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INFLUENCE OF CONSERVATION TILLAGE FOR SPRING WHEAT SOWING ON SOIL STRUCTURE

Summary

The research was carried out in 2012-2014 at the Agricultural Experimental and Didactic Department of Gorzyń, a branch of Brody, belonging to the Poznań University of Life Sciences, as part of a static experiment established in 2006. The influence of the type of cover crop: white mustard and mixture of yellow lupine as well as field pea along with the method of the soil tillage for sowing cover crop and repeated cultivation of spring wheat on soil structure were investigated. The research carried out showed that the most favorable effect on the soil value structure index was exerted by the ploughing of white mustard, followed by ploughing or direct sowing of spring wheat. Direct sowing of both white mustard and spring wheat increased the weighted average diameter of aggregates (MWDa) in soil layers 0-10 and 10-20 cm. White mustard cultivation in a cover crop contributed to an increase in the rate of soil lumping and a significant decrease in soil pulverising in both analyzed soil layers (0-10 and 10-20 cm).
***Key words**: soil structure, spring wheat, white mustard, yellow lupine, field pea*

WPŁYW UPRAWY KONSERWUJĄCEJ POD PSZENICĘ JARĄ NA STRUKTURĘ GLEBY

Streszczenie

Badania prowadzono w latach 2012-2014 w Rolniczym Zakładzie Doświadczalno-Dydaktycznym w Gorzyniu, filia Brody, należącym do Uniwersytetu Przyrodniczego w Poznaniu, w ramach doświadczenia statycznego założonego w roku 2006. Badano wpływ rodzaju międzyplonu ścierniskowego: gorczycy białej i mieszanki łubinu żółtego z grochem siewnym odmiany Tarchalska oraz sposobu uprawy roli pod wysiew międzyplonu ścierniskowego i monokulturowej uprawy pszenicy jarej na strukturę gleby. Wykazano, że najkorzystniej na wartość wskaźnika struktury gleby wpłynęło wykonanie podorywki pod wysiew gorczycy białej, następnie zaś orki siewnej lub siewu bezpośredniego pszenicy jarej. Wykonanie siewu bezpośredniego zarówno gorczycy białej, jak i pszenicy jarej, wpływało na zwiększenie średniej ważonej średnicy agregatów (MWDa) w warstwach gleby 0-10 i 10-20 cm. Uprawa gorczycy białej w międzyplonie ścierniskowym przyczyniła się do wzrostu wskaźnika zbrylenia gleby oraz istotnego zmniejszenia rozpylenia gleby w obu analizowanych jej warstwach (0-10 i 10-20 cm).
***Słowa kluczowe**: struktura gleby, pszenica jara, gorczyca biała, łubin żółty, groch siewny*

1. Introduction

Modern tillage technologies are characterized by a great diversity. However, they seek to create and maintain a suitable soil structure which, among other things, depends on the selection and use of soil tillage equipment [10]. Harvest residues have a very important influence on structure formation, mainly by increasing the content of organic matter in soil and ultimately organic carbon. These substances unambiguously improve the physical properties of the soil [1, 13, 20]. Many authors claim that the soil structure is mainly determined by the way it is cultivated and by the content of organic matter [6, 14]. This correlation led to the search for soil cultivating new technologies, known as conservation tillage, which affected the spatial distribution of the soil material, its solid phase and the size and distribution of the particles [15]. The change of management and introduction of post-harvest residues into the soil is an indispensable aspect of this type of cultivation. Large-area farms are less and less using manure, which makes it necessary to look for other sources of organic matter. A good way of replacing manure is to cultivate cover crops [2], which are ultimately a valuable source of soil binder that binds together the particles of the solid phase of the soil and determines its structure [11].

The search for development opportunities for individual and large-area farms through the implementation and use of conservation tillage is entered in the assumptions of the Polish development policy, in particular with regard to rural areas (especially those directly adjacent to urbanised areas), which are stimulated by intersectoral and intermunicipal cooperation [17]. Therefore, in this respect, it is necessary not only to passively implement a knowledge-based economy, but also to provide effective leadership of a strategic nature, i.e. technological leadership [21, 22]. There is a shortage of practical measures to promote new technologies in farming and relatively difficult access to the necessary sources of financing. These should eliminate or at least reduce the already existed barriers of development.

The adopted research hypothesis assumed that simplification of tillage in combination with monoculture especially after many years of its apply, leads to stabilization of habit conditions.

Due to this perspective, it is justified to undertake the research proposed in this paper both for cognitive and utilitarian reasons. The aim of the study was therefore to identify the influence of different tillage methods for stubble intercrop sowing and repeated spring wheat tillage on soil structure.

2. Materiał and methods

The research was conducted in 2012-2014 at the Agricultural Experimental and Didactic Department of Gorzyń, a branch of Brody (52° 25′ 85″ N, 16° 18′ 10″ E), belonging to the University of Life Sciences in Poznań within the framework of a static experiment established in 2006. The experiment was based on the method of random blocks in four repetitions on plots of 45 m^2 of land on luvisol qualified for the class IVa. Forecrop for spring wheat was winter wheat. The first-order factor included the type of stubble cover crop: white mustard (20 kg·ha^{-1}) and yellow lupines + field pea (100 + 100 kg·ha^{-1}). The second factor included the method of the soil tillage for sowing cover crop and spring wheat cultivated in the main crop.

At the time of spring wheat harvest the stability of soil structure in layers 0-10 and 10-20 cm was determined in one repeat on each plot by dry separation method. Average objective samples (500 g) were sieved for 2 minutes on a set of sieves a holes size of 0,25; 0,5; 1,0; 3,0; 5,0; 7,0 and 10 mm after air-drying. Then, each sample from the sieves was weighed on an electronic scale and the percentage of aggregates fraction was determined. On this basis, selected soil structure indicators were calculated:
- weighted average diameter of the aggregate (MWDa), as well as the following indices: cloddines (B), structures (W), and pulverisation (S) according to formulae [18]:

$$B = \frac{\text{\% share of aggregates mass with a diameter >10 mm}}{\text{\% share of aggregates mass with a diameter <10 mm}} \quad (1)$$

$$S = \frac{\text{\% share of aggregates mass with a diameter <0,25 mm}}{\text{\% share of aggregates mass with a diameter >0,25 mm}} \quad (2)$$

$$W = \frac{\text{\% share of aggregates mass with a diameter 1 - 10 mm}}{\text{\% share of aggregates mass with a diameter >10 mm and diameter <0,25 mm}} \quad (3)$$

The results were statistically evaluated using ANALWAR-5.2.FR analysis and presented as averages from the years 2012-2014. For a detailed comparison of the averages, the Tukey test was used with the significance level α=0.05.

3. Results and discussion

The value of soil cloddines index (B) in both soil layers 0-10 and 10-20 cm was higher after cultivation of the white mustard cover crop, however the differences were not confirmed mathematically (Table 1).

No influence of the tillage method of sowing cover crop and spring wheat as well as interactions of experimental factors on the value of the discussed index was found. Replacement of the cover crop and wheat ploughing with direct spring ploughing of both species resulted in an increase in the cloddines rate in the layer 0-10 cm after mustard sowing by 31.2% and in the increase in the lupine with field pea in the layer 10-20 cm by 37.5%.

Similar results were obtained in earlier studies of Majchrzak [12], in which the application of direct sowing technology in comparison to inversion and simplified tillage increased the soil cloddines index by 64.7 and 60%, respectively. An increase in the analyzed index was also found after cultivation of white mustard, but only when sown with the use of direct sowing technology. Wojciechowski et al. [23] believe that simplifications in wheat cultivation are conducive to an increase in the cloddines index (B) in the 0-10 cm layer, while in the 10-20 cm layer they indicate a decrease in its value. Daraghmeh also indicates an increase in the number of macroaggregates under conditions of simplified tillage systems [4]. On the other hand, Kordas and Majchrowski [8] obtained an increase in the value of soil cloddines index after the application of cover crop.

The pulverisation index of soil aggregates (S) in both layers depended on the type of cover crop (Table 2). Significantly greater soil pulverising occurred in the objects where yellow lupine with field pea were sown in comparison with white mustard. In the soil layers (0-10 cm and 10-20 cm), the cultivation of white mustard in cover crop reduced the value of the soil pulverisation index by 11.8%.

This is confirmed by the opinions of Kordas and Majchrowski [8], that ploughing a stubble intercrop may have an impact on reducing soil pulverising. In the author's experiment, however, no influence of soil tillage for sowing cover crop and spring wheat on the value of pulverising soil aggregates index was found. Its highest value in both layers was obtained after direct sowing of yellow lupine with field pea and wheat after plough tillage.

Wojciechowski et al. [23] report a higher value of the pulverising index in the direct wheat sowing in relation to the traditional tillage, in both tested layers (0-10 and 10-20 cm). Parylak et al. [16] and Wacławowicz et al. [19] indicate a tendency to decrease the value of the pulverisation rate under the influence of simplifications in tillage and direct sowing.

Table 1. Soil cloddines index (B)
Tab. 1. Wskaźnik zbrylenia gleby (B)

Cover crop (A)	Variants of tillage (B)				Mean
	Skimming/ Plough	Skimming/ direct sowing	Direct sowing/ Plough	Direct sowing/ direct sowing	
layer 0-10 cm					
White mustard	0.16	0.18	0.20	0.21	0.19
Yellow lupine + field pea	0.19	0.17	0.18	0.18	0.18
Mean	0.18	0.18	0.19	0.20	–
$LSD_{0,05}$	A – n.s.; B – n.s.; A/B – n.s.				
layer 10-20 cm					
White mustard	0.19	0.19	0.24	0.19	0.20
Yellow lupine + field pea	0.16	0.16	0.16	0.22	0.18
Mean	0.18	0.18	0.20	0.21	–
$LSD_{0,05}$	A – n.s.; B – n.s.; A/B – n.s.				

n.s. – not significant difference *Source: own study / Źródło: opracowanie własne*

Table 2. Index of pulverisation of the soil aggregates (S)
Tab. 2. Wskaźnik rozpylenia gleby (S)

Cover crop (A)	Variants of tillage (B)				Mean
	Skimming/ Plough	Skimming/ direct sowing	Direct sowing/ Plough	Direct sowing/ direct sowing	
layer 0-10 cm					
White mustard	0.15	0.15	0.16	0.14	0.15
Yellow lupine + field pea	0.17	0.18	0.19	0.16	0.17
Mean	0.16	0.17	0.17	0.15	–
$LSD_{0,05}$	A– 0.012; B – n.s.; A/B – n.s.				
layer 10-20 cm					
White mustard	0.14	0.16	0.14	0.15	0.15
Yellow lupine + field pea	0.16	0.16	0.19	0.17	0.17
Mean	0.15	0.16	0.17	0.16	–
$LSD_{0,05}$	A– 0.012; B – n.s.; A/B – n.s.				

Source: own study / Źródło: opracowanie własne

The type of cover crop used as well as the method of tillage of the soil for its sowing and then spring wheat in both studied layers had no significant influence on the value of the soil structure index (W) (Table 3). A significant influence on the examined parameter, but only in the layer of 0-10 cm, was exerted by the interaction of the type of cover crop and the way of soil tillage. With reference to the cultivation of yellow lupine and field pea after ploughing and spring wheat in direct sowing of white mustard after ploughing followed by spring wheat after ploughing or in the direct sowing technology, the indicator of soil structure increased significantly by 20.4% and 22.7%, respectively.

In the research by Wacławowicz et al. [20] the highest value of the structure index (W) was observed in the conditions of abandoning tillage and using direct sowing. Similarly, Wojciechowski et al. [23] stated that compared to traditional cultivation, the use of simplifications in soil cultivation had a more positive impact on soil structure indicators.

The conducted studies did not reveal any significant influence of the analyzed experiment factors on the MWDa value in both layers (Table 4). Higher values were obtained by sowing white mustard as cover crop by 4.1% (layer 0-10 cm) and around 2% (layer 10-20 cm). In both analyzed layers the highest weighted average diameter of the aggregate was characteristic for the objects on which direct sowing of both cover crop and spring wheat was performed. This confirms the popular opinion of other authors concerning the beneficial effect of simplified tillage on this index of Carter [3], Hajabbasi and Hemmat [5], Kordas et al. [9], Kasper et al. [7], Wacławowicz et al. [20].

Table 3. Soil structure index (W)
Tab. 3. Wskaźnik struktury gleby (W)

Cover crop (A)	Variants of tillage (B)				Mean
	Skimming/ Plough	Skimming/ direct sowing	Direct sowing/ Plough	Direct sowing/ direct sowing	
layer 0-10 cm					
White mustard	0.54	0.53	0.45	0.45	0.49
Yellow lupine + field pea	0.46	0.44	0.46	0.50	0.46
Mean	0.50	0.49	0.46	0.48	–
$LSD_{0,05}$	A– n.s.; B – n.s.; A/B – 0.081				
layer 10-20 cm					
White mustard	0.52	0.47	0.51	0.52	0.51
Yellow lupine + field pea	0.50	0.51	0.49	0.47	0.49
Mean	0.51	0.49	0.50	0.50	–
$LSD_{0,05}$	A– n.s.; B – n.s.; A/B – n.s.				

Source: own study / Źródło: opracowanie własne

Table 4. Mean diameter of aggregates (MWDa)
Tab. 4. Średnia ważona średnica agregatu (MWDa)

Cover crop (A)	Variants of tillage (B)				Mean
	Skimming/ Plough	Skimming/ direct sowing	Direct sowing/ Plough	Direct sowing/ direct sowing	
layer 0-10 cm					
White mustard	2.51	2.13	2.63	2.78	2.51
Yellow lupine + field pea	2.44	2.33	2.17	2.69	2.41
Mean	2.48	2.23	2.40	2.74	–
$LSD_{0,05}$	A – n.s.; B – n.s.; A/B – n.s.				
layer 10-20 cm					
White mustard	2.57	2.49	2.62	2.64	2.58
Yellow lupine + field pea	2.51	2.55	2.49	2.55	2.53
Mean	2.54	2.52	2.56	2.60	–
$LSD_{0,05}$	A – n.s.; B – n.s.; A/B – n.s.				

Source: own study / Źródło: opracowanie własne

4. Conclusions

1. Ploughing for white mustard, followed by ploughing or direct sowing of spring wheat had the most favorable effect on the value of the indicator of soil structure.
2. Direct sowing of white mustard followed by spring wheat increased the value of weighted average diameter of aggregates (MWDa) in both analyzed layers (0-10 and 10-20 cm).
3. Compared to the leguminous mixture (yellow lupin + field pea), the sowing of white mustard in the cover crop contributed to an increase in the of soil cloddines and a significant reduction in soil pulverising in both analyzed its layers (0-10 and 10-20 cm).

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