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The evaluation of soil compaction parameters in the field trial with different soil tillage

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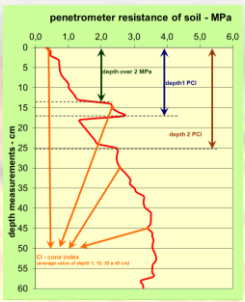
Introduction

Soil compaction is a process that occurs during intensive farming. In many places, the compaction of soils serious cause significant deterioration of soil fertility and soil production capabilities, limits the full genetic potential of varieties and reduce the effectiveness of inputs in the production process of crops. Penetrometer resistance indicates the degree of soil compaction. It is the soil resistance against the penetration of the cone penetrometer into the soil. High compaction adversely affects plant growth and is so a criterion when selecting the method of soil tillage.

. It was evaluated the course resistance to penetration in the soil profile. Was determined Cone Index (CI). This is the average value of the measured data with a depth of 0.01 m, 0.15 m, 0.45 m, 0.30 m. The graphical evaluation was determined 1PCI - (Peak Code Index)- is the first maximum value resistance to penetration is higher than 2 MPa and 2PCI second maximum value resistance to penetration is higher than 2 MPa. It was determined soil depth, in which penetrometer resistance for the first time exceeded 2 MPa. The first maximum value penetrometer soil resistivity (1PCI) can be considered as an attribute of soil compaction. The second maximum compaction (2PCI) usually arises in a natural way the pressure of the overlying soil layers or technology as a remnant of deeper soil tillage. .

Evaluation of soil compaction



Limits values for critical properties of compacted soils (Lhotsky, 2000)

Fysical soil properties	Soil type (content of particles below 0.01 mm in %)					
	C > 75	C – CL 75 - 46	L 45 - 39	SL 38 - 21	LS 20 - 11	S < 10
Bulk density (g.cm^{-3})	> 1,35	> 1,40	> 1,45	> 1,55	> 1,60	> 1,70
Porosity (%)	< 48	< 47	< 45	< 42	< 40	< 38
Minimum air capacity (%)	10	10	10	10	10	10
Resistance to penetration (MPa)	2,8 – 3,2	3,3 – 3,7	3,8 – 4,2	4,5 – 5,0	5,5	> 6,0
when soil moisture	28 - 24	24 – 20	18 - 16	15 -13	12	10

Material and methods

The evaluation of agro-technical measures on the soil compaction parameters was compared in the field trial AGRO 2 in the maize production region on the School Farm of Mendel University Brno (Žabčice). The experiment AGRO 2 is established since 2003. The experiment site was on gleyic fluvisol (FMG). In terms grain size composition of the soil is heavy to very heavy.

The study is focused on comparison of soil compaction parameters in the different soil tillage systems to different plant. The experiment AGRO 2 can be characterized as a crop rotation for the management system with animal husbandry (all straw is harvested, to silage maize and sugar beat is fertilized with manure) with the following variants:
- Soil tillage – I. Ploughing, II. Loosening; III. Direct sowing
- Crop rotation – 1. alfalfa 1st year, 2. alfalfa 2nd year, 3. winter wheat, 4. silage maize, 5. winter wheat, 6. sugar beet, 7. spring barley.

Measurements were made in spring 2012. It was used hand cone penetrometer with digital recorder Penetrologger from the firm Eijkelkamp. The equipment conforms to the ASAE (American Society of Agricultural Engineers) S313.3 (1999a). For the actual measurement was chosen diameter of 1 cm2, 60 °. Speed of penetration into the soil was set to 3 cm.s-1. In each variant the field experiment was performed 5 measurements of penetration. During the measurements were recorded using a soil moisture probe, which is a part of Penetrologger.

The evaluation of the measured data corresponds to the standard ASAE EP 542 (1999b). For evaluation software was used PenetroViewer ver. 8.5. .

Results and discussions

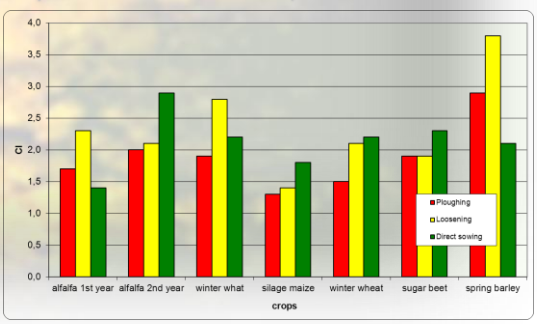
Measurements of penetrometer resistance recorded by hand penetrometer for each variant showed a different course of soil penetrometer resistance in different methods of stand establishment of individual crops in the crop rotation in experiment AGRO2. Penetrometer resistance increases with increasing depth. The value of soil penetrometer resistance that restricts root growth, according to ASAE EP542 (1999b) determined the level of 2 MPa. Lhotsky (2000) determined a limit value for heavy soil compaction in the interval from 3.3 to 3.7 MPa. For compacted layer of soil is usually considered when the value of penetrometer resistance rises sharply and then falls again. The first maximum value penetrometer soil resistivity (1PCI) can be considered as an attribute of soil compaction. The second maximum compaction (2PCI) usually arises in a natural way the pressure of the overlying soil layers or technology as a remnant of deeper soil tillage. From the measured values is not clearly seen that for some crops occurred above described effect rises sharp and falls penetrometer resistance of soil. The course penetrometer resistance exhibits a rather slow increase with depth, however, the differences between the variants soil tillage. For most crops, it is seen that the minimum soil tillage technology and technology without tillage showed higher soil penetrometer resistance against variants with ploughing, this conclusion is confirmed by the values Cone index (CI) shown in Table 1. and Graph 1.

Tab. 1.: Characteristics of soil penetration resistance in field experiment AGRO 2

crop	alfalfa 1st year			alfalfa 2nd year			winter wheat			silage maize		
preceding crop	spring barley			alfalfa 1st year			alfalfa 2nd year			winter wheat		
soil tillage	Ploughing	Loosening	Direct sowing	Ploughing	Loosening	Direct sowing	Ploughing	Loosening	Direct sowing	Ploughing	Loosening	Direct sowing
soil moisture (%)	17,40	19,00	27,80	24,50	24,60	23,80	20,20	18,00	20,00	18,30	19,40	20,10
Cone index (CI)	1,70	2,30	1,40	2,00	2,10	2,90	1,90	2,80	2,20	1,30	1,40	1,80
1 PCI (m)	0,24	0,25	0,11	0,07	0,05	0,03	0,13	0,24	0,10	0,05	0,11	0,06
2 PCI (m)	0,29	0,42	0,22	0,16	0,14	0,31	0,34	0,49	0,18	0,29	0,25	0,10
soil depth over 2 MPa (m)	0,28	0,19	-	0,04	0,04	0,01	0,28	0,14	0,08	0,28	0,68	0,28

crop	winter wheat			sugar beet			spring barley		
preceding crop	silage maize			pšenice ozimá			sugar beet		
soil tillage	Ploughing	Loosening	Direct sowing	Ploughing	Loosening	Direct sowing	Ploughing	Loosening	Direct sowing
soil moisture (%)	17,00	20,20	22,00	17,70	23,00	20,20	23,00	22,00	27,00
Cone index (CI)	1,50	2,10	2,20	1,90	1,90	2,30	2,90	3,80	2,10
1 PCI (m)	0,22	0,20	0,09	0,12	0,19	0,15	0,12	0,24	0,11
2 PCI (m)	0,30	0,33	0,28	0,33	0,34	0,27	0,40	0,30	0,19
soil depth over 2 MPa (m)	0,34	0,27	0,18	0,26	0,22	0,15	0,06	0,03	0,05

Graph. 1.: Cone index in field experiment AGRO 2



The measurement of penetrometer resistance of the variant tillage in spring barley after sugar beet has the characteristics of compacted soil. The negative effects of this bad state were exacerbated by adverse weather in 2012. The cause of this unfavourable situation can be seen in the negative impacts use of improper harvesting machines (1 row harvester), when the soil is more burdened crossings relatively heavy machinery and date of entry harvesting machines for harvesting sugar beets to the field.

Comparison of different attributes of soil compaction at different tillage for each crop of crop rotation AGRO 2 shows in Table 1. The data in the table shows that the minimum soil tillage without ploughing had lower soil compaction characteristics (see Table 1) evaluated by using the CI. The table also shows that minimum soil tillage technology showed higher values of moisture of the soil. This confirms the advantage of minimum soil tillage technology in the form of better water management.

Conclusions

Presented results showed differences among particular variants of soil tillage systems and among crops, as well. Soil compaction is the result of unsuitable soil tillage and usage of inappropriate machines and tools. Improper choice of fore-crop harvest (especially when soil is wet) plays also important role in this relation. Nowadays, there are efficient possibilities how to eliminate soil compaction. Deeper loosening without soil inverting could be a solution for it.

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