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The Effect of Subsoiling on Changes of Compaction and Water Permeability of Silt Loam

Łukasz Borek, Andrzej Bogdał, Krzysztof Ostrowski
University of Agriculture in Krakow

1. Introduction

Soil, or the surface layer of the earth's crust, is a natural medium for plant growth. Therefore, it is believed that food production is directly or indirectly dependent on the soil. In other words, life on Earth depends on the soil – it is a degradable and, unfortunately, non-renewable resource. Some 33% of the global acreage of soils is either moderately or heavily degraded by such factors as: erosion caused by water and/or wind, high salinity, compaction, sealing, contamination, acidification, and loss of organic carbon (Hillel 2007). Soil compaction is a significant problem of agriculture nowadays. It is directly connected with the mechanization of field treatments. Compaction is a physical form of soil degradation: it changes the soil structure, water and air permeability, porosity, and it inhibits penetration by plant roots (Hakl et al. 2007; Nawaz et al. 2013). The various ways to control the degree of soil compaction include soil improvement treatments, for instance, subsoil ploughing, which is also called subsoiling. Such treatments have a direct impact on the physical properties of soils and they indirectly affect the optimization of air-water conditions and the growth of crop plants (Matula 2003; Ragassi et al. 2012).

Water management in agricultural areas has gained more importance recently, mainly because the growing period has extended and the pattern of meteorological phenomena has become unpredictable: above all, the frequency of droughts and floods has increased (Szafrański et al. 2009, Trnka et al. 2013). Climate changes, connected with higher air temperatures and lower total precipitation in the growing period, combined with its growing time-space irregularity, have led to the occurrence of water crises in various parts of the world (Ragab & Prudhomme 2002). On the other hand, suitable conditions for the provision of watering systems enabling the supplementation of water deficiency in crop plants do not exist everywhere.

Agriculture is the most water-consuming industry: it uses the highest volume of global water resources, affecting the crop yield (Qadir et al. 2003). If in good condition, the soils may play a strategic part, not only in solving the problem of food for the ever growing population but also in slowing down climate changes (Krużel et al. 2015, Szymanowski et al. 2018).

The results of previous research indicate that subsoil ploughing and other soil improvement treatments have a desirable effect on air-water conditions in soils with an exceedingly compacted subsoil. A loosened soil has a higher infiltration capacity and helps transform the surface runoff into the subsurface runoff.

The objective of this paper is to assess the effect of subsoiling on changes of the compaction and water permeability of silt loam.

2. Material and Methods

The effect of soil improvement by subsoiling on changes in the soil compaction and water permeability was investigated for arable land in two agricultural objects, situated in the south of Poland, in the localities of Strzybnik (Racibórz District, Śląskie Province, 50°8’13,33’’ N, 18°8’46,1’’ E) and Prusy (Kraków District, Małopolskie Province, 50°7’5,0” N, 20°4’49,9” E). In the region of Object 1, in the multi-annual period 1971-2000, average annual air temperature was 8.5°C and total precipitation was 616 mm (according to IMGW – Institute of Meteorology and Water Management – station in Racibórz). In the region of Object 2, the data were 8.1°C and 663 mm, respectively (IMGW station Kraków) – table 1. Depending on changes in meteorological conditions, there are soils with periodically too high moisture contents in both objects, depending on changes in meteorological conditions (Bogdał et al. 2016).

In the field experiment, a 7-tined passive subsoiler from Maschio was used in Strzybnik, and a 3-tined passive subsoiler was used in Prusy. The effective operating depth of the working elements of the two subsoilers was between 50 and 60 cm, and the tines/coulters were spaced every 50 cm.

The field soil tests were carried out in the years 2011-2015 (Table 2). The tests were carried out on brown- and black earth (chernozem), which are good/very good in terms of soil fertility classes. The soil samples were taken from a total of 8 sampling points: 4 samples before (S1, P1, P2 and P3) and 4 after the subsoiling (S1', P1', P2' and P3'), and the essential morphological features were determined based on them. From each genetic horizon, from 3 to 6 undisturbed samples were collected for laboratory analyses into 100 cm^3 steel cylinders without disturbing the sample structures, and an approximately 1 kg sample with a disturbed structure was collected.

Table 1. The average sums of precipitations totals and air temperatures in the multi-annual period 1971-2000
Tabela 1. Średnie sumy opadów atmosferycznych i temperatur powietrza w wieloleciu 1971-2000

Station IMGW	Months												Jan-Dec
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation total [mm]													
Racibórz	28	26	32	45	67	79	94	74	56	41	40	34	616
Kraków	35	30	35	50	74	94	81	76	60	50	40	38	663
Average air temperature [°C]													
Racibórz	–1,3	–0,2	3,8	8,2	13,5	16,1	17,8	17,7	13,6	9,0	3,6	0,2	8,5
Kraków	–2,3	–0,9	3,1	8,0	13,4	16,2	17,8	17,5	13,2	8,4	2,8	–0,6	8,1

Table 2. Characteristics of research stations
Tabela 2. Charakterystyka stanowisk badawczych

Information	Object	
	Strzybnik (S)	Prusy (P)
Number of soil-sampling points	2	6
Date of subsoiling	10.2010	09.2014
Date of tests in the field (BS)	25.06.2012	7.04.2011/28.04.2015
Date of tests in the field (AS)	25.06.2012	4–5.10.2014/28.04.2015
Crop plant	maize	wheat

BS – field without subsoiling, AS – field with subsoiling

The field measurement of permeability of for the topsoil (10-20 cm) and subsoil horizons (40 cm) was performed using a double-ring infiltrometer from the Dutch manufacturer Eijkelkamp. The tests were carried out in three repetitions and the results of only two (most similar) of them were used in the analysis. Fluctuations in water permeability vs. time were plotted for each horizon. Moreover, linear trends and their corresponding equations (i) and coefficients of determination (R^2) were added. Infiltration rate was calculated for the respective time intervals ΔT, using the following formula (Gulliver & Anderson 2008):

$$i = \frac{864 \cdot 4 \cdot V}{3.14 \cdot D_r^2 \cdot \Delta T} \ [m \cdot d^{-1}] \qquad (1)$$

where:
V – volume of water added in time (ΔT) into the measuring cylinder [cm^3],
D_r – diameter of the inner ring [cm^2],
ΔT – infiltration time for the water volume ΔV [s].

Average rate of infiltration of water vs. duration of measurement was described by the power function:

$$i_t = i_1 \cdot t^{\varepsilon} \ [m \cdot d^{-1}] \qquad (2)$$

where:
i_t – infiltration rate at the time t from the beginning of the infiltration process [$m \cdot d^{-1}$],
i_1 – infiltration rate in the first time unit [$m \cdot d^{-1}$],
t – infiltration time [min],
ε – coefficient, depending on soil properties [–].

Infiltration classes for the various horizons were adopted according to the FAO classification (FAO 1971): infiltration is very slow – <0.024 $m \cdot d^{-1}$; low – 0.024-0.12 $m \cdot d^{-1}$; moderately slow – 0.12-0.48 $m \cdot d^{-1}$; moderate – 0.48-1.56 $m \cdot d^{-1}$; moderately rapid – 1.56-4.20 $m \cdot d^{-1}$; rapid – 4.20-5.81 $m \cdot d^{-1}$; very rapid – >5.81 $m \cdot d^{-1}$.

The following parameters were determined in three repetitions in order to assess the effect of subsoiling on changes of soil compaction: bulk density and moisture – by gravimetry (oven and balance); specific density – by pycnometry; organic carbon by the Tiurin's method (as organic matter); particle size distribution – by areometry. The names of soil texture classes were given according to the Polish Soil Science Society. Soil classification was established according to the Polish Soil Science Classification and the FAO–WRB classification.

Based on the results of laboratory analyses total porosity in the soil were found. Next, using the results of determination of actual moisture [% v/v], soil water resources [mm] were determined for all the genetic horizons of the soil profiles investigated (Landon 1991).

The significance of soil profile subsoiling to changes in the compaction and water permeability of silt loam was determined by means of statistical analyses using the *Statistica 12.5 PL* software. The parameters used for the purpose were bulk density (a measure of soil compaction) and steady infiltration. The statistical analyses were based on the results of determination of bulk density in all the repetitions. In the case of steady infiltration, the results of two repetitions were used. Basic descriptive statistics of the soil samples were determined, including the following: minimum value ($x_{min.}$), maximum value ($x_{max.}$), mean (x), median (Me), percentile 25 and 75%, standard deviation (SD), and coefficient of variation (CV). Because of a lack of normality of distribution of the properties investigated, the significance of differences in the general population distributions in the respective soil horizons before and after subsoiling were calculated using the non-parametric, statistical Mann-Whitney U test – the variant for two small independent samples at the significance level of $\alpha = 0.05$. This analysis was preceded by Stevens's series test to check the randomness of the data.

3. Results and Discussion

The soil composition in Strzybnik and in Prusy is highly uniform, with silt loam (SiL) in all its genetic horizons. With a high percentage of silt (61-74%), these soils are classified as heavy, silt soils. Silt soils are not easily cultivated as they tend to swell or shrink depending on their moisture content (Boivin et al. 2006). Moreover, secondary compaction often occurs in such heavy silt loams, causing an increased surface run-off, in particular on slopes, thus leading to erosion (Jourgholami et al. 2017). Their properties, especially air-water conditions, are frequently varied in time. The phenomenon is mainly caused by the pattern of meteorological conditions, landform features, and agrotechnical treatments.

Specific densities of the soils for the objects investigated ranged from 2.60-2.68 $g{\cdot}cm^{-1}$ (Table 3) and tended to be lower in the topsoil horizons (Ap), which is normal for mineral soils (Hillel 1998). Bulk densities for the soils, affecting their porosity, ranged from 1.45 to 1.73 $g{\cdot}cm^{-1}$; therefore, the soils are qualified as poorly compacted (pc) to heavily compacted (hc) (Table 3). As demonstrated by Berisso et al. (2012) commonly used agricultural machinery can compact the soil to 0.9 m depth, the effect may persist for at least 14 years, and important soil functions are affected. In mitigation of arable soil compaction a key role plays subsoiling (Chamen et al. 2015).

Total porosity of the soils in Strzybnik was higher in all the genetic horizons for the soil profile with subsoiling (39.3-41.6%) in comparison with same horizons for the soil without subsoiling (35.5-41.4%) (Table 3). In the case of Prusy, total porosity of the soils without subsoiling was not always the highest in the topsoil horizons. The fact may be accounted for by the soils' heavy texture (particle size distribution), leading often to what is called secondary compaction, as well as high activity of soil organisms, especially earthworms; they make their little canals which are visible in the soil profiles, thus improving the soil porosity and change its air-water conditions. The application of subsoiling improved the soil porosity (40.9-44.5%) in comparison with the soil without subsoiling (39.3-43.5%), which is especially visible in the subsoil horizons below the Ap horizon – differences in the thickness of the genetic levels of soils before and after subsoiling were resulted from a change in porosity and from the fact that the pits were made at a certain distance from each other. Wang et al. (2014) observed that subsoiling affected on reduced soil bulk density in the 0-30 cm soil layer, but more importantly the treatment increased total porosity (Table 3).

The largest amounts of organic matter were recorded for the topsoil horizons (1.0-1.5%) in both Objects, and the lowest were recorded for the parent rock layer in Strzybnik (0.1-0.2%). In the soils in Prusy, the lowest content of organic matter was found for the subsoil horizons (Table 3). The soil organic matter is one of the parameter which influence to the physicochemical properties of soils (Widłak 2016).

Table 3. Selected physical and water properties of soils
Tabela 3. Wybrane właściwości fizyko-wodne gleb

Profile number	Genetic horizons	Depth	Specific density	Soil bulk density	Degree of compaction[1]	Total porosity	Organic matter	Soil moisture	Actual soil water resources
		[cm]	[g·cm^{-3}]		[–]	[%]		[% v/v]	[mm]
S1	Ap	0–27	2.63	1.54	c	41.4	1.1	16.9	46
	Bw	27–100	2.68	1.69	c	36.9	0.3	24.1	176
	C	100–150	2.68	1.73	hc	35.5	0.2	28.7	144
S1’	Ap	0–40	2.62	1.53	c	41.6	1.1	15.4	62
	Bw	40–90	2.68	1.59	c	40.7	0.2	18.9	95
	C	90–150	2.67	1.62	c	39.3	0.1	28.3	169
P1	Ap	0–30	2.61	1.50	c	42.5	1.0	38.6	116
	Bw	30–100	2.63	1.53	c	41.8	0.7	34.0	238
	C	100–150	2.62	1.52	c	41.9	0.7	40.4	202

Table 3. cont.
Tabela 3. cd.

Profile number	Genetic horizons	Depth	Specific density	Soil bulk density	Degree of compaction[1]	Total porosity	Organic matter	Soil moisture	Actual soil water resources
		[cm]	[g·cm^{-3}]		[–]	[%]		[% v/v]	[mm]
P1’	Ap	0–35	2.61	1.52	c	41.7	1.0	37.8	131
	Bw	35–105	2.63	1.48	pc	43.7	0.7	34.9	243
	C	105–150	2.62	1.45	pc	44.5	0.7	37.2	164
P2	Ap	0–35	2.62	1.54	c	41.2	1.2	37.1	130
	Bw	35–60	2.61	1.56	c	40.2	0.4	38.2	96
	Bw/C	60–94	2.61	1.48	pc	43.3	0.8	40.1	136
	C	94–150	2.60	1.49	pc	42.7	0.8	41.9	234
P2’	Ap	0–40	2.62	1.54	c	41.1	1.2	38.3	156
	Bw	40–65	2.61	1.54	c	40.9	0.4	35.2	86
	Bw/C	65–99	2.61	1.52	c	41.9	0.8	35.5	120
	C	99–150	2.60	1.48	pc	43.1	0.8	40.1	205
P3	Ap	0–27	2.61	1.58	c	39.5	1.5	36.2	98
	B	27–80	2.62	1.54	c	41.3	0.4	33.2	176
	B/C	80–100	2.60	1.58	c	39.3	0.8	37.1	74
	C	100–150	2.62	1.48	pc	43.5	1.0	36.1	181
P3’	Ap	0–32	2.61	1.45	pc	44.5	1.5	33.2	106
	B	32–85	2.62	1.46	pc	44.4	0.4	34.2	181
	B/C	85–105	2.60	1.47	pc	43.3	0.8	34.8	70
	C	105–150	2.62	1.47	pc	44.0	1.0	35.8	161

[1] Degree of compaction: pc – poorly compacted, c – compacted, hc – heavily compacted

In Strzybnik, higher actual moisture contents were recorded for the soil without subsoiling (S1: 16.9-28.7 % v/v; S1': 15.4-28.3% v/v) (Table 3). The highest moisture content was observed for the bedrock horizon and the values were getting lower toward the surface soil horizons. Lower moisture contents and higher porosities after subsoiling were also reported by Martínez et al. (2011). In Prusy, although it is rather hard to define an unambiguous trend in the distribution of actual moisture content for the soil with and without subsoiling, bulk moisture content is usually lower in soils after subsoiling as a rule (33.2-40.1% v/v) than before (33.2-41.9 % v/v). Strausbaugh & Windes (2006) reported that subsoiling resulted in higher soil moisture contents in the subsoil horizon and deeper soil profile horizons. In 1.50-m deep soil profiles, soil water resources [mm] were higher in the soil without subsoiling.

In the field with subsoiling in Strzybnik, in the topsoil horizon at 10 cm, the soil water permeability in steady conditions after 180 minutes was i_{st} = 1.86 m·d^{-1} (Fig. 1b); according to the FAO classification, this corresponds to the moderately rapid infiltration class. Water permeability was 447% higher than that for the field without subsoiling where, after 180 minutes $i_{st.}$ = 0.34 m·d^{-1}; this corresponds to the moderately slow infiltration class (Fig. 1a). In the subsoil horizon at 40 cm, water permeability before and after subsoiling was lower than that in the topsoil horizon (Fig. 1). After some 110 minutes, values corresponding to the moderately slow infiltration class were obtained (Fig. 1c and 1d).

Soil compaction has an effect on the crop yield, it affects the ability of plants to take root and prevents water infiltration deep down into the soil profile (Hamza et al. 2011). According to Zhao et al. (2013), within its impact zone, subsoil ploughing has a major effect on its physical properties, especially its ability to infiltrate rainwater and transform surface runoff into subsurface runoff.

In Prusy, at the sampling point P1' in the field with subsoiling in the topsoil horizon at 20 cm, steady infiltration was i_{st} = 4.80 m·d^{-1} (Fig. 2b) after 140 minutes, corresponding to the rapid infiltration class.

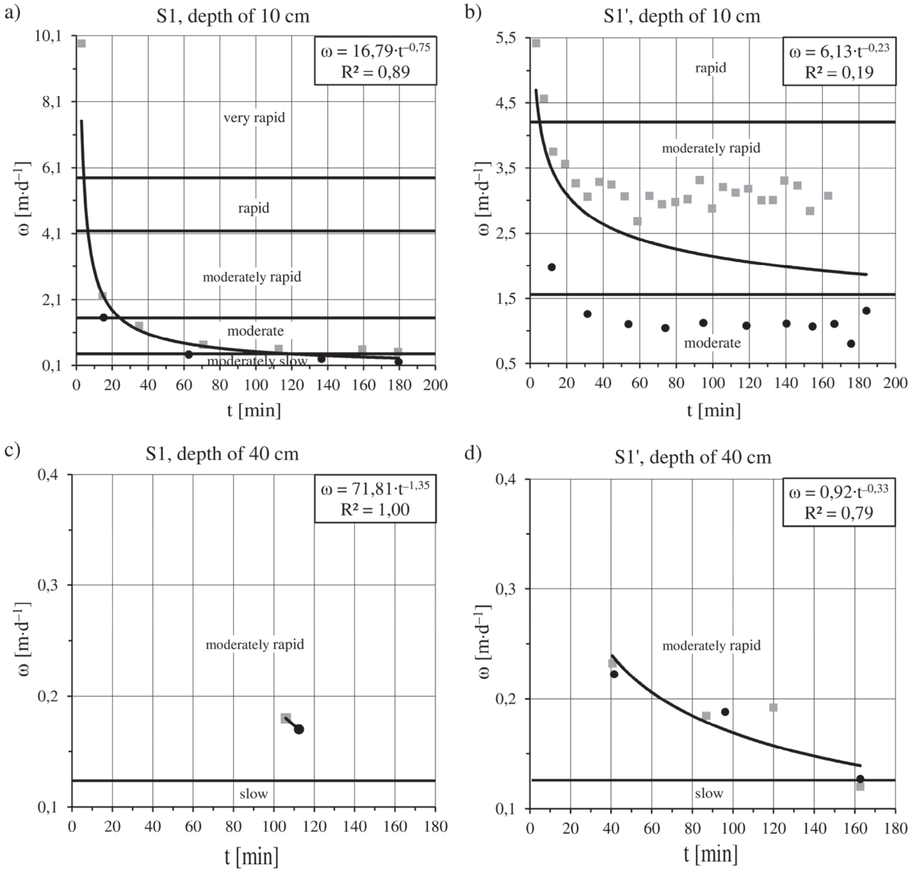

Fig. 1. Soil water permeability for the Strzybnik object: a) and c) soil without subsoiling (S1), b) and d) soil with subsoiling (S1'); ● – first repetition, ■ – second repetition

Rys. 1. Przepuszczalność gleb na obiekcie Strzybnik:
a) i c) gleba nie głęboszowana (S1), b) i d) gleba głęboszowana (S1');
● – pierwsze powtórzenie, ■ – drugie powtórzenie

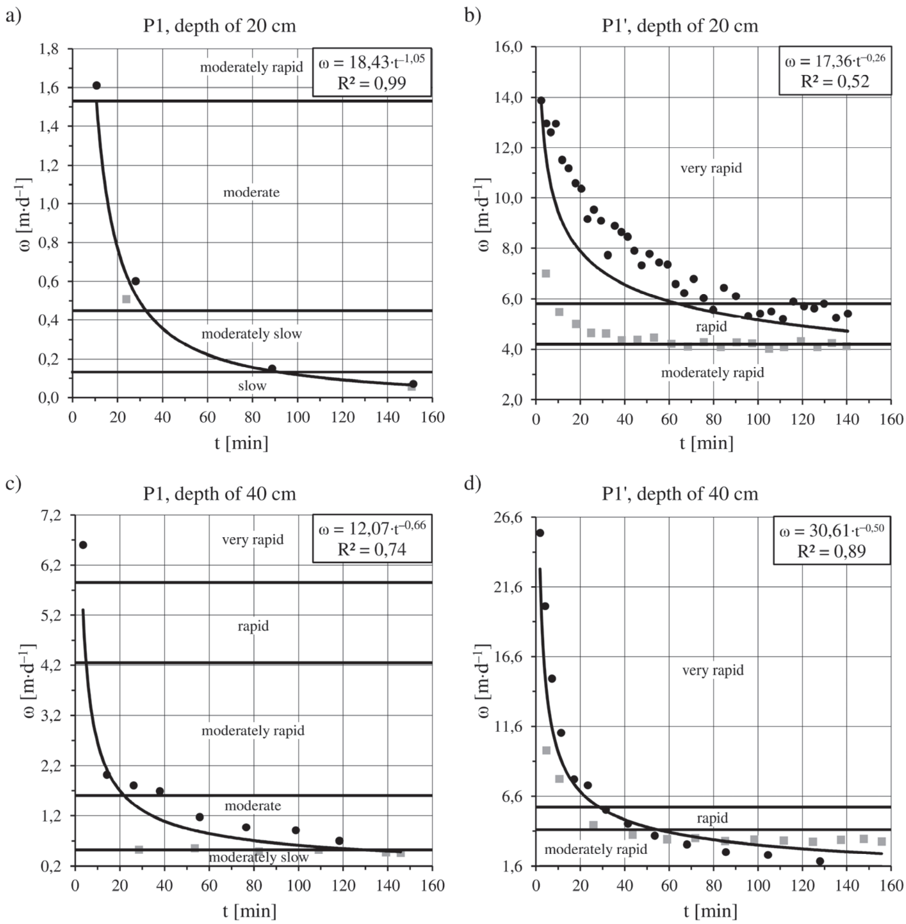

Fig. 2. Soil water permeability for the Prusy object: a) and c) soil without subsoiling (P1), b) and d) soil with subsoiling (P1'); ● – first repetition, ■ – second repetition

Rys. 2. Przepuszczalność gleb na obiekcie Prusy: a) i c) gleba nie głęboszowana (P1), b) i d) gleba głęboszowana (P1'); ● – pierwsze powtórzenie, ■ – drugie powtórzenie

The value was 48 times as high as that for the soil without subsoiling (P1), where infiltration after 150 minutes was about 0.10 $m \cdot d^{-1}$ (Fig. 2a), corresponding to the low infiltration class. In the subsoil horizon at 40 cm, steady infiltration after 150 minutes was 443% higher than that for the field with subsoiling (i_{st} = 2.50 $m \cdot d^{-1}$), in comparison with that without subsoiling (i_{st} = 0.46 $m \cdot d^{-1}$) and corresponded to the moderately rapid and moderately slow infiltration classes, respectively (Fig. 2c and 2d). The subsoil horizon of the soil without subsoiling showed 4.6-times as high infiltration capacities as the topsoil horizon; this is attributable to the presence in the horizon of earthworms (*Lumbricus terrestris*), which loosen and break up the soil by making canals in it (Mossadeghi-Björklunda et al. 2016). The subsoiling resulted in improved infiltration of the topsoil and subsoil horizons.

At the sampling point P2 in the field without subsoiling, in the topsoil horizon, steady infiltration after 110 minutes was 1.15 $m \cdot d^{-1}$, corresponding to the moderate infiltration class (Fig. 3a) according to the FAO classification. At P2' after subsoiling, in the same horizon, infiltration increased by 139% (Fig. 3b) and measurement time was as long as 160 minutes; this resulted in a steady infiltration of 2.75 $m \cdot d^{-1}$ and changed the infiltration class from moderate to moderately rapid. In the field without subsoiling, at P2, in the subsoil horizon, the value of steady infiltration after 100 minutes was 3.37 $m \cdot d^{-1}$, corresponding to the moderately rapid infiltration class (Fig. 3c). After subsoiling, infiltration which stabilized after some 160 minutes, was lower (i_{st} = 1.90 $m \cdot d^{-1}$) than that recorded before subsoiling – this qualifies the soil infiltration capacity to the moderately rapid class (Fig. 3d).

In Prusy, before subsoiling, at the sampling point P3 at 15 cm, steady infiltration was 0.15 $m \cdot d^{-1}$ after 120 minutes, corresponding to the moderately slow infiltration class (Fig. 4a). After subsoiling, in steady conditions after 140 minutes infiltration was nearly 8 times as high, namely i_{st} = 1.14 $m \cdot d^{-1}$, satisfying requirements for the moderate infiltration class (Fig. 4b). In the subsoil horizon without subsoiling, at 40 cm, after 120 minutes, steady infiltration was 1.72 $m \cdot d^{-1}$, which is higher than for the topsoil horizon (Fig. 4c and 4a); this classifies the soil water permeability as moderately rapid. However, that value of steady infiltration was clearly lower (by 338%) than that in the soil with subsoiling – 7.55 $m \cdot d^{-1}$ after 140 minutes, which corresponds to the very rapid water infiltration class (Fig. 4d).

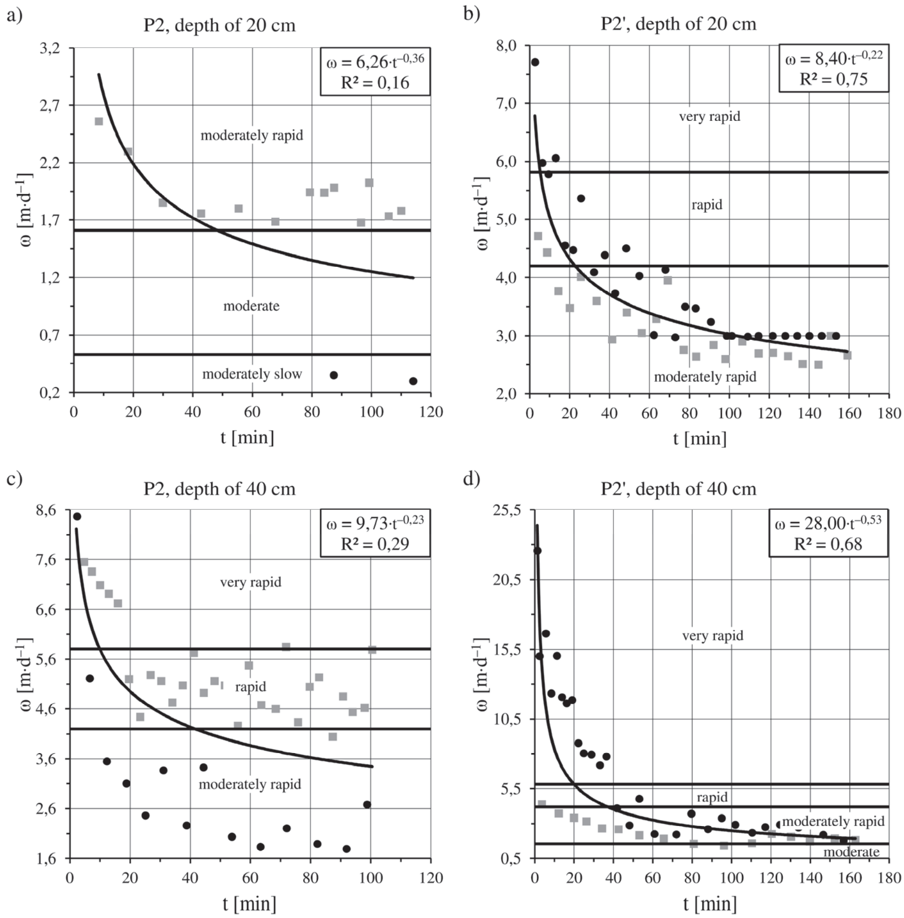

Fig. 3. Soil water permeability for the Prusy object: a) and c) soil without subsoiling (P2), b) and d) soil with subsoiling (P2'); ● – first repetition, ■ – second repetition

Rys. 3. Przepuszczalność gleb na obiekcie Prusy: a) i c) gleba nie głęboszowana (P2), b) i d) gleba głęboszowana (P2'); ● – pierwsze powtórzenie, ■ – drugie powtórzenie

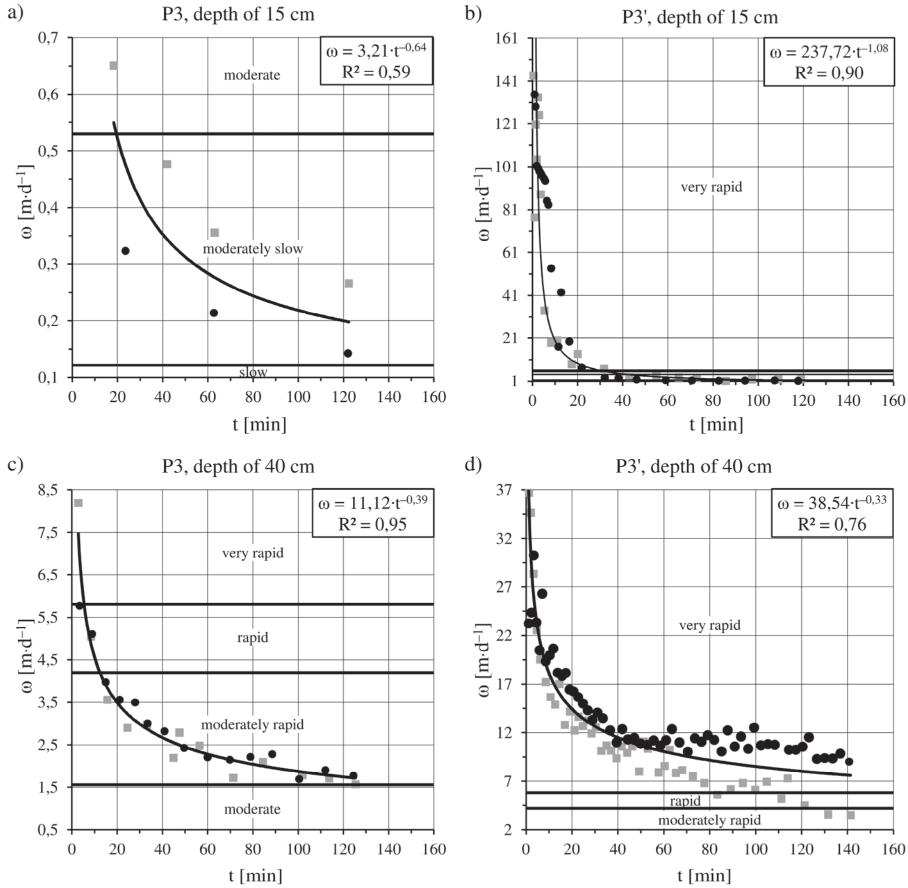

Fig. 4. Soil water permeability for the Prusy object: a) and c) soil without subsoiling (P3), b) and d) soil with subsoiling (P3’); ● – first repetition, ■ – second repetition

Rys. 4. Przepuszczalność gleb na obiekcie Prusy: a) i c) gleba nie głęboszowana (P3), b) i d) gleba głęboszowana (P3’); ● – pierwsze powtórzenie, ■ – drugie powtórzenie

In silt loam, the topsoil bulk density was statistically significantly lower (P = 0.003) after subsoiling than before subsoiling. Similarly in subsoil, despite a small difference in mean values, bulk density was statistically significantly lower after subsoiling: P = 0.022 (Table 4). This is confirmed in the report of Borghei et al. (2008) whose findings show that subsoiling as a soil improvement technique resulted in a significant decrease in the value of bulk density.

Table 4. Essential descriptive statistics of selected physical and water properties of soils without (BS) and with (AS) subsoiling and the Mann-Whitney U test results

Tabela 4. Podstawowe statystyki opisowe niektórych właściwości fizyko-wodnych gleb oraz wyniki testu U Manna-Whitneya

Statistical parameters:		x_{min}	x_{max}	n	x	Me	SD	CV [%]	Probability (P) in the Mann-Whitney U test
Soil bulk density [$g \cdot cm^{-3}$]									
Silt loam (SiL)	topsoil (BS)	1.51	1.63	18	1.56	1.56	0.036	2.3	0.003[1]
	topsoil (AS)	1.43	1.58	18	1.51	1.51	0.051	3.4	
	subsoil (BS)	1.52	1.70	15	1.57	1.55	0.054	3.5	0.022[1]
	subsoil (AS)	1.42	1.61	15	1.51	1.49	0.056	3.7	
Infiltration of water [$m \cdot d^{-1}$]									
Silt loam (SiL)	topsoil (BS)	0.09	1.73	8	0.41	0.23	0.307	128.1	0.002[1]
	topsoil (AS)	1.00	5.42	8	2.80	2.83	2.170	49.2	
	subsoil (BS)	0.12	5.79	8	1.64	1.12	3.624	108.4	0.189
	subsoil (AS)	0.16	9.01	8	2.77	1.90	7.752	93.9	

[1]statistically significant differences ($P < 0.05$) for the level of significance $\alpha = 0.05$

After the application of subsoiling in silt loams, steady infiltration for the topsoil was statistically significantly higher than that for the soils treated by conventional techniques only (Table 4). Also in the subsoil horizons, permeability was improved by subsoiling, on average, from 1.64 to 2.77 $m \cdot d^{-1}$, although the difference appeared to be statistically insignificant for the assumed level of significance, $\alpha = 0.05$. The variability of steady infiltration values was high (CV > 100%) for the soils without subsoiling and moderate for those with subsoiling (Table 4).

Drewry et al. (2000) report that subsoiling loosens and breaks up the topsoil, thus improving its porosity and hydraulic conductivity. Abu-hamdeh (2003) found that subsoil ploughing reduced the degree of soil compaction, which was reflected in lower bulk densities. Botta et al. (2006) report that the desirable effect of subsoil ploughing is noticeable for a maximum of 2 years, whereas Drewry et al. (2000) report a time limit of 2.5 years after subsoiling.

3. Conclusion

The assessment of the efficacy of subsoil ploughing of heavy soils indicates a statistically significant decrease in bulk densities for the topsoil and subsoil as well as an increase in steady infiltration for the two horizons, although it is statistically significant for the topsoil only. Improving the topsoil water permeability is expected to help control surface runoff and erosion. Therefore, the use of subsoiling in heavy, compacted arable land is justified, as it may be sufficient for improving its air-water conditions if the soil water resources are slightly lower or higher than necessary, without resorting to technical methods of soil improvement.

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Wpływ głęboszowania na zmiany zagęszczenia i przepuszczalność gleb pyłowo-ilastych

Streszczenie

Gleba jako naturalne środowisko rozwoju roślin w około 95% odpowiada za produkcję żywności. Około 33% światowego areału gleb jest średnio lub silnie zdegradowanych. Jedną z istotnych przyczyn degradacji gleb jest jej nadmierne zagęszczenie powodowane przez mechanizację prac polowych. Ograniczaniu zagęszczania gleb sprzyjają zabiegi agromelioracyjne – w tym głębokie spulchnianie, tzw. głęboszowanie – które wpływa na optymalizację warunków powietrzno-wodnych w glebie oraz na wzrost plonu roślin. W pracy oceniono wpływ zabiegu głęboszowania na zmiany zagęszczenia i przepuszczalności wodnej gleb pyłowo-ilastych. Badania prowadzono na gruntach ornych dwóch obiektów rolniczych położonych w powiecie raciborskim i powiecie krakowskim. W pracy wykazano, że zabieg głębokiego spulchniania spowodował statystycznie istotne zmniejszenie gęstości objętościowej (zagęszczenia) gleb zwięzłych w warstwach ornych i podornych oraz zwiększenie infiltracji ustalonej, które tylko w warstwie ornej okazało się statystycznie istotne. Uzyskane wyniki badań potwierdzają, że głęboszowanie zagęszczonych zwięzłych gleb uprawnych jest uzasadnione, ponieważ w przypadku wystąpienia niewielkich niedoborów lub nadmiarów wody w glebie może okazać się zabiegiem wystarczającym do uregulowania stosunków powietrzno-wodnych, bez konieczności wykonywania kosztownych melioracji technicznych. Ponadto, zwiększenie porowatości oraz wodoprzepuszczalności gleby powinno zmniejszać spływy powierzchniowe i tym samym ograniczyć zjawiska erozyjne.

Abstract

Soil, as the top layer of the Earth's surface, is a natural medium for the growth of plants. It is estimated that 95% of global food comes from our soils so we depend on the soil. About 33% of global soil is moderately to highly degraded. Soil compaction, caused by the mechanization of field treatments, is one of the major problems in agriculture nowadays. Subsoiling is one of the ways to reduce soil compaction and improve the air-water properties of arable soils. An assessment of the effect of subsoiling on the degree of compaction and water permeability of silt loam is presented in this paper. Soil tests were carried out in arable land, situated in the Racibórz and Kraków districts in the south of Poland. The results of the research show positive effects of subsoiling on the air-water relationship in the soil. In the majority of profiles, an increase in the percentage of total porosity in the first and second genetic horizons of the subsoiled soil was observed. The assessment of the efficacy of the subsoiling of heavy soils indicates a statistically significant decrease in bulk density for the topsoil and subsoil and a significant increase in steady infiltration only in the topsoil. The results show that subsoiling of arable compacted soils is justified, because in the case of slight deficiencies or excess water in the soil it may be a sufficient treatment to regulate air and water relationship, without the need for costly technical drainage. In addition, increasing the porosity and water permeability of soil should reduce surface runoff and thus reduce the phenomenon of erosion.

Słowa kluczowe:
zagęszczenie gleb, głęboszowanie, przepuszczalność gleb

Keywords:
soil compaction, subsoiling, soil water permeability