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Impact of cover crops and tillage on porosity of podzolic soil**

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Abstract. The aim of the study was to determine the influence of cover crops biomass, mixed with the soil on different dates and with the use of different tools in field conditions. The cover crop biomass had a beneficial influence on the total porosity of the 0-20 cm layer of the soil after winter. The highest porosity was achieved with cover crops of buckwheat, phacelia and mustard, the lowest with rye. During the vegetation period the highest porosity of soil was observed in the ridges. Among the remaining non-ploughing cultivations, pre-winter use of stubble cultivator proved to have a beneficial influence on the soil porosity, providing results comparable to those achieved in conventional tillage. The differential porosity of the soil was modified not only by the catch crops and the cultivation methods applied, but also by the sample collection dates, and it did change during the vegetation period. The highest content of macropores after winter was observed for the phacelia cover crop, and the lowest in the case of cultivation without any cover crops. Pre-winter tillage with the use of a stubble cultivator increased the amount of macropores in soil in spring, and caused the biggest participation of mesopores as compared with other non-ploughing cultivation treatments of the soil. The smallest amount of mesopores was found in the ridges.

Keywords: grubber, non-ploughing cultivation, cover crops

INTRODUCTION

The tendency to divert from ploughing and to replace it with other methods of cultivation and tillage simplification is a world-wide trend, used in agriculture for years. It is also becoming increasingly popular in Poland. The abandonment of traditional ploughing, performed with the use of mouldboard plough, is mostly the result of economic grounds. Ploughing is the most energy-consuming of agricultural methods, requiring the most resources (Dzienia, 2006). The environmental protection is also a decisive factor. Organic farming is usually based on ploughless tillage. Apart from its undisputed advantages, such as deep loosening of soil, its aeration, reduction of weed infestation, covering of post-crop remains, increase of root growth zone, ploughing has also numerous disadvantages. They are: the destruction of the natural protective layer of soil, the destruction of soil structure, the drying of the arable layer, interference in the circulation of nutrients, increased pace of organic matter decomposition, depopulation of soil fauna and disturbance of the biological activity of the soil. Ploughing encourages water and wind erosion. The plough leads to the creation of ploughed sole and ploughing out of stones and inactive subsoil (Bertol *et al*., 2005; Dexter and Czyż, 2011; Zimny, 1997). That is why the world agriculture replaces traditional tillage with cultivations that do move the soil, but without turning it over (Zimny, 1997). The conservation cultivation becomes more and more popular, with covering plants playing the major role in it (Çakir, 2010). Also the pro-ecological actions encourage us to search for other sources of organic matter. The shortage of farmyard manure means that the use of covering plants, in the form of summer or winter cover crops whose biomass is introduced in the soil, plays an ever increasing role. The plant residues mixed with the soil change its physical properties in two ways. On the one hand – mechanically, on the other – being a source of organic matter, and consequently humus, the cover crops beneficially influence the soil structure, leading to the stabilization of soil aggregates (Kęsik and Błażewicz-Woźniak, 2010). The plants, by covering the soil surface for some time, protect it from water and wind erosion, preventing the nutrients from being washed down to the deeper layers of soil profile

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(Dabney *et al*., 2001; Kraska, 2011). Thanks to the deep penetration of the soil by the cover crops roots the soil structure is improved.

When left over in the form of mulch, they increase the humidity of the soil, increase the water infiltration rate, regulate temperature, reduce erosion and compaction of the soil, increase the diversity of crops and soil organisms (Çakir, 2010). Mulching mimics the processes of organic matter decomposition, as present in nature, in which the dead plant mass, covering the soil in form of litter, decomposes gradually on the surface of the soil. Intensively used agricultural soils face the largest problem in proper shaping of macroporosity that affects the water infiltration, its flow to the pedon, and gas exchange between the soil and the atmosphere (Słowińska-Jurkiewicz *et al*., 2004). The soil porosity, especially the distribution of macro- and micropores, largely influences the growth of plants, by modifying the resistance of soil to roots and the availability of water (Farkas *et al*., 2006; Lipiec *et al.*, 2006; Witkowska-Walczak and Turski, 2004).

The aim of the study was to determine the influence of cover crops biomass, mixed with the soil on different dates and with the use of different tools, as well as no-tillage cultivation, on the total and differential porosity of podzolic soil in field conditions.

MATERIAL AND METHOD

The field experiments were conducted in the years 2009-2011 at the Felin Experimental Station of the University of Life Sciences in Lublin, Poland (51°23'N, 22°56'E), on a grey-brown podzolic soil (AP) derived from medium silty loam (BN-78/9180-11). These are soils that are difficult to cultivate, prone to the compacting influence of rains, easily crusting during droughts. The soil contained, on average, 1.06-1.15% of humus in its 0-20 cm layer, and was mildly acidic (pH in 1 M KCl 5.76-5.90) prior to the sowing of cover crops. The contents of available phosphorus, potassium and magnesium were: P – 146.8, K – 111.5, Mg – 102.9 mg kg^{-1} of the soil. The experiment was designed with use of completely randomised blocks, in four replications. The area of a single plot was 33 m^2.

The experiment took the following factors into account:

I. Cover crop plants: spring rye (*Secale cereale*), common oats (*Avena sativa*), common vetch (*Vicia sativa*), white mustard (*Sinapis alba*), phacelia (*Phacelia tanacetifolia*), buckwheat (*Fagopyrum esculentum*), fodder sunflower (*Helianthus annuus*);

II. Soil cultivation:

1. Conventional ploughing tillage, with a complex of pre-winter cultivation (pre-winter ploughing to 25-30 cm depth) and spring, presowing cultivation (harrowing, cultivating) (CT);
2. A complex of presowing cultivation, sowing of cover crops (1st decade of August), pre-winter tillage with the use of stubble grubber cultivator (25 cm depth) (mixing the green mass with soil) and forming ridges in spring (Gz+Aw+Rw);
3. A complex of presowing cultivation, sowing of cover crops (1st decade of August), pre-winter cultivation with the use of subsoiler (30 cm depth) (mixing the green mass with soil), cultivation with soil aggregate (10-15 cm depth) in spring (cultivator+harrow+string rolling) (GLz+Aw);
4. A complex of presowing cultivation, sowing of cover crops (1st decade of August), pre-winter tillage with the use of stubble grubber cultivator (25 cm depth) (mixing the green mass with soil), cultivation with soil aggregate (10-15 cm depth) in spring (Gz+Aw);
5. A complex of presowing cultivation, sowing of cover crops (1st decade of August), spring tillage with the use of stubble grubber cultivator (25 cm depth) (mixing the mulch with soil) (NTz+Gw);
6. A complex of presowing cultivation, sowing of cover crops (1st decade of August), cultivation with soil aggregate (10-15 cm depth) in spring (NTz+Aw).

The control was conventional tillage (CT) without cover crops.

The cover crop plants were sown after the forecrop of winter wheat was cleared. Immediately after the wheat was harvested, the soil was disc-harrowed and then ploughed about 15 cm deep and harrowed. Each year the cover crops were sown on the same date, that is on August 1st. Taking the previous year experiences into account, larger than recommended quantities of sowing material were used. The effect was that the sowing rates were set as follows (kg ha^{-1}): rye – 300, oats – 300, vetch – 200, mustard – 200, phacelia – 50, buckwheat – 200, and sunflower – 125. In 2010 it proved necessary to seed an additional 1.5 kg of phacelia and 3.0 kg of common vetch seeds on an area of 200 m^2 – which was done on August 18th. The grown plant mass of the cover crops was either disintegrated and mixed with the soil prior to the onset of winter or left on the surface of the soil in the form of mulch, according to the scheme of the experiment. The weather conditions during the vegetation period of 2009-2011 are shown in Table 1.

The analyses of the physical properties of the 0-20cm layer of the soil were performed on 3 dates (April 10th-prior to spring cultivation, June 15th and September 20th). The soil samples were collected in cylinders of 100 cm^3 each. The total and differential porosity values were calculated on the basis of water retention curves *ie* the relation between soil water potential and water content (moisture). The pF determinations were performed at the Institute of Agrophysics of the Polish Academy of Sciences in Lublin. The soil water potential ranged from 0.1 kJ m^{-3} (pF 0) to 1 500 kJ m^{-3} (pF 4.2). The total porosity was taken as the amount of water at 0.1 kJ m^{-3} (pF 0). The amount of macropores was calculated as the difference between the water content at

Table 1. Mean monthly air temperatures and amount of precipitation at ES Felin in the years 2009-2011

Year	Month					
	IV	V	VI	VII	VIII	IX
			Temperature (°C)			
2009	11.4	13.6	16.4	19.9	19.0	15.3
2010	9.4	14.5	18.0	21.6	20.2	12.5
2011	10.2	14.3	18.6	18.4	18.8	15.2
Mean for 1951-2000	7.5	13.0	16.5	17.9	17.3	12.9
			Amount of precipitation (mm)			
2009	2.9	71.1	125.5	57.1	54.7	21.0
2010	24.5	156.7	65.6	101.0	132.8	119.0
2011	29.9	42.2	67.8	189.0	65.3	5.4
Mean for 1951-2000	40.6	58.3	65.8	78.0	69.7	52.1

0.1 kJ m^{-3} (pF 0) and 16 kJ m^{-3} (pF 2.2). The amount of mesopores was taken as the difference between water content at 16 kJ m^{-3} (pF 2.2) and 1500 kJ m^{-3} (pF 4.2), and the quantity of micropores – as the value of moisture at 1 500 kJ m^{-3} (pF 4.2) (Witkowska-Walczak and Turski, 2004). The results were subjected to statistical analysis of variance. The statistical significance was tested with the use of the Tukey test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The total porosity of the soil in the years 2010-2011 averaged 39.2% and changed during the vegetation period, with the highest values observed in June and the smallest in April (Table 2). Immediately after winter, before spring cultivation, it averaged 37.7% in the 0-20 cm layer of the soil. Irrespective of the cover crop plant species used, the biomass of cover crops increased the porosity of the arable layer of the soil in April. A significant increase in the total porosity of the soil, compared to the Control, was observed in the case of mustard and phacelia cover crops (38.8%). Similar to the experiments of Kęsik *et al.* (2007), the biomass of rye and vetch did not influence the total porosity of the soil, compared to conventional tillage without cover crops. This insignificant effect of vetch can also be explained by the small volume of biomass left in the field by this cover crop. In the experiments of Mulumba and Lal (2008) the total porosity increased with increase of mulch amount. Among the compared soil cultivation methods, the largest porosity in spring was observed in the case of pre-winter use of stubble grubber cultivator (Gz) (39.3% on average) and the smallest in uncultivated objects (NTz).

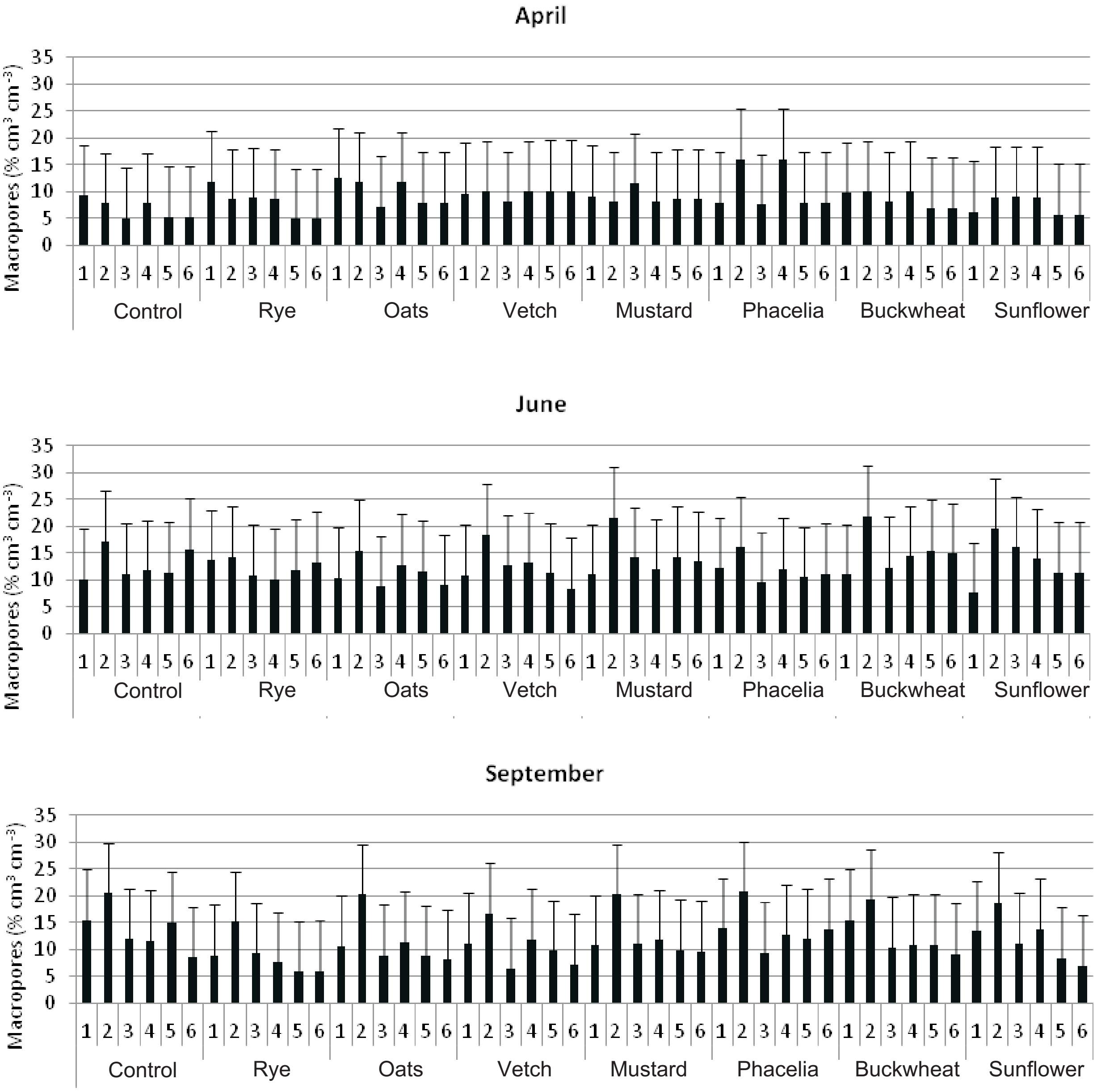
In the second decade of April spring cultivation was performed, according to the scheme of the experiment. The differentiation of spring tillage made the June values of total soil porosity higher than the values achieved in April. The highest value of porosity of arable layer of soil was granted by buckwheat (40.1% on average), phacelia (40.0%) and mustard (39.8%) cover crops. Irrespective of the soil sample collection date, the mixing of the biomass of buckwheat and phacelia significantly influenced the total soil porosity, when compared to the control samples from fields without cover crops. The increase in the porosity of the soil, after many years of use of cover crops, was also confirmed by Zhaoa *et al.* (2009). The soil in ridges formed in spring (Gz+Aw+Rw) was characterized by the highest porosity both in June and in September. The lowest total porosity of the arable layer of the soil was observed when the cultivation was performed only in spring (NTz+Gw or NTz+Aw). Pre-winter use of stubble cultivator and spring use of aggregate (Gz+Aw) were able to provide total porosity comparable to conventional tillage, performed with the use of mouldboard plough (CT). In the experiments of Farkas *et al.* (2006), ploughing and deep loosening created the most favourable soil conditions for the plants. Compared to that, Bujak and Frant (2005) ascertained that the influence of cultivation methods on the density and porosity of the soil was inconsiderable – both in selected years of the experiments, and on different dates of sample collection.

The differential porosity of the 0-20 cm layer of soil was modified both by the cover crops used, the cultivation methods applied, and the dates of sample collection, and it did change during the vegetation period (Figs 1-3, Table 2). The seasonal variability of soil properties was confirmed by the experiments of Farkas *et al.* (2006). In our experiment, the macropores (∅>30 μm) accounted for 8.7% of the arable soil layer. The phacelia cover crop made that proportion rise up to an average of 10.6%, while its smallest (6.8%) values were recorded in the fields without cover crops (Control). In

T a b l e 2. Total and differential porosity of the soil in 0-20 cm layer depending on cover crops and soil tillage in April, June and September

Factors	Total porosity (% vol.)			$\bar{x}$	Amount (% vol.) of											
					Macropores			$\bar{x}$	Mesopores			$\bar{x}$	Micropores			$\bar{x}$
	IV*	VI	IX		IV	VI	IX		IV	VI	IX		IV	VI	IX	
Cover crop																
Control	36.2	39.8	40.1	38.7	6.8	12.9	13.9	11.2	20.7	20.7	20.6	20.7	8.7	6.2	5.6	6.8
Rye	36.8	39.3	38.1	38.1	7.9	12.4	8.8	9.7	19.1	18.0	19.3	18.8	9.9	8.9	10.0	9.6
Oats	37.9	39.4	39.5	38.9	9.8	11.4	11.4	10.9	19.6	18.5	18.6	18.9	8.5	9.4	9.5	9.1
Vetch	37.8	39.7	39.5	39.0	9.7	12.5	10.5	10.9	19.6	18.4	19.6	19.2	8.5	8.8	9.4	8.9
Mustard	38.8	40.9	39.6	39.8	9.0	14.4	12.2	11.9	22.4	19.3	19.3	20.3	7.4	7.2	8.0	7.5
Phacelia	38.8	40.3	40.8	40.0	10.6	11.9	13.8	12.1	21.7	21.4	19.9	21.0	6.5	7.0	7.2	6.9
Buckwheat	38.1	41.7	40.4	40.1	8.6	15.0	12.7	12.1	23.7	20.0	19.9	21.2	5.7	6.7	7.8	6.7
Sunflower	36.9	40.8	39.8	39.2	7.4	13.3	12.1	10.9	23.3	21.0	20.2	21.5	6.2	6.4	7.5	6.7
Soil tillage																
Oz+Aw	38.2	39.3	40.4	39.3	9.5	10.9	12.5	11.0	20.9	20.6	19.6	20.4	7.8	7.8	8.3	8.0
Gz+Aw+Rw	39.3	43.6	45.6	42.8	10.1	18.1	19.0	15.7	22.3	18.8	18.6	19.9	6.9	6.8	8.1	7.3
GLz+Aw	36.8	39.5	38.3	38.2	8.2	12.0	9.8	10.0	20.7	19.5	19.8	20.0	8.0	8.1	8.7	8.3
Gz+Aw	39.3	40.3	39.8	39.8	10.1	12.5	11.4	11.3	22.3	20.5	21.2	21.3	6.9	7.2	7.2	7.1
NTz+Gw	36.2	39.4	38.2	37.9	7.2	12.2	10.1	9.8	20.7	19.4	19.4	19.8	8.3	7.8	8.7	8.3
NTz+Aw	36.2	39.3	36.8	37.4	7.2	12.2	8.7	9.4	20.7	19.2	20.2	20.0	8.3	7.9	7.9	8.0
Mean	37.7	40.2	39.8	39.2	8.7	13.0	11.9	11.2	21.3	19.7	19.8	20.3	7.7	7.6	8.1	7.8
Years																
2010	37.2	38.4	37.6	37.7	9.1	11.0	8.1	9.4	19.4	18.8	20.6	19.6	8.7	8.6	8.8	8.7
2011	38.1	42.0	42.1	40.7	8.4	15.0	15.7	13.0	23.1	20.5	19.0	20.9	6.7	6.6	7.4	6.9
$NIR_{0.05}$ for:																
Catch crops	n.s.	n.s.	2.6	1.3	3.8	3.8	3.8	1.8	n.s.	n.s.	n.s.	1.5	2.1	2.1	2.1	1.0
Tillage	2.2	2.2	2.2	1.0	3.2	3.2	3.2	1.5	1.6	1.6	1.6	1.3	n.s.	n.s.	n.s.	0.8
Month	-	-	-	0.6	-	-	-	0.8	-	-	-	0.7	-	-	-	0.5
Years	1.0	1.0	1.0	0.4	n.s.	1.5	1.5	0.6	1.3	1.3	1.3	0.5	0.8	0.8	0.8	0.3

n.s. – no significant differences, *months.


April

June

September

Fig. 1. Amount of macropores (∅>30 µm) in 0-20 cm layer of soil in April, June and September depending on cover crops and soil tillage (mean for years 2010-2011). 1 – Oz+Aw; 2 – Gz+Aw+Rw; 3 – GLz+Aw; 4 –Gz+Aw; 5 – NTz+Gw; 6 – NTz+Aw (LSD$_{0.05}$).

June, after spring cultivation and mixing the whole biomass with the soil, the largest proportion of macropores was guaranteed by buckwheat (15.0%) and mustard (14.4%) cover crops, the smallest amount of large pores was found in objects where the biomass of oats was mixed with the soil (11.4%). The influence of buckwheat and mustard on the amount of large pores in the soil lasted till September, when the smallest amount (8.8%) of macropores was found in the objects where the biomass of rye was mixed with the soil. Irrespective of the cover crop plants, the largest (10.1%) proportion of macropores in the porosity of the arable layer of the soil after winter was found in objects grubbed prior to the onset of winter (Gz). The fewest large pores were found in the soil uncultivated prior to winter (NTz) – 7.2% on average. The rise of the proportion of large pores in conventionally cultivated soil (CT) in comparison to uncultivated soil (NT) was confirmed by numerous authors (Fernandez-Ugalde *et al*., 2009; Lipiec *et al*., 2006; Martinez *et al*., 2008). The spring cultivation of the soil significantly increased the amount of macropores in the arable layer of the soil, when compared to the early spring period, and in June large pores amounted for an average of 13.0%. Their largest proportion, up to the end of vegetation period, was found in soil formed in ridges in spring (Gz+Aw+Rw). The smallest amount of

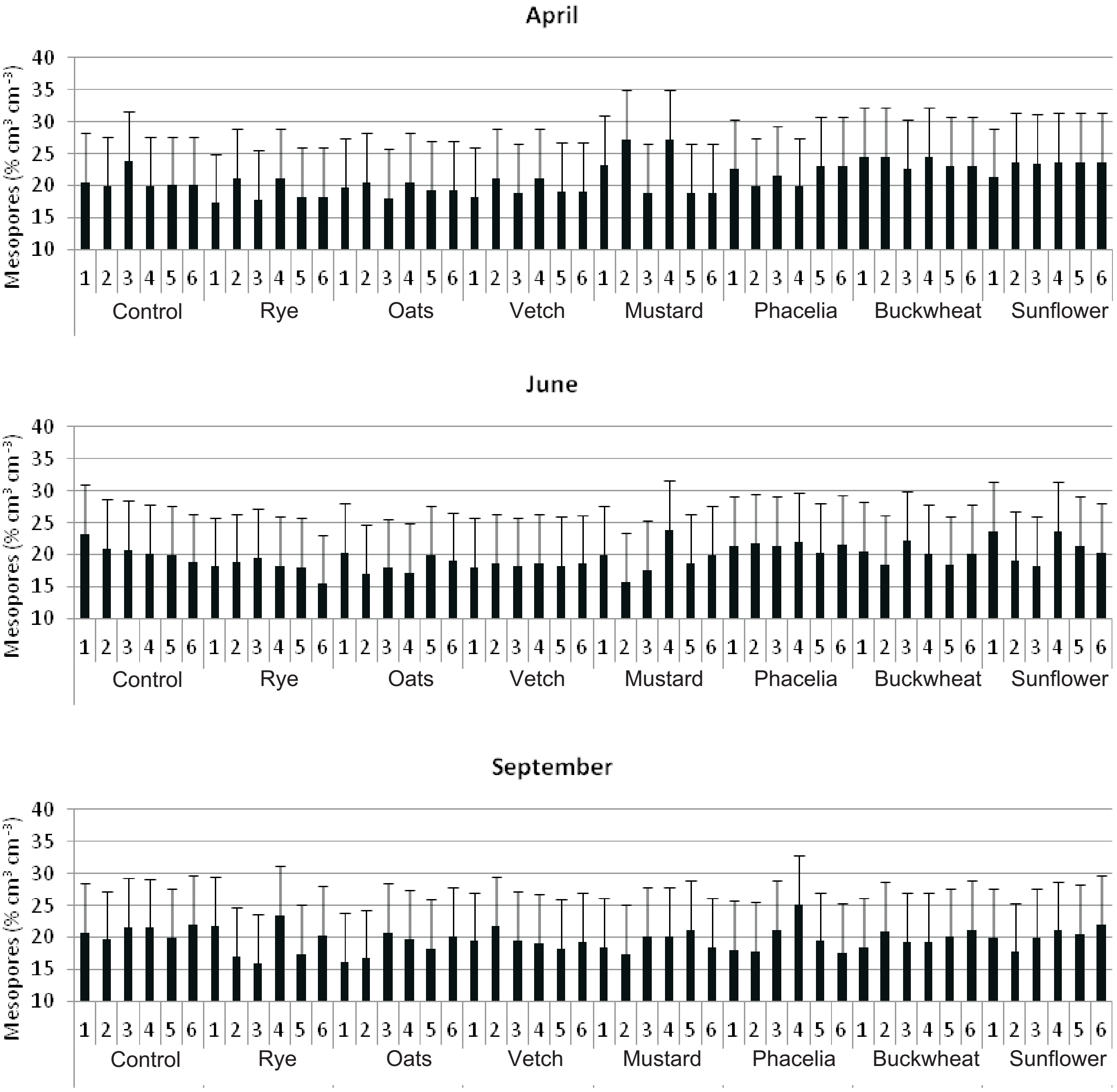


Fig. 2. Amount of mesopores (∅ 0.2-30 µm) in 0-20 cm layer of soil in April, June and September depending on cover crops and soil tillage (mean for years 2010-2011). Explanations as in Fig. 1.

macropores in June was found in conventionally cultivated (CT) soil (10.9% on average), and in September in the case of the soil in which the cultivation was limited to the spring use of aggregate (NTz+Aw) (8.7%). It may be assumed that after temporary loosening of the soil due to its spring cultivation, there followed its fast subsidence.

Mesopores (∅ 30-0.2 µm) amounted for an average of 20.3% of arable layer of the soil (Table 2). Their proportion in the soil was the highest in spring (21.3%), prior to spring cultivation, only to fall down later on. The cover crops used in the experiment did not significantly influence the proportion of mesopores, but there was a visible tendency for their amount in the arable layer of the soil to be slightly higher in spring and in the middle of summer, after mixing the soil with biomass of sunflower, buckwheat or phacelia. Winter cover crops had a residual effect on soil aggregation after spring tillage operations in the experiments of Hermawan and Bomke (1997). The beneficial influence of cover crops on that feature disappeared, in the case of our experiment, in September. Irrespective of the dates of soil sample collection, average for the whole period of vegetation, the biomass of sunflower, buckwheat or phacelia significantly increased the amount of mesopores in 0-20 cm layer of the soil, when compared with the influence of the biomass of cereals or

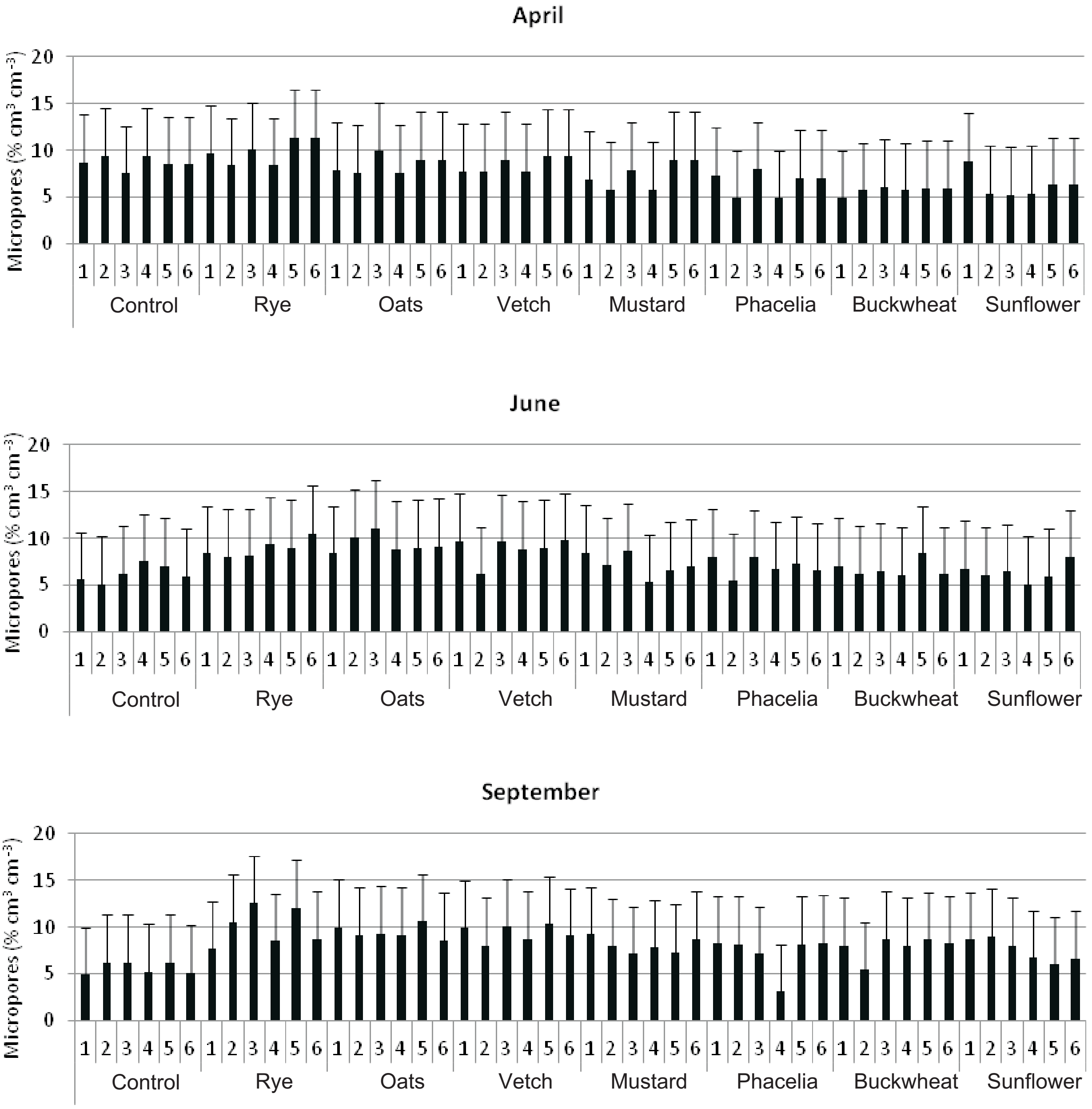


Fig. 3. Amount of micropores (∅< 0.2 μm) in 0-20 cm layer of soil in April, June and September depending on cover crops and soil tillage (mean for years 2010-2011). Explanations as in Fig. 1.

vetch. The pre-winter cultivation of the soil with the use of stubble grubber cultivator (Gz) allowed for the highest participation of mesopores, when compared with other non-ploughing methods of cultivation. The amount of mesopores in the arable layer of the soil in June, after pre-winter use of stubble cultivator, was comparable with the proportions found in conventional, mouldboard-plough cultivation, while in April and September it was even higher than that. The smallest amount of mesopores was found in soil formed in ridges in spring (Gz+Aw+Rw). The decrease in the number of mesopores causes a decrease of soil water available for plants (Bowanko *et al*., 2004).

Micropores (∅<0.2 μm) constituted an average of 6.9% of the arable layer of the soil and their amount significantly increased in September, when compared with other dates (Table 2). It was a result of heavy precipitation and self-subsidence of the soil (Bryk *et al*., 2004). The biomass of cereals (rye and oats) and vetch increased the amount of micropores in the 0-20 cm layer of the soil, when compared to other cover crops and cultivation without cover crops. The improvement of the micropore structure of soil in organic farming in comparison with conventional tillage system was already ascertained by Dąbek-Szreniawska *et al*. (2002). The smallest amount of micropores was found in the soil cultivated prior to winter with the use of stubble grubber cultivator, and in spring with the use of aggregate (Gz+Aw), as well as in the soil formed in ridges in spring (Gz+Aw+Rw). The largest proportion of micropores was found in soil cultivated pre-winter with subsoiler (GLz+Aw), and when the cultivation was limited to spring only (NT+Aw or NT+Gw). In reduced cultivation of onion, with the use of rye and vetch mulches (Kęsik *et al.*, 2006), the volume of micro- (∅ <0.2 μm) and mesopores (∅ 30-0.2 μm) in the arable layer of the soil did not significantly depend on the different methods of pre-winter tillage. The simplification of cultivation, and the no-tillage (NT) cultivation in particular, lead, in most cases, to the compaction of the soil (Czyż and Dexter, 2009; Rashidi and Keshavarzpour, 2011).

The differential porosity of the 0-20 cm layer of the soil was modified by the weather conditions during the years of the experiment. Generally speaking, the total porosity of the arable layer of the soil was lower in 2010 than in 2011. The amount of macropores and mesopores was also smaller, while the proportion of micropores larger. The higher compaction of the soil in 2010 was a direct result of large volume of precipitation (Table 1). According to Słowińska- Jurkiewicz *et al*. (2004), the structure of the surface layer of the examined podzolic soil, created from a silty material, was characterized by low stability and high susceptibility to densification by rain.

The analysis of the interaction of all the factors of the experiment did not confirm statistically significant differences in the amount of macropores in the 0-20 cm layer of the soil in spring (Fig. 1). A slightly higher (16.0%) volume of macropores was observed in treatments in which the biomass of phacelia was mixed with the soil with the use of a stubble cultivator prior to winter, and the smallest in objects that were not cultivated prior to winter (NTz) when the soil was covered with rye mulch (4.9%) or without cover crops (5.3%). Similar results were obtained by Kęsik *et al*. (2006). In June and September the largest amount of macropores was granted by mixing the biomass of cover crops with the soil prior to winter, with the use of stubble cultivator, and the formation of soil in ridges in spring (from 15.1 to 21.8%) (Gz+Aw+Rw). The smallest amount of macropores in the arable layer of the soil in June was found in the soil mixed prior to winter with the biomass of sunflower, with the use of a plough (7.6%) (Oz); and in September in treatments in which rye mulch covered the soil over the winter, to be mixed with it in spring (5.9%) (NT+Aw or NT+Gw).

Mesopores are the decisive factor in determining the availability of water for plants. Significantly the largest proportion of those in the arable soil layer in spring (LSD = 7.78*) was granted by the pre-winter mixing of the biomass of mustard with the use of stubble cultivator (mustard+Gz) (27.3%) (Fig. 2). The smallest amount of mesopores in the arable layer of the soil was found in treatments in which the soil was mixed with the biomass of rye in a pre-winter ploughing (rye+Oz) (17.3%). This dependence appeared also in June. In that time the pre-winter mixing of the soil with the biomass of sunflower with the use of stubble cultivator (sunflower+Gz+Aw) and conventional tillage (CT) proved to have a beneficial influence. In September the largest amount (25.2%) of mesopores was found in soil of the phacelia+Gz+Aw combination, while the smallest (17.0%) in the rye+GLz+Aw combination.

Pores of diameter smaller than 0.2 μm constituted from 3.1 to 12.6% of the 0-20 cm soil layer, depending on the factors of the experiment and the sample collection date (LSD=5.19*) (Fig. 3). The largest proportion of micropores in spring was found in soil uncultivated prior to winter and covered with rye mulch (rye+NTz), the smallest in the following combinations: phacelia+Gz, buckwheat+Oz and sunflower+GLz. In June the differences in micropore content of the soil between different combinations were statistically insignificant. In September the major proportion of micropores was found in the soil from the following combinations: rye+GLz+Aw (12.6%), rye+NT+Aw (12.0%) and oats+Gz+Aw (10.6%), the smallest in the combinations of: Oz+Aw (4.9%) and NTz+Aw (5.1%) – both without the use of cover crops. The obtained results of total and differential porosity of podzolic soil are further confirmed by the experiments of Witkowska-Walczak and Turski (2004).

CONCLUSIONS

1. The biomass of the cover crop plants had a beneficial influence on the total porosity of the 0-20 cm layer of the soil after winter. The positive influence of some of the cover crops was also visible up to the end of the vegetation period. The cover crops of buckwheat, phacelia and mustard granted the highest soil porosity, while the lowest was attributed to rye.

2. During the vegetation period the ridged soil had the largest porosity in its arable layer. Among the remaining non-ploughing methods of cultivation, the pre-winter use of stubble cultivator had a beneficial influence on the porosity of the soil, providing porosity comparable to that of conventional tillage.

3. The differential porosity of the 0-20 cm layer of the soil was modified both by the cover crop used, the cultivation methods, and the sample collection dates, and it did change during the vegetation period.

4. The largest amount of macropores in the arable layer of the soil after winter was granted by phacelia cover crop, the smallest by cultivation without any cover crops.

5. The pre-winter use of stubble cultivator increased the amount of macropores in the arable layer of the soil in spring, and after differentiating methods of cultivation in spring their amount was the largest in ridges, particularly if the soil was previously mixed with the biomass of the cover crops.

6. The largest amount of mesopores in the arable layer of the soil after winter was granted by mixing the soil with the biomass of mustard with the use of stubble cultivator, the smallest when the biomass of rye was mixed with the soil by either a pre-winter plough or spring aggregate use.

7. Irrespective of the cover crops used, the prewinter use of stubble cultivator provided the largest amount of mesopores, when compared with other non-ploughing methods of cultivation. The smallest amount of mesopores was found in ridged soil.

8. The largest amount of micropores was found after pre-winter cultivation with a subsoiler, and when the fields were only cultivated in spring. The smallest amount of micropores was found in the soil cultivated, prior to winter, with the use of stubble cultivator and aggregate in spring, and in ridges formed in spring.

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