The influence of soil compaction on water retention of soil under red clover sward

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Abstract

This paper presents results of the researches carried out in 1996-1998 in Mydlniki on silty soil. Results showed that multiple passes of tractor wheels changed air and water properties of the soil under red clover. The available and productive retention decreases in accordance to number of passes. This is a result of the decrease of the field water capacity connected with large pores. These changes are observed in every layer of the investigated soil, but the largest differences are noticed in 0-5 cm layer. Multiple passes of tractor wheels cause decreasing of red clover yields. Yield is inversely proportional to the number of passes.

1. Introduction

The soil compaction by tractor wheels is one of the most important factors, which decrease plant yielding (WALCZYK, 1995). It is especially important on grasslands and perennials species because there are not ploughing and other opening operations. The soil compaction accumulates during many years and cause to plant yielding. All machines passes take places on the field surface covered by plants. Damages of the shoots and roots decrease plant yield (GRYNIA et al., 1997). Worsening of the soil physical properties such as: increasing of the soil density, decreasing of the porosity, changes in the structure of the porosity and decreasing of the air permeability lead to decreasing of plant yield. Changes in the soil physical properties, mentioned before, cause changes in water retention properties (DOMZAL et al., 1984). The water retention properties of the soil are factors that determine plant yielding especially in the dry and warm summer.

2. Materials and methods

Research was carried out during 1996 - 1998 in Mydlniki near Kraków. The experiment was established using randomised blocks in four replicates on brown deluvial developed from silt on light silty loam.

Red clover (*Trifolium pratense*) were sown on a experiment field. The plots were compacted by wheel of Ursus-360 tractor (weight 2056 kg). Wheel passes covered a whole plots surface (7 m^2). The combination of the passes was as follows: control (0), one pass (1), two passes (2), four passes (4), six passes (6). Plant yields were determined after each cut. In autumn 1998 soil samples (volume 100 cm^3) were collected from three soil layers: 0-5 cm, 10-15 cm and 20-25 cm. The prepared samples were saturated with water on a suction plate, and then water retention was determinated:

- Available water retention - calculated as a difference of the moisture between field water capacity (–15.5 kPa water potential) and moisture of the stable withering (–1554.8 kPa water potential).
- Productive water retention - calculated as a difference of the moisture between field water capacity (–15.5 kPa water potential) and moisture of the total retardation of the plant growth (for –491.8 kPa water potential).

3. Results and discussion

3.1 Water retention

The pressure caused by tractor wheel passes result in significant changes of the soil density, the total porosity and a content of water bounded with different forces. It results in a decrease of the available and productive water retention in the investigated soil layers in direct proportion (*Table 1*).

Six passes over soil surface caused a significant increase in the soil density in comparison with non-compacted objects. Changes of this value are not significant for the depth of soil sample were taken. The compaction results in changes of the structure of porosity. The pressure produced by tractor wheels caused decreasing of the macropores (>20 mm) fraction and mezopores (20-0.2 mm) fraction. Micropores (<0.2 mm) are a fraction, resistant to the soil compaction.

The soil compaction causes a decreasing of water retention (available and productive) in investigated soil layers and it leads to increasing of the soil density and changes in the structure of porosity. Influence of soil compaction on water retention properties is confirmed by DOMZAL (1979, 1983) and DOMZAL et al. (1984). Decreasing in retention property leads to decreasing in plant yielding especially in the warm and dry time, when there is an insufficient water supply.

3.2 Red clover yielding

Plant reaction on compaction was the most visible during the second cut in 1996 (*Table 2*). First cut in 1997 was equalised and significant differences we noticed only between control and plot with six passes. The same situation we could see in 1998. There were no significant differences between means on all combinations of the experiment during the first cut. This is a result of a long period of time between the third cut in autumn and the first cut in spring following year. Then plants can regenerate injuries. We could notice a decreasing of plant yields in second and third cut according to number of passes.

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Table 1: **The water – air properties of investigated soil layers**

Soil layer (cm)	Number of tractor passes	Soil density ($Mg.m^{-3}$)	Total porosity ($cm^3.100\ cm^{-3}$)	Content (%) of pore with diameter (µm)			Water retention ($cm^3.100\ cm^{-3}$)	
				> 20	20-0,2	< 0,2	productive	available
0-5	0	1,38	45,3	9,7	15,3	20,3	11,3	15,3
	1	1,47	43,0	8,0	14,0	20,9	10,2	14,0
	2	1,45	40,8	6,3	13,2	21,4	10,3	13,2
	4	1,54	40,5	8,6	10,9	21,0	7,9	10,9
	6	1,53	38,8	8,8	10,6	19,0	7,9	10,6
10-15	0	1,44	41,6	8,6	17,0	16,0	11,2	16,0
	1	1,46	41,3	10,2	11,9	19,3	8,7	13,9
	2	1,44	39,4	7,4	14,6	17,3	10,7	14,6
	4	1,45	38,2	8,0	12,0	18,1	8,8	12,0
	6	1,54	38,8	8,5	11,1	19,2	8,2	11,1
20-25	0	1,45	42,0	10,1	12,2	19,7	8,7	12,2
	1	1,44	42,2	11,6	14,8	15,8	11,1	13,8
	2	1,45	38,8	7,0	13,7	18,2	10,0	13,7
	4	1,48	38,4	8,3	11,8	18,2	8,7	11,8
	6	1,48	38,8	9,1	12,8	16,8	10,0	12,8
Means for passes	0	1,42	43,0	9,5	14,8	18,7	10,4	14,8
	1	1,45	42,2	9,9	13,6	18,7	10,0	13,9
	2	1,44	39,7	6,9	13,8	19,0	10,3	13,8
	4	1,49	39,0	8,3	11,6	19,1	8,4	11,6
	6	1,52	38,7	8,8	11,5	18,3	8,7	11,5
Means for depth	0-5	1,47	41,6	8,3	12,8	20,5	9,5	12,8
	10-15	1,47	39,9	8,6	13,3	18,0	9,5	13,3
	20-25	1,46	40,0	9,2	13,1	17,7	9,7	13,0
$LSD_{0,05}$:								
passes		*0,044*	*1,16*	*1,7*	*1,6*	*n.s.*	*1,49*	*1,64*
depth		*n.s.**	*0,90*	*n.s.*	*n.s.*	*1,8*	*n.s.*	*n.s.*
interaction		*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*

* n.s.-non significant differences

Table 2: **Yielding of *Trifolium pratense* (t DM/ha)**

Number of passes	1996		1997			1998		
	1st cut	2nd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
0	4,58	1,62	7,87	5,79	2,98	6,45	4,42	4,53
1		1,12	7,72	5,50	2,63	6,85	4,17	4,03
2		0,62	8,40	5,09	2,66	7,23	3,98	4,05
4		0,18	6,51	4,84	2,12	7,17	3,54	3,36
6		0,02	6,32	4,65	1,98	6,63	3,03	3,11
$LSD_{0,05}$		*0,25*	*1,42*	*0,95*	*0,52*	*n.s.**	*0,90*	*0,67*

* n.s.-non significant differences

4. Conclusion

❶ The pressure produced by tractor wheels causes significant increase in the soil density and decrease in the total porosity of the investigated soil layers.

❷ Multiple passes of tractor wheels lead to decreasing of the available and productive water retention. The depth of collected samples is a factor, which does not lead to changes in water retention.

❸ Changes in air and water properties are connected with decreasing macropores and mezopores fractions. Micropores are fraction resistant to the soil compaction.

❹ Multiple passes of tractor wheels cause decreasing of *Trifolium pratense* yields. Yield is inversely proportional to the number of passes. The largest differences are visible in the first year of cultivation.

5. References

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