. Due to its sorption properties, the soil regulates pH and stores nutrients delivered in fertilizers. Grain size is the main factor determining water retention of the soil profile. A larger sand fraction causes the reduction in water retention and vice versa. According to Ślusarczyk (1979), the difference in plant available water capacity (AWC) can be more than double in the soils with different soil texture classes. The soil profile (1m thick) and formed from loose sand (pl) will retain only 92 mm of field available water, while a lightly loamy sand (pgl) - 138 mm, and a heavy loam (gc) - 240 mm. That is why grain size is the main criterion of soil classification and the main factor for plant types determination for cultivation.

Soil texture classifications applied in Poland and worldwide divide particle-size distribution into fractions and sub fractions of soil texture classes. The percentage of soil fraction classes determines the distribution of mineral soils into groups and subgroups (sand, silt, clay). Over the last few years, Polish soil science used two parallel soil texture classes: the Polish Society of Soil Science (PSSS 1956) (Musierowicz 1956) and the soil texture classes standard BN-78/9180-11 (BN1978 standard) (Różański 2010). In addition, geology. geotechnics and road construction engineering are using separate systems of grain size classification (Drzymała, Mocek 2004; Głażewski et al. 2010). In 1998, new Polish Standard of soil texture classes PN-R-04033 (standard 1998) has been established. It replaced the sectoral norm of soil texture classes (BN1978 standard). But the BN1978 standard and standard 1998 soil texture classifications are not compatible. The PN-R-04033 standard introduced changes into texture classes which caused moving upper range of sand from 1 to 2 mm and the inclusion of coarse silt fraction into fine sand sub fraction. Other changes involved transferring fine particles (0.02-0.002 mm) identified as clay into fine silt sub fraction. Introduced in 1998, norm (PN-R-04033) is "highly compatible" with USDA in terms of fraction limits, whereas the texture classes differ significantly. The USDA standard is used in many countries around the word USA, Australia, Canada and other countries (Drzymała, Mocek 2004). The Polish soil texture classes established in 2008 (PSSS2008) is similar to the USDA soil texture class and to the standard PN-R-04033 mentioned above. Important research achievements and implementations related to agriculture, environment and soil water balance in Poland are based on previous soil texture classes (BN1978 standard). Previous soil particle size and soil texture classes are used in analytical work, monitoring, and mapping of different environmental processes and agricultural advisory services. Developing Soil-agricultural maps in the scale from 1:5000 to 1:500 000, as well as performing soil science land classification are excellent examples of the mapping legacy in Poland. Agricultural maps were used in different environmental studies (Stuczyński et al. 2006), and for the evaluation of agricultural drought (Doroszewski et al. 2012) Another example is the development of fertilizer advisory system based on agronomic categories that is also compatible with soil texture classes (BN1978 standard) (Fotyma 2001; Zalecenia 1990). One of the disadvantages of using different grain size systems is a lack of direct and precise comparison of analytical mapping research results on the international scale. As a consequence of the soil classification system changes, a key conversion factor must be used for textural classes transition from old to new system (Kabała, Marzec 2007).

In Poland, agronomic categories were designed for farming advising need of. Those categories are the basis on which soil fertility, dosage and frequency of fertilisation, liming and tillage equipment are determined. Since 1986, four agronomic categories (Fertilizers recommendations, 1990) have been established based on previous soil texture classes (BN1978 standard). With the development of new soil classification system and soil textural classes (PSSS 2008 classification), new agrotechnical/agronomic categories were defined. This new division includes five agronomic categories. New agrotechnical categories defined according to the new soil texture classification (PSSS 2008 classification) may differ in terms of fine particle content with respect to the previous categories (BN1978 standard). A question may be asked: whether these differences could influence the real impact of the rates of fertilizer ?

The aim of this paper is a quantitative and qualitative comparison of the compatibility of the agronomic categories defined according to the old soil texture classes (BN1978 standard) with agrotechnic categories defined according to the new soil texture classes (PSSS 2008 classification).

DIVISION OF SOIL INTO AGRONOMIC CATEGORIES

The basis for the allocation of agronomic categories according to soil classification PSSS 1978 (BN-standard) [table 1] is the content of fine particles of grain size (c<0.02 mm) also called fine earth. Fine particles include grain size of coarse silty clay (0.02-0.006 mm), medium clay (0.006-0.002 mm), and colloidal and fine clay (<0.002 mm). Agronomic categories were created by grouping soil units with a similar content of fine particles according to BN1978 standard [table 2]. However, system PSSS 2008 classification is based on the sand, silt and clay content.

System BN1978 standard distinguishes four agronomic categories: 1) very light, including soil units with 10 % content of fine particles, 2) light, including soil units between 10-20% of fine particles content, 3) medium, including soil units between 20-35% of fine particles content, 4) heavy, including soil units with >35% of fine particles [table 1].

TABLE 1. AGRONOMIC CATEGORIES ACCORDING TO SOIL TEXTURE CLASSIFICATION BN1978STANDARD, (*FERTILIZER RECOMMENDATIONS, 1990)*

Agronomic category	Soil textural groups	% fraction < 0.02 mm
Very light	loose sand – pl loose silty sand – plp slightly loamy sand – ps slightly loamy silty sand – psp	0 – 10
Light	loamy light sand – pgl loamy silty light sand – pglp loamy heavy sand – pgm loamy silty heavy sand – pgmp silt – płz sandy silt – płp	11 - 20
Medium	light loam – gl light silty loam – glp loamy silt – płg	21 – 35
Heavy	medium loam – gs medium silty loam – gsp heavy loam – gc heavy silty loam – gcp clayay silt– płi clay – i silty clay – ip	>35

TABLE 2. AGRONOMIC CATEGORIES ACCORDING TO SOIL PSSS2008 CLASSIFICATION

Agronomic category	Soil textural groups	Perecentage of soil fraction		
		Sand 2.0-0.05 (mm)	Silt 0. 05-0.002 (mm)	Clay < 0.002 (mm)
I. Very light	Loose sand (pl)	c => 90	(%py + 2 x %i) <= 10	
	Slightly loamy sand (ps)	85 <= c < 95	(%py + 2 x %i) > 10 i (%py + 1.5 x %i) <= 15	
II. Light	Loamy sand (pg)	70 <= c < 90	(%py + 1.5 x %i) > 15 i (%py + 2 x %i) <= 30	
III. Medium	Sandy loam (gp)	65 <= c < 85	(%py + 2 x %i) > 30 i	
			c <= 35	c <= 20
		or		
		43 <= c < 65	28 <= c <= 50	c <= 7
	Lightly loam (gl)	52 <= c < 65	15 < c <= 41	7 < c <= 20
	Loamy silt (pyg)	8 <= c < 50	50 < c <= 80	c <= 12
	Silt (pyz)	c < 20	c > 80	c <= 12

Agronomic category	Soil textural groups	Perecentage of soil fraction		
		Sand 2.0-0.05 (mm)	Silt 0. 05-0.002 (mm)	Clay < 0.002 (mm)
IV. Heavy	Sandy-clayaly loam (gpi)	45 <= c < 80	c <= 28	20 < c <= 35
	Loam (gz)	23 <= c < 52	28 < c <= 50	7 < c <= 27
	Clayay loam (gi)	20 <= c < 45	15 < c < 53	27 < c <= 40
	Clayay-silty loam (gpyi)	c < 20	40 < c < 73	27 < c <= 40
	Loamy silt (pyi)	c < 38	50 < c < 88	12 < c <= 27
V. Very heavy	Sandy clay (ip)	45 <= c < 65	c <= 20	35 < c <= 55
	Silty claz (ipy)	c < 20	40 < c < 60	40 < c < 60
	Clay (iz)	c < 45	c <= 40	40 < c <= 60
	Heavy clay (ic)	c < 40	c < 40	c > 60

The new system PSSS 2008 classification distinguishes five agrotechnic categories involving soils units with a similar fraction of sand, silt and clay [table 2]. The new division possibly allows for the merging of very light and light soils categories into one category of light soils, and to combine heavy soils and very heavy soils into one category of heavy soils. It also separates the soils with a high content of silt fraction into additional subcategories of medium silty subcategory and heavy silty subcategory.

METHODS

Particle size analysis and agronomic categories distribution were carried out on the basis of 316 soil samples collected from the database of Polish soil chemistry monitoring. That includes 216 points located on arable mineral soil, which is a typical soil cover of the country (Siebielec et al. 2013), and 100 points from samples taken under the conversion work of soil textural classes on Polish agricultural soil map into the WRB system. The study involved the determination of individual fractions and sub-fractions, and subsequently the groups and subgroups of the soil classification systems BN1978 standard and PSSS 2008 classification. The determination of soil particle size composition was done using the sieve-sedimentation method (SSM) for sand fraction > 0.1 mm and aerometric method for the fraction of silt and clay according to both soil textural classification (BN1978 standard and PSSS 2008 classification). This was followed by the separation of categories into both agronomic system and converting them to fine particles (< 0.02 mm) and clay fraction (<0.002 mm). The mean content of each fraction, the standard error, confidence intervals 0.95 and a statistical significance were calculated. The study also assessed the interrelationships between individual fractions in the soils and the participation of clay fraction (<0.002 mm) from the fine particles fraction (<0.02).

RESULTS

The analysed soil samples (316) were divided into four agronomic categories in accordance with the old textural groups (BN1978 standard) and into four agronomic/agrotechnic categories in accordance with the new edition of textural groups (PSSS 2008 classification). Agronomic category V which was called "very heavy soils" by the PSSS 2008 classification did not occur in the analysed sample due to the lack of soils with a high clay fraction content. According to the old categories (BN1978 standard), the amount of soils included in the agronomic category

TABLE 3. TRANSITION OF SOIL TEXTURAL GROUPS FROM BN1978 STANDARD TO PSSS2008 CLASSIFICATION

Agronomy categories	BN1978 standard			PSSS2008 classification		
	Soil textural groups	No of samples	Sum	Soil textural groups	No of samples	Sum
I	pl plp ps psp	7 0 28 2	n = 37	pl plp ps psp pgl	7 0 23 0 1	n = 31
II	pgl pglp pgm pgmp płz	38 4 28 15 4	n = 89	ps psp pgl pglp pgm pgmp płz	5 2 37 4 15 1 0	n = 64
III	gl glp płg	37 30 27	n = 94	pgm pgmp płz gl glp płg gs gsp gcp płi ip	13 14 4 37 27 24 1 14 1 31 1	n = 167
IV	gs gsp gc gcp płi i ip	12 20 10 4 40 2 8	n = 96	glp płg gs gsp gc gcp płi i ip	3 3 11 6 10 3 9 2 7	n = 54

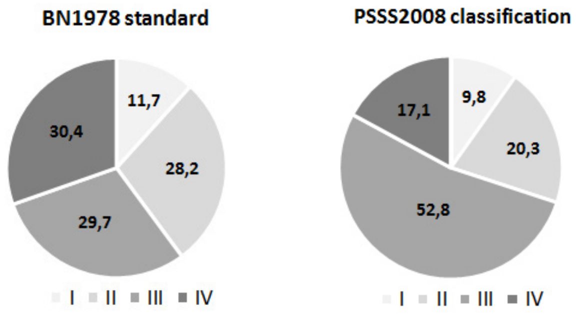

Fig. 1. Percentage share of agronomic categories according to: BN1978 standard and PSSS2008 classification

I 'very light' is the lowest of the whole set as it consists of 37 trials. Soils under other categories, such as II 'light', III 'medium" and IV 'heavy' are equally comparable and represent respectively, 89, 94 and 96 samples (Table 3, 4). The quantity of soil samples in the new I categories (PSSS 2008 classification) was reduced to 31. Quantitative category changes are related to the transition of 5 loamy sand samples (ps) and of 2 silty loamy sand samples to the II category. The number of soil samples in the new II category (PSSS 2008 classification) was reduced from 89 to 64. The changes are related to the transition of 13 samples of heavy loamy sand (pgm) and 14 soil samples of silty heavy loamy sand (pgmp) to the category III (Table. 3). The highest quantitative change under the new soil texture classification (PSSS 2008 classification) occurred in category III (94 up to 167 samples). These changes consist of samples shifted from category II, 31 samples of clay silt (płi) and 14 samples of silty medium loam (gsp) shifted from category IV. The main category change from 96 to 54 occurred in the category IV. This is mainly due to the shifting to category III (tab. 3, 4).

Percentage share determination of categories II and IV increased by 7.9 and 13.3% respectively from BN1978 standard to PSSS 2008 classification for the whole population (Fig. 1) while the proportion of category III was lowered by as much as 23.1%. This implies a significant shift in the classification catego-

TABLE 4. COMPARISON OF SOIL AGRONOMIC CATEGORIES ACCORDING TO SOIL CLASSIFICATION OF BN1978 STANDARD AND PSSS2008 CLASSIFICATION

BN1978 standard		PSSS2008 classification					
	Number	I	II	III	IV	V	Sum
I	37	30	7	-	-	-	37
II	89	1	57	31	-	-	89
III	94	-	-	88	6	-	94
IV	96	-	-	48	48	-	96
Sum	316	31	64	167	54	-	316

ry in both agronomic systems under consideration. The numerical distribution analysis has shown that 7 soil samples from category I (BN1978 standard) can be qualified for category II (PSSS2008 classification) (Table 4), and similarly 31 (35%) trials from category II were classified as category III and one as category I. The most stable category was category III where 88 attempts (94%) remained in the same category and only 6 were moved to category IV. The largest shift occurred in category IV (BN1978 standard) where half of the trials were qualified for category III (PSSS2008 classification) (Table 4). The changes concern mainly silty soil samples (clayey silt and medium silty loam). The total category changes between the two systems involved 93 samples (29%) of the analysed samples.

The analysis revealed a slight lowering of fine particles (<0.02 mm) content in category I and II PSSS 2008 classification compared to the corresponding categories of BN1978 standard., An inverse relationship was observed in the case of category III and IV (Table 5, Fig. 2) but statistically significant differences have been found only in the case of categories I and IV (Table 5). The average clay fraction (<0.002 mm) content for category I, II and III PSSS 2008 classification are respectively 1.4, 2.1 and 6.3% lower than the comparable category in the system BN1978 standard, which are, respectively, 1.6, 2.7 and 6.9% (Table 6, Fig. 2). Statistically significant differences have been notified only in the case of categories I and III (Table 6). But the largest standard error differences of clay fraction content were found in the categories I, II and III BN1978 standard. (Table 6).

TABLE 5. DIVERSITY OF FINE PARTICLES < 0,02 MM FOR AGRONOMIC CATEGORY

Agronomic category	Statistics	Classification system			
		BN1978 standard		PSSS2008 classificiation	
I	Mean	7.49a	n = 37	7.23b	n = 31
	Standard error	0.98		1.55	
	Confidence interval –95%	5.56		4.17	
	Cofidence interval +95%	9.42		10.29	
II	Mean	15.53	n = 89	13.69	n = 64
	Standard error	0.64		1.08	
	Confidence interval –95%	14.22		11.56	
	Cofidence interval +95%	16.73		15.82	
III	Mean	27.18	n = 94	29.69	n = 167
	Standard error	0.61		0.67	
	Confidence interval –95%	25.9		28.38	
	Cofidence interval +95%	28.31		31.01	
IV	Mean	47.38a	n = 96	50.05b	n = 54
	Standard error	0.61		1.18	
	Confidence interval –95%	46.18		47.73	
	Cofidence interval +95%	48.57		52.37	

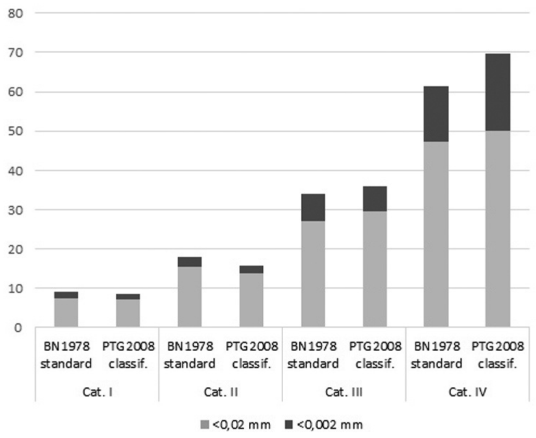

Fig. 2. Percentage of fine particle (< 0.02 mm) and colloidal fraction (< 0.002 mm) in agronomic categories according to soil texture classifications BN1978 standard and PSSS2008 classification

The relationship between fine particle fraction (<0.02 mm) content and clay fraction (<0.002 mm) content based on the analysed data is not very strong. The correlation coefficient is $R^2 = 0.65$ (Fig. 3). As an example, one can observe that soil with 10% of fine earths (<0.02 mm) may have 1 to 5% of clay earths (<0.002 mm) or that a soil with 30% of fine earths may have 3 to 20% of clay earths.

TABLE 6. DIVERSITY OF COLLOIDAL PARTICLES < 0,002 MM FOR AGRONOMIC CATEGORYS

Agronomic category	Statistics	Classification systems			
		BN1978 standard		PSSS2008 classification	
I	Mean	1.57a	n = 37	1.39b	n = 31
	Standard error	0.89		0.75	
	Confidence interval –95%	-0.19		-0.09	
	Cofidence interval +95%	3.32		2.86	
II	Mean	2.67	n = 89	2.05	n = 64
	Standard error	0.58		0.52	
	Confidence interval –95%	1.47		1.03	
	Cofidence interval +95%	3.75		3.08	
III	Mean	6.92a	n = 94	6.34b	n = 167
	Standard error	0.56		0.32	
	Confidence interval –95%	5.83		5.7	
	Cofidence interval +95%	8.02		6.97	
IV	Mean	14.11	n = 96	19.75	n = 54
	Standard error	0,55		0.57	
	Confidence interval –95%	13.02		18.64	
	Cofidence interval +95%	15.2		20.87	

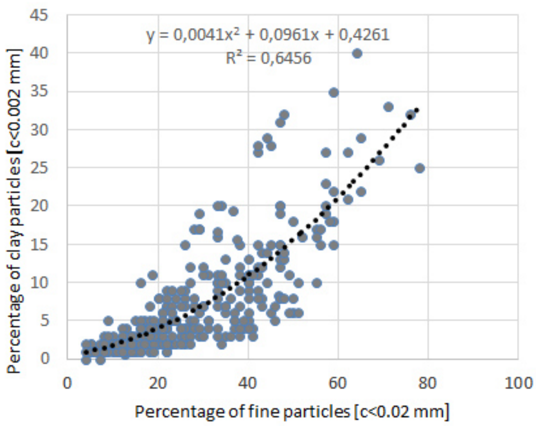

Fig. 3. Relationship between content of fine particles (<0.02 mm) and content of colloidal fraction (<0.002) of investigated soils

DISCUSSION AND SUMMARY

The old agronomic categories (BN1978 standard) were created based only on the content of fine particles (<0.02 mm). Creation of new categories (PSSS 2008 classification) is based mostly on the clay fraction (<0.002 mm) and subsequently on silt content (0.05 mm < c < 0.002 mm) and to a lesser extent on sand fraction (2.0 mm < c < 0.05 mm). Classification of soil in both systems leads to a differentiation of the agronomic categories and to a category shifting of some soil samples between old and new system.

These differences relate to both the number of soil samples selected for each category and to the average fraction of fine particles and of colloidal fractions.

Classification according to the new system (PSSS 2008_classification) caused a decrease of samples classified in categories I, II, IV of respectively 16, 28 and 44% (Table 4) in comparison with BN1978 standard. There was a significant decrease of the amount of samples classified in the category III (up to 78%). Most samples (70%) are marked as medium silty loam (gsp) and clayay silt (płi) 78% of agronomical category IV system (BN 1978 standard) does not fulfill the criteria for category IV in the new system (PSSS 2008 classification), where the requirements for classification as silts and clays are higher.

The fine particles (< 0.02 mm) content changed but statistically significant differences were observed only in categories I and IV (table 5). The average decrease in colloidal fraction (<0.002 mm) was found in the first three categories and an increase in the fourth category (Table 6). However, the content of a clay particles (< 0.002 mm) with differences statistically significant were observed only in categories I and III. The content of a clay and fine particles is very important to assess soil fertility but the clay fraction content (<0.002 mm) is more significant.

The tests calibration for soil mineral determination were carried out using the old soil texture classification (BN1978 standard) and old agronomic categories, which were based only on the fine particles earths (<0.02 mm). Interchangeable use of old and new agronomic categories in some cases can lead to incorrect fertilizer application (too small or to high fertilizer doses). Relationships between the content of fine particles fractions and the contents of clay fraction are only general. It is thus impossible to apply a simple conversion between both categories.

CONCLUSIONS

The results of this study indicate significand differences in the fine earths fraction (<0.02 mm) in the I and IV agronomic categories and significand differences in the clay fraction (<0.002 mm) in the I and III categories when comparing soil textural groups (BN1978 standard and PSSS 2008 classification).

The system of evaluation of soil pH as well as magnesium and potassium abundance considers agronomic category of the soil, which depends on fine earth fraction (<0.02 mm) content due to BN1978 standard. There is also an urgent need to determine if the changes in soil categorisation due to the new system (PSSS 2008) would influence recommended fertilizers doses.

New agrotechnical categories (PSSS2008 classification) based mainly on clay (<0.002 mm) content can also be the basis for the evaluating agrochemical soil parameters (soil pH, magnesium, potassium) and fertilization rates recommendation.

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