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CHANGES IN SOME SOIL PROPERTIES UNDER THE EFFECT OF DIVERSIFIED TILLAGE FOR MAIZE DEPENDING ON THE FORECROP

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Abstract. Research on the effect of forecrop and diversified tillage on soil properties in maize agrotechnics was carried out in the years 2010-2013 at the Agricultural Production Farm in Kowróz (53°07′ N; 18°34′ E), Kuyavian-Pomeranian Voivodeship. On light clay soil, two-factor field experiment was carried out. First factor was the forecrop: winter wheat, spring barley, and maize, and the second factor was the tillage method: plough tillage, deep ploughless tillage, and shallow ploughless tillage. Directly before sowing and at the stage of intensive maize growth (BBCH 32-37), physical properties of the soil were determined, namely compaction, bulk density, moisture, and respiration. After forecrop harvest, pH_{KCl} and the content of the assimilable forms of macroelements in the soil were evaluated, and after maize harvest also mineral nitrogen content. It was found that the forecrop affected soil compaction but only before successive crop sowing, as well as soil respiration. Tillage method significantly affected, however, its physical properties. On the plot after winter wheat, soil of ploughless tillage was less firm than after spring barley and maize, whereas maize as forecrop increased, regardless of the tillage method, CO_2 emission from the soil. Substitution of plough tillage with shallow ploughless treatments, regardless of the forecrop, caused an increase in compaction, bulk density, moisture, and mineral nitrogen after the successive crop harvest, and on the plot after maize also in soil respiration. On the other hand, forecrop and tillage method had no significant effect on the contents of the assimilable forms of macroelements in the soil, in spite of its small increase as a result of ploughless tillage on the plot after maize.

Key words: bulk density, compaction, macroelements, moisture, pH, plough tillage, ploughless tillage, respiration

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INTRODUCTION

Tillage is the basic element of agrotechnics and strongly affects the conditions and effects of field plant production [Lal *et al*. 2007, Małecka and Blecharczyk 2008, Klikocka *et al*. 2011], including cultivated field agrocenosis [Orzech *et al*. 2014]. Particular treatments, their groups and entirety make it possible to form soil properties depending on plant needs. Tillage changes fast and to a large extent, among others, soil bulk density, compaction, porosity, and moisture [Pabin *et al*. 2007, Aikins and Afuakwa 2012], and over a longer period it also affects its chemical and biological properties [Ernst and Emmerling 2009, Swędrzyńska *et al*. 2013]. Under the effect of tillage and as interaction with habitat conditions, balance of organic matter and nutrients in the soil is formed [Lenart and Perzanowska 2013, Abdollahi and Munkholm 2014]. However, tillage is a time- and energy-consuming activity, and too intensive tillage may cause soil degradation [Morris *et al*. 2010].

Contemporary tillage is characterized by a reduction in number and intensity, and also in depth, of the conducted treatments. Although its basic aim is still the preparation of favourable conditions for plant growth and yield, more and more attention is being paid to its effect on the environment and on the energy and economic effect of plant production technology [Smagacz 2010, Jaskulski *et al*. 2012]. Tillage method in the agrotechnics of a given plant should therefore take into account, in addition to its requirements, also soil conditions formed by earlier agricultural activity, including forecrop plants. Biology and agrotechnics of the particular cultivated plants affect in different way soil properties and the possibility to carry out tillage and sowing treatments [Weber 2011]. Therefore, it is justifiable to assume that the type and scope of the changes in soil properties caused by diversified plough or ploughless tillage carried out at different depths depends on the forecrop plant in crop rotation.

The aim of the study was to determine and compare the changes in some physical and chemical soil properties under the effect of diversified tillage for maize sown on plots after winter wheat, spring barley, and maize.

MATERIAL AND METHODS

Two-factor field experiment set at split-subblock design with two repetitions for every plot was carried out in the years 2010-2013 at the Agricultural Production Farm in Kowróz (53°07′ N; 18°34′ E), Kuyavian-Pomeranian Voivodeship. Experiments were located every year on light clay, class IVa. Average content of the assimilable forms of macroelements in the soil layer of 0-20 cm of the experimental field before the onset of the experiments was 113 P $mg \cdot kg^{-1}$ soil (very high richness), 184 K $mg \cdot kg^{-1}$ soil (high richness), 56 Mg $mg \cdot kg^{-1}$ soil (average richness), and its pH amounted to 6.3.

Maize was grown after three forecrops, first factors: winter wheat, spring barley, and maize. The second factor was the tillage method: plough tillage, deep ploughless tillage, and shallow ploughless tillage. Tillage was conducted according to a scheme (Table 1) on plots 12 m × 50 m in size. Plough skimming was carried out at the depth of circa 10 cm, pre-winter ploughing at 25-30 cm, chisel cultivation at 25 cm, pre-sowing aggregate cultivation at 5-8 cm, stubble disc harrowing at 10-12 cm, and pre-sowing at 8-10 cm. The other elements of agrotechnics were typical for maize cultivation for grain.

Table 1. Scheme of tillage for maize depending on its method and forecrop
Tabela 1. Schemat uprawy roli pod kukurydzę w zależności od jej sposobu oraz przedplonu

Tillage method Sposób uprawy roli	Forecrop – Przedplon		
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza
Plough – Płużna	*p, b, oz, b, as	p, b, oz, b, as	oz, b, as
Deep ploughless – Bezorkowa głęboka	ap, g, as, as	ap, g, as, as	g, as, as
Shallow ploughless – Bezorkowa płytka	t^1, t^2	t^1, t^2	t^2

* p – plough skimming – podorywka, oz – pre-winter ploughing – orka przedzimowa, b – harrowing – bronowanie, as – pre-sowing passive aggregate cultivation – uprawa przedsiewna agregatem biernym, ap – stubble cultivator aggregate cultivation – uprawa ścierniska agregatem kultywatorowym, g – chisel cultivation – gruberowanie, t^1 – stubble disc harrowing – talerzowanie ścierniska, t^2 – pre-sowing spring disc harrowing with cage roller – talerzowanie wiosną z wałem strunowym – przedsiewne

Assessment of the properties of the upper soil layer (0-30 cm) consisted in the determination directly before sowing and at the stage of intensive maize growth (BBCH 32-37) of: compaction with the use of Eijkelkamp hydraulic probe, bulk density with the use of cylinders and a sample uptake kit (0753SC) by Eijkelkamp, and moisture by drying-weighing. After forecrop and maize harvest, soil pH was determined in KCl solution (concentration 1 $mol \cdot dm^{-3}$) and the content of the assimilable forms of macroelements with the standard methods of Egner-Riehm and Schachtschabel. Mineral nitrogen content was marked in 1% K_2SO_4 extract with the colorimetric method directly after maize harvest. Its amount in the upper soil layer was calculated on the basis of N_{min} content and soil bulk density. Soil respiration was evaluated in the spring before maize sowing and at the stage (BBCH 32-37) with the use of SRC-1 Soil Respiration Chamber and EGM-4 analyser by PP Systems.

Results were statistically processed. Analysis of variance of the data from every year was carried out, and subsequently its synthesis, while evaluating the effect of main factors and their interactions on soil properties on average in the three study years. Significance of average object differences was determined with the Tukey's test ($p = 0.05$). Statistical program packet ANALWAR-5.2-FR was used. In the case of the lack of significant effect of the experimental factors on the agrochemical soil properties after maize harvest, absolute value and direction of their changes in relation to the value after forecrop harvest were determined.

RESULTS

Directly before maize sowing, the compaction of the arable soil layer on the plot after itself and spring barley was significantly higher than after winter wheat. This relation took place in the case of ploughless tillage, both deep and shallow. After plough tillage, soil compaction was the lowest and did not depend on the forecrop (Table 2). Effect of the tillage method on this characteristic remained also during maize growth. At the stage of BBCH 32-37, soil compaction was the lower the deeper it was tilled, with the exception of the plot after spring barley, where the compaction of the soil of deep and shallow ploughless tillage did not differ significantly. Only in the case of plough tillage, soil compaction during maize growth depended on the forecrop. On the plot after maize, it was significantly lower than after winter wheat.

Table 2. Soil compaction (MPa) before sowing and during maize growth depending on the forecrop and tillage method
Tabela 2. Zwięzłość gleby (MPa) przed siewem i w okresie wegetacji kukurydzy w zależności od przedplonu i sposobu uprawy roli

Tillage – Uprawa roli (B)	Forecrop – Przedplon (A)			Mean Średnia
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza	
Before sowing – Przed siewem				
Plough – Płużna	0.91	0.96	1.03	0.97
Deep ploughless – Bezorkowa głęboka	1.44	1.63	1.63	1.57
Shallow ploughless – Bezorkowa płytka	1.93	2.21	2.28	2.14
Mean – Średnia	1.43	1.60	1.65	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A 0.110 B 0.059 B × A 0.102 A × B 0.136				
Stage BBCH 32-37 – Faza BBCH 32-37				
Plough – Płużna	2.21	2.14	2.07	2.14
Deep ploughless – Bezorkowa głęboka	2.33	2.38	2.35	2.35
Shallow ploughless – Bezorkowa płytka	2.45	2.46	2.51	2.48
Mean – Średnia	2.33	2.33	2.31	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 0.056 B × A 0.098 A × B 0.119				

ns – ni – non-significant differences – różnice nieistotne

Tillage method also affected soil bulk density, regardless of the forecrop. Bulk density of the soil ploughed before winter was lower than the one with ploughless tillage. On the other hand, ploughless tillage shallowing caused its increase both before maize sowing and at the stage of BBCH 32-37 (Table 3).

Table 3. Soil bulk density before sowing and during maize growth depending on the forecrop and tillage method, $g \cdot cm^{-3}$
Tabela 3. Gęstość gleby przed siewem i w okresie wegetacji kukurydzy w zależności od przedplonu i sposobu uprawy roli, $g \cdot cm^{-3}$

Tillage – Uprawa roli (B)	Forecrop – Przedplon (A)			Mean Średnia
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza	
Before sowing – Przed siewem				
Plough – Płużna	1.52	1.54	1.54	1.53
Deep ploughless – Bezorkowa głęboka	1.59	1.60	1.59	1.59
Shallow ploughless – Bezorkowa płytka	1.62	1.64	1.64	1.63
Mean – Średnia	1.58	1.59	1.59	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 0.015 B × A ns – ni A × B ns – ni				
Stage BBCH 32-37 – Faza BBCH 32-37				
Plough – Płużna	1.61	1.61	1.59	1.60
Deep ploughless – Bezorkowa głęboka	1.63	1.65	1.62	1.63
Shallow ploughless – Bezorkowa płytka	1.65	1.64	1.65	1.65
Mean – Średnia	1.63	1.63	1.62	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 0.016 B × A ns – ni A × B ns – ni				

ns – ni – non-significant differences – różnice nieistotne

Soil moisture before maize sowing was higher than during its intensive growth. At both times, this characteristic depended on the tillage method. Soil of shallow ploughless tillage contained more water than the soil of both plough and ploughless deep tillage (Table 4). Effect of tillage on soil moisture during maize growth did not depend on the plot. Before sowing, it depended, however, on the forecrop and only on the plots after spring barley and maize did the soil of shallow ploughless tillage contain more water than the soil of deep and plough tillage.

Table 4. Soil moisture before sowing and during maize growth depending on the forecrop and tillage method, % of weight
Tabela 4. Wilgotność gleby przed siewem i w okresie wegetacji kukurydzy w zależności od przedplonu i sposobu uprawy roli, % wag.

Tillage – Uprawa roli (B)	Forecrop – Przedplon (A)			Mean Średnia
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza	
Before sowing – Przed siewem				
Plough – Płużna	11.40	11.63	11.47	11.50
Deep ploughless – Bezorkowa głęboka	11.27	11.80	11.93	11.67
Shallow ploughless – Bezorkowa płytka	11.87	12.13	13.50	12.50
Mean – Średnia	11.51	11.86	12.30	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 0.250 B × A 0.471 A × B 0.523				
Stage BBCH 32-37 – Faza BBCH 32-37				
Plough – Płużna	9.30	9.43	9.90	9.54
Deep ploughless – Bezorkowa głęboka	9.47	9.60	9.67	9.58
Shallow ploughless – Bezorkowa płytka	10.37	10.30	10.33	10.33
Mean – Średnia	9.71	9.78	9.97	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 0.360 B × A ns – ni A × B ns – ni				

ns – ni – non-significant differences – różnice nieistotne

Forecrop and tillage method to a small extent affected the agrochemical properties of the upper soil layer from forecrop harvest to maize harvest (Table 5). Only a tendency for pH decrease occurred, as well as for a decrease in the content of assimilable phosphorus and potassium forms on the plots after spike cereals. However, on the plot after maize, slight increase in their content occurred, mainly in the soil of ploughless tillage.

Amount of mineral nitrogen that remained in the 0-30 cm soil layer after maize harvest depended on the tillage method (Table 6). In the soil of shallow tillage, its higher amount was found than in the soil of deep plough and ploughless tillage but only on the plot after maize. With this tillage method, the amount of mineral nitrogen in the soil on the plot after maize was significantly higher than after spike forecrop.

CO_2 emission from the soil depended on the forecrop and was at the same time strongly modified by the tillage method (Table 7). Before maize sowing, the highest respiration occurred on the plot after that plant, especially when after harvest shallow plough tillage was carried out. On the plots after spike cereals, respiration of the soil of shallow tillage was, on the other hand, lower than of the soil of deep ploughless and plough tillage. Effect of the forecrop and tillage method on soil respiration during maize growth was similar to the one before its sowing, although the amount of emitted CO_2, in particular on the plots after winter wheat and spring barley, was higher.

Table 5. Change in agrochemical soil properties after maize growth depending on the forecrop and tillage method
Tabela 5. Zmiana agrochemicznych właściwości gleby po okresie wegetacji kukurydzy w zależności od przedplonu i sposobu uprawy roli

Tillage – Uprawa roli	Forecrop – Przedplon		
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza
pH			
Plough – Płużna	-0.15	-0.15	0.05
Deep ploughless – Bezorkowa głęboka	-0.15	-0.25	0.00
Shallow ploughless – Bezorkowa płytka	-0.05	-0.20	-0.20
Phosphorus P, $mg \cdot kg^{-1}$ soil – Fosfor P, $mg \cdot kg^{-1}$ gleby			
Plough – Płużna	1.75	-4.58	3.71
Deep ploughless – Bezorkowa głęboka	-3.92	-7.42	2.84
Shallow ploughless – Bezorkowa płytka	-2.40	-4.14	7.63
Potassium K, $mg \cdot kg^{-1}$ soil – Potas K, $mg \cdot kg^{-1}$ gleby			
Plough – Płużna	-13.28	-6.23	4.57
Deep ploughless – Bezorkowa głęboka	-12.04	-7.06	14.53
Shallow ploughless – Bezorkowa płytka	-2.49	-5.81	11.21
Magnessium Mg, $mg \cdot kg^{-1}$ soil – Magnez Mg, $mg \cdot kg^{-1}$ gleby			
Plough – Płużna	0.00	-0.91	-0.31
Deep ploughless – Bezorkowa głęboka	-1.21	-0.91	0.30
Shallow ploughless – Bezorkowa płytka	0.30	0.30	1.51

Table 6. Amount of mineral nitrogen after maize harvest depending on the forecrop and tillage method, $kg \cdot ha^{-1}$
Tabela 6. Ilość azotu mineralnego po zbiorze kukurydzy w zależności od przedplonu i sposobu uprawy roli, $kg \cdot ha^{-1}$

Tillage – Uprawa roli (B)	Forecrop – Przedplon (A)			Mean Średnia
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza	
Plough – Płużna	27.5	27.5	26.7	27.2
Deep ploughless – Bezorkowa głęboka	27.7	27.5	29.1	28.1
Shallow ploughless – Bezorkowa płytka	29.8	29.7	33.6	31.0
Mean – Średnia	28.3	28.2	29.8	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A ns – ni B 1.66 B × A 2.54 A x B 2.72				

ns – ni – non-significant differences – różnice nieistotne

Table 7. Soil respiration before sowing and during maize growth depending on the forecrop and tillage method, g $CO_2 \cdot m^{-2} \cdot h^{-1}$
Tabela 7. Respiracja gleby przed siewem i w okresie wegetacji kukurydzy w zależności od przedplonu i sposobu uprawy roli, g $CO_2 \cdot m^{-2} \cdot h^{-1}$

Tillage (B) Uprawa roli (B)	Forecrop – Przedplon (A)			Mean Średnia
	winter wheat pszenica ozima	spring barley jęczmień jary	maize kukurydza	
Before sowing – Przed siewem				
Plough – Płużna	0.26	0.29	0.41	0.32
Deep ploughless – Bezorkowa głęboka	0.23	0.27	0.45	0.32
Shallow ploughless – Bezorkowa płytka	0.19	0.21	0.53	0.31
Mean – Średnia	0.23	0.26	0.46	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A 0.047 B ns – ni B × A 0.036 A × B 0.055				
Stage BBCH 32-37 – Faza BBCH 32-37				
Plough – Płużna	0.33	0.33	0.44	0.36
Deep ploughless – Bezorkowa głęboka	0.35	0.32	0.46	0.38
Shallow ploughless – Bezorkowa płytka	0.29	0.25	0.52	0.36
Mean – Średnia	0.32	0.30	0.48	
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla: A 0.067 B ns – ni B × A 0.052 A × B 0.079				

ns – ni – non-significant differences – różnice nieistotne

DISCUSSION

Effect of the forecrop on the physical properties of the soil was low and often insignificant. Greater effect occurred in the case of intercrop cultivation with bringing in its biomass into the soil. This type of forecrop, according to Wanic *et al*. [2013], affects positively water content in the soil, particularly in its upper layer. In the present study, when growing maize on plots after winter wheat, spring barley, and directly after itself, effect of the forecrop was found only on soil compaction, and only before its sowing. At earlier developmental stages, the effect was insignificant. Forecrop had a greater effect on soil compaction and moisture before maize sowing in the case of ploughless rather than plough tillage. On the plot after maize, the soil was more compact and moist than after spike cereals, whereas after ploughing those properties on all the plots were of similar values. Favourable effect of maize as forecrop on the moisture of soil of ploughless tillage may have resulted from a high amount of post-harvest residue on the plot surface. Stubble crop elements, crumbled straw, and spadix axes formed mulch, which favours snow accumulation and limits water flow and its evaporation. Such conclusion is justifiable in the presence of the results of many studies that indicate a favourable effect of soil mulching on its moisture [Kęsik *et al*. 2006, Pabin *et al*. 2007]. Water content in the soil during growth depends to a great extent also on the size of transpiring plant biomass. In the present study, the highest moisture of the soil of shallow ploughless tillage may have resulted from lower transpiration on that plot. Although maize biomass production was not determined, earlier studies conducted in this experiment indicate lower plant yield at shallow ploughless tillage in comparison with plough tillage [Jaskulska *et al*. 2013, 2014].

Results of numerous studies indicate that change in the physical properties of the soil as a result of intensive treatments is not always long-lasting. Soil has a tendency to come back, after a certain period, to the condition characteristic for its granulation, habitat, and agrotechnical conditions [Bujak and Frant 2005]. In the studies by Kuc [2014], in the spring before maize sowing, soil bulk density in the layer of 5-10 cm of plough tillage with deep pre-winter ploughing was higher than the one of soil mulched with straw mixed with skimming cultivator. In the autumn after maize harvest, soil bulk density on both plots did not differ significantly. In the present study, soil properties diversified by tillage methods lasted throughout maize growth. At the BBCH 32-37 stage, compaction and bulk density of the soil of plough tillage were lower than of the soil of ploughless tillage.

In a short period, especially the chemical properties of soil undergo small changes, for example the content of assimilable forms of nutrients or pH, although in some studies the differences already after one or two years are big enough to be statistically significant [Kraska 2011]. Rajewski *et al*. [2012], while comparing the effect of traditional and conservative tillage on some chemical properties of the soil, found that assimilable phosphorus content in the layers of 5-10 cm and 20-25 cm differed on average by 4.5 $mg \cdot kg^{-1}$. Similar differences, statistically insignificant, were found in the present study as a result of plough and ploughless tillage of different depths. Somewhat greater differences, as in the studies by the quoted authors, by circa 7.0%, occurred in the content of assimilable potassium. Increase in the content of this element on the plot after maize by 2.5-7.9% may have been caused by a big amount of post-harvest residue rich in potassium which decomposed in the subsequent growth period and lower yield of the successive crop on this plot [Jaskulska *et al*. 2013], due to lower nutrient uptake. Significant changes in the physical properties of the soil under the effect of agrotechnical elements occur after a longer time, which is confirmed by the results of static experiments. Małecka *et al*. [2012], in a perennial experiment in which the effects of different tillage systems on soil properties were compared, found that the renunciation of plough tillage caused, among others, an increase in moisture, bulk density, and soil compaction, as well as a decrease in capillary water capacity; an increase in the contents of organic carbon, total nitrogen, assimilable potassium and magnesium, and a decrease in phosphorus in the soil layer of 0-10 cm, as well as an increase in soil biological activity.

The highest CO_2 emission ought to be seen in high soil biological activity resulting from organic matter inflow and its mixing with soil upper layer through ploughless tillage on the plot after maize and of shallow ploughless tillage. Kuzyakov [2006] indicates that microorganism activity related to the presence of organic matter in the soil is the main factor for the intensity of CO_2 emission from the soil.

CONCLUSIONS

Soil properties in maize agrotechnics were formed directly and interdependently by its components. Forecrop affected soil compaction before sowing and soil respiration, whilst the tillage method affected its physical properties. On the plot after winter wheat, soil of ploughless tillage was less firm than after spring barley and maize. Maize as forecrop increased, regardless of the tillage method, CO_2 emission from the soil. Replacement of plough tillage with shallow ploughless treatments, regardless of the forecrop, caused an increase in compaction, bulk density, soil moisture, and the amount of mineral nitrogen after successive crop harvest, and on the plot after maize also in soil respiration. Forecrop and tillage method, however, had no significant effect on the contents of assimilable forms of macroelements in the soil, in spite of its small increase as a result of ploughless tillage on the plot after maize.

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ZMIANA NIEKTÓRYCH WŁAŚCIWOŚCI GLEBY POD WPŁYWEM ZRÓŻNICOWANEJ UPRAWY ROLI POD KUKURYDZĘ W ZALEŻNOŚCI OD PRZEDPLONU

Streszczenie. Badania nad wpływem przedplonu i zróżnicowanej uprawy roli na właściwości gleby w agrotechnice kukurydzy przeprowadzono w latach 2010-2013 w Zakładzie Produkcji Rolnej w Kowrozie (53°07′ N; 18°34′ E), województwo kujawsko-pomorskie. Na glebie o uziarnieniu gliny lekkiej wykonano dwuczynnikowe doświadczenie polowe. Czynnikiem pierwszego rzędu był przedplon: pszenica ozima, jęczmień jary i kukurydza, a drugiego rzędu – sposób uprawy roli: uprawa płużna, uprawa bezorkowa głęboka, uprawa bezorkowa płytka. Bezpośrednio przed siewem i w fazie intensywnego wzrostu kukurydzy (BBCH 32-37) określono właściwości fizyczne gleby: zwięzłość, gęstość objętościową, wilgotność oraz jej respirację. Po zbiorze przedplonów oceniono pH_{KCl} oraz zawartość w glebie przyswajalnych form makroskładników, a po zbiorze kukurydzy także zawartość azotu mineralnego. Stwierdzono, że przedplon wpłynął na zwięzłość gleby, ale tylko przed siewem rośliny następczej oraz na respirację gleby. Sposób uprawy roli oddziaływał natomiast istotnie na jej właściwości fizyczne. W stanowisku po pszenicy ozimej gleba uprawiana bezpłużnie była mniej zwięzła niż po jęczmieniu jarym i kukurydzy, natomiast kukurydza jako przedplon wzmagała, bez względu na sposób uprawy roli, wydzielanie CO_2 z gleby. Zastąpienie uprawy płużnej płytkimi zabiegami bezorkowymi, niezależnie od przedplonu, spowodowało zwiększenie zwięzłości, gęstości objętościowej, wilgotności gleby i ilości azotu mineralnego po zbiorze rośliny następczej, a w stanowisku po kukurydzy także respiracji gleby. Przedplon i sposób uprawy roli nie miały natomiast istotnego wpływu na zawartość przyswajalnych form makroskładników w glebie, mimo niewielkiego jej zwiększenia w wyniku uprawy bezpłużnej w stanowisku po kukurydzy.

Słowa kluczowe: gęstość, makroskładniki, pH, respiracja, uprawa bezorkowa, uprawa płużna, wilgotność, zwięzłość

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