IMPACT OF MANURE AND SELECTED CONDITIONNERS ON PHYSICAL PROPERTIES OF CLAY SOIL

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Abstract
The article discusses the results of measurement of soil physical properties that has been done within field trial established at Sloveč in the year 2014 comparing with 2018. There were different variants of fertilizing and soil activator (NeoSol and Z'fix) used. Soil physical properties, i.e. soil bulk density and cone index were measured. The results indicate that at soil upper layer, cone index of all the trial variants dropped relative to control regardless of the manure treatment with Z'fix, or the application of NeoSol. Concerning soil bulk density, a drop in values can be discerned with the application of cattle manure. One variant was increase with no apparent pattern of treatment. Subsequently, draft of chosen tillage implements was measured.

Key words: *activator of organic matter; cattle manure; soil properties; draft; bulk density.*

INTRODUCTION

According to *Bünemann et al. (2018)*, the minimum soil characteristics indicators should include physical, chemical and biological indicators. *Bünemann et al. (2018)* include soil organic matter and structure among the most important indicators of soil quality. One of the basic problems of modern agriculture is soil compaction. Soil compaction results in loss of yield and high soil density. Soil compaction has negative impact on environment. The negative effect of soil compaction is manifested through increased bulk density, soil cone index, and other variables. This all leads to reduction in porosity, hydraulic soil properties, stability and other variables (*Alakukku, 1996*). All these parameters are connected together and influence crop yields. *Celik et al. (2010)* confirmed organic applications to significantly lower the soil bulk density and penetration resistance. According to *Javůrka and Vach (2008)*, it has been shown that excessive soil compaction reduces the growth rate of crop roots, extends them and penetrates into the lower soil layers (rooting depth). In compacted soils, crops that make up the economic yield of underground organs - sugar beets or potatoes - are most affected. For other crops, soil compaction results in lower water and nutrient intake compared to the normally developed root system. Soil compaction occurs in a vast array of soils and climates. Deteriorates with low organic matter content in soil. The low supply of water to the soil, due to compaction, leads to additional fertilizer requirements, leading to increased production costs (*Hamza, 2005*).
The impact of using soil activator of organic matter is among the less explored topics. It can have effect on physical and chemical properties of soil. It can be also assumed that changes in soil properties will be reflected in the long term rather than immediately after application. According to *Podhrázská et al. (2012)*, repeated conventional tillage and application of PRP Sol did not demonstrate any improvement in soil physical properties (density, porosity, soil compaction, reduced water content in soil).
In terms of economy and operation, energy demand of soil tillage is one of the crucial elements. Tillage is the base operation in agricultural systems and its energy consumption represents a consid-erable portion of the energy consumed in crop production (*Larson and Clyma, 1995*). *McLaughlin et al. (2002), Liang et al. (2013)* and *Peltre et al. (2015)* reported manure amendments to have significant effect on reduction in tillage implement draft. Prolonged application and higher rates brought advanced reduction. The primary aim of the project supported by the Technology Agency of the Czech Republic is verify the impact of cattle manure and biological activator of soil on soil production properties.

MATERIALS AND METHODS

Trails field examining effect of substance for soil amendment and fermented manure were established in 2014. The research was carried out until 2017, when other variants were added. The measurement were done in autumn every year. In 2014 were done on 2nd October after the barley harvest. In 2018

measurement were done on 1st November. The trial field is located near Sloveč in Central Bohemia (GPS: N 50°14.256', E 15°20.705', altitude: 273 m). The topography is gently sloping, facing southwest. Soil type on the location Sloveč is very heavy and the soil is thus difficult to cultivate. The content of clay particles under 0.01 mm was 30 % of weight at the depth from 0 to 0.3 m. Volumetric moisture in the top soil layer (0 to 0.30 m) was 35.65 % and total porosity was 40.15 %. Bulk density was 1.46 $g.cm^{-3}$.

Each trial fields was 45 meters wide and 140 meters long selected to be homogenous and to avoid headland. On this plot was applicated fertilizer out according to the plan. There were used cattle manure, NPK 15-15-15 (Lovofert), NeoSol, Z'fix. Fertilizers were Cattle manure and NPK. NeoSol is soil activator from PRP Technologies company, which is formed by a matrix of calcium and magnesium carbonates that is well bind to the soil solution and regulate the environment, where microorganisms can develop. Z'fix is a granular mix composed of calcium and magnesium carbonates, designed to control fermentation processes in manure and compost. Z'fix was applied directly to the bedding in the presence of animals. Both activators is not a fertilizers, they are supposed to improve conditions for the transformation of organic matter.

Fertilization of individual variants is shown in Table. 1. The difference in variants was in used fertilizers, biological transformers of organic matter. Dosage of cattle manure was 50 t.ha-1, of PRP Sol 200 kg.ha-1, and of NPK 200 kg.ha-1. Than the field was ploughed afterwards. In spring, seedbed preparation was carried out.

Tab. 1 Fertilization of individual variants of trial fields at Sloveč.

Variant	Fertilization
I a	cattle manure with Z'fix + NPK
II a	cattle manure with Z'fix + NeoSol+ NPK
III a	cattle manure+ NPK
IV a	cattle manure + NeoSol + NPK
V a	NeoSol + NPK
VI a	NPK (Control)

There were used Two basic methods for measuring physical properties of soil. Firstly it was undisturbed soil samples using Kopecky's cylinders (volume 100 cm3). Secondly, cone index measuring method was used by registred penetrometer PEN 70 developed at CULS Prague was employed. Moisture was measured by Theta Probe (Delta-T Devices Ltd, UK). The proposed soil tillage implements were measured by means of a drawbar dynamometer with strain gauges S-38/200 kN (LUKAS, Czech Republic) between two tractors (see Fig. 1). Data acquisition system NI CompactRIO (National Instruments Corporation, USA) was employed and its sample rate was set at 0.1 s. The data were then processed by MS Excel (Microsoft Corp., USA) and Statistica 12 (Statsoft Inc., USA) programs.

Fig. 1 Photo of draft measurement of chisel plough Horsch Tiger 5 AS at Sloveč in autumn 2018.

RESULTS AND DISCUSSION

Table 2 shows the overall average values of the basic physical properties of soils. There is a clear difference in volumetric soil moisture between the two years due to exceptionally dry weather over the whole vegetative period of the year 2018. This clearly increased the values of cone index which depends on soil moisture. Illustrative aggregate values at three different depths are presented in the Table 2. Because of drastically different climatic conditions in both year is more interesting relative differences to the control variant than absolute values.

Tab. 2 The overall averages of soil moisture and bulk density, and operating conditions and overall results of measurement of soil tillage implement drafts at Sloveč in autumn of 2014 and 2018.

	Fall 2014	**Fall 2018**
Soil properties		
vol. moisture at 0.00 – 0.05 m [%]	35.16	20.78
cone index at 0.08 m [10^6 Pa]	1.124	0.913
cone index at 0.12 m [10^6 Pa]	1.326	1.477
cone index at 0.16 m [10^6 Pa]	1.571	2.977
bulk density at 0.05- 0.10 m [$g.cm^{-3}$]	1.763	1.518
red. bulk density at 0.05- 0.10 m [$g.cm^{-3}$]	1.367	1.248
Draft measurement		
tractor	NH TG285	JD 9560 RT
engine power [HP]	285	560
implement	chisel plough	tine cultivator
implement type	Strom Terraland TN 3000	Horsch Tiger 5 AS
working width [m]	3	5
working depth [m]	0.117	0.122
working speed [$km.hour^{-1}$]	7.81	7.94

Year-on-year changes in relative cone index values at upper soil layer are presented in Fig. 2 and 3. Cone index of all the trial variants dropped relative to control regardless of the manure origin, manure treatment with PRP Fix, or the application of PRP Sol.

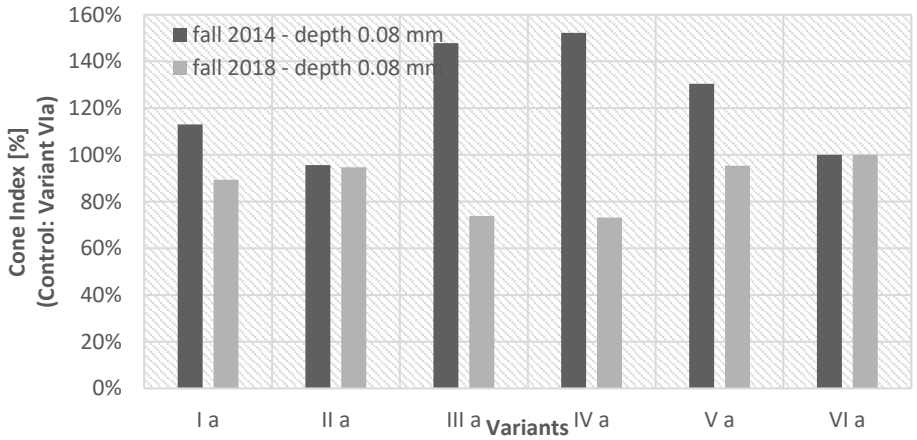

Fig. 2 Graph comparing relative differences of soil cone index values at the depth of 0.08 m at Sloveč in autumn 2014 and 2018 (Variant VIa – 100 %).

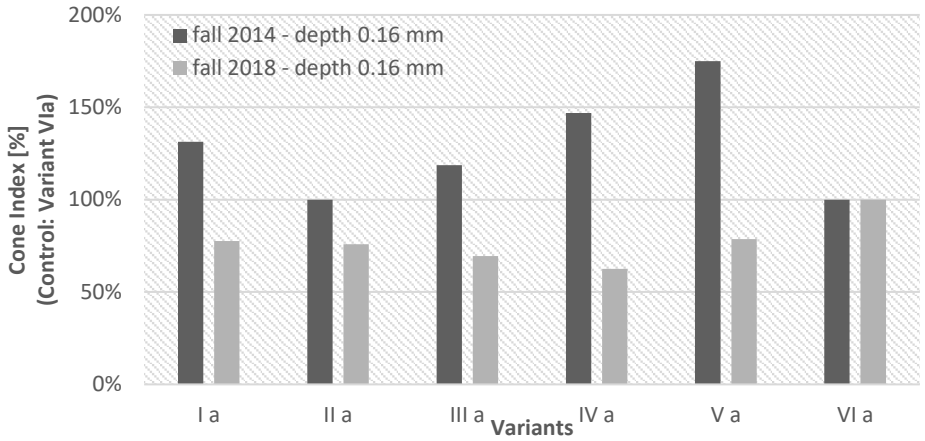

Fig. 3 Graph comparing relative differences of soil cone index values at the depth of 0.16 m at Sloveč in autumn 2014 and 2018 (Variant VIa – 100 %).

On the other hand, overall soil bulk density values decreased, although moderately only. Fig. 4 demonstrates relative comparison to the control variant. A drop can be discerned with the application of cattle manure. Small differences is in variant Va. The increase occurred without obvious cause.

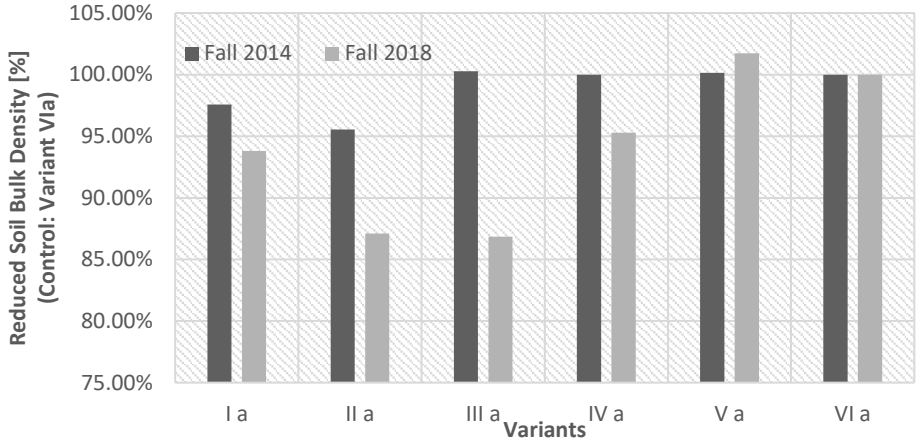

Fig. 4 Graph comparing relative differences of reduced soil bulk density at Sloveč in autumn 2014 and 2018 (Variant VIa – 100 %).

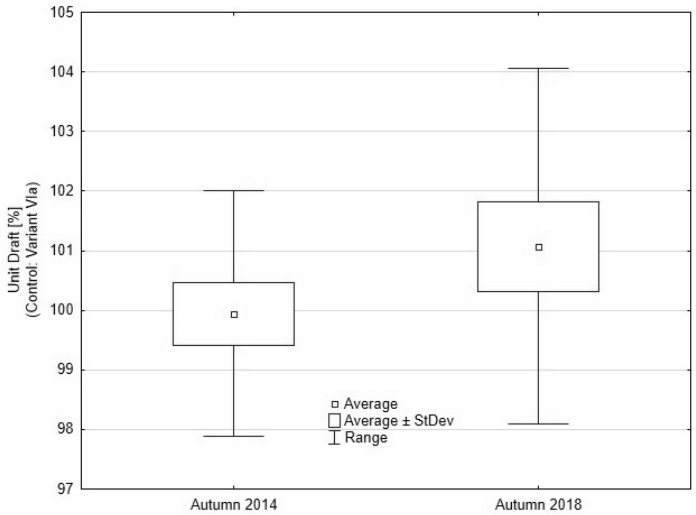

Fig. 5 Graph comparing relative differences of implement unit draft related to control at Sloveč in autumn 2014 and 2018 (control variant VIa excluded).

Fig. 5 presents aggregate unit draft values compared to the control. Due to the different climatic conditions and soil tillage implements used, absolute values cannot be considered. The ratio of individual measured unit draft values to the average value of the control variant is therefore used for evaluation. There a slight increase in unit draft after manure and soil and manure activators.
When taking into account relative differences of individual variants (Fig. 6), the increase was attained in three cases. It was variant IIIa, Iva and Va. The majority differences were in Iva with application Cattle manure, NeoSol and NPK.

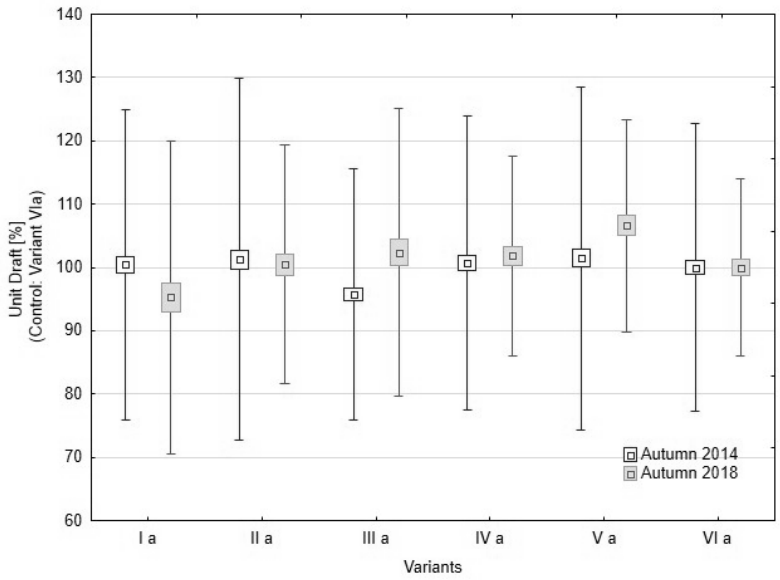

Fig. 6 Graph comparing relative differences of implement unit draft with respect to individual variants at Sloveč in autumn 2014 and 2018

The original assumptions of the research were not mostly confirmed. The experimental measurements confirmed conclusions of *Podhrázská et al. (2012)* that says there is no relationship between the application of the biological soil activator NeoSol and the improvement of the physical properties of the soil. In opposite, *Schjønning et al. (1994)* suggested, that long term fertilizer application can be rewarding to improve soil strength and soil density than manure or inorganic fertilizer treatments. *Celik et al. (2010)* re-ported, that cone index values can be decrease compared to the control variant. With higher application rates of manure, soil bulk density as well. Both these two assumptions was not confirmed

CONCLUSIONS

So far, the work has not proved the beneficial effect of substances for soil (NeoSol) and manure amendment (Z'fix) and of cattle manure on soil cone index and on implement draft force reduction. At soil upper layer, cone index of all the trial variants dropped relative to control regardless of the manure origin, manure treatment with Z'fix, or the application of NeoSol. Concerning soil bulk density, a drop in values can be discerned with the application of cattle manure. One variant was increase with no apparent pattern of treatment.
Subsequently, draft of chosen tillage implements was measured. The unit draft remained practically unchanged relative to the control within one variant, decreased within two variants, and increased within another three variants. The latter two were the variants where the most treatments were accomplished, i.e. application of cattle manure (with and without Z'fix), of NeoSol, and of NPK. It could be therefore assumed that higher number of machinery passes may have resulted in the increased implement draft. The assumed benefits of manure and soil activators may not have had time to take effect. Instead, the impact of higher number of machinery passes due to their application may have been manifested.
The necessity of long-term examination of the effects of activators of organic matter should be emphasized. Research needs to be validated in more locations in order to eliminate the influence of the local

environment. The effects of activators of organic matter are among the less explored topics. In connection with changing composition of organic fertilizer (fewer manure and slurry but more compost and waste from biogas plants), the increased importance of activators of organic matter can be expected.

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