ORGANIC MATTER-INDUCED CHANGES IN WATER-STABLE AGGREGATION

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Introduction

The most important function of soil is that it is the basic media of crop production (Várallyay, 2002). Consequently, sustaining and ameliorating of soil structure is crucial. Decline of soil structure and degradation of its stability are frequently caused by tillage, crop management and getting moist (Chan et al., 2003).
Soil structure is built up by groups of primary particles that cohere to each other, and which are called aggregates (Kemper and Rosneau, 1986). (Di Gléria et al., 1957). Water-stability is often investigated by wet sieving. Earlier reported methodological problems were solved and circumstances affecting soil structure were standardized with the new modified wet sieving method proposed by Six (2000). The Normalised Stability Index (NSI) characterises aggregate stability by comparing the aggregate distribution after two differently disrupting wetting methods. The two different wetting methods are: (1) fast wetting, namely rapid immersion in water (Slaking (S)), which disrupts the aggregates to the highest extent, therefore produce the lowest aggregate amount; and (2) slow wetting, namely capillary wetting (Capillary (C)) to field capacity, which disrupts the aggregates to the lowest extent and therefore achieves the highest aggregate amount. The capillary wetting method was earlier tried by us to get different size fractions to evaluate the distribution of soil organic matter in soils (Huisz et al., 2006).
In this paper our aim was to test the standardised wet sieving method proposed by Six (2000). We investigated the effect of farmyard manure addition on soil structure and its quality and on the stability of aggregates.

Material and methods

Site description

The soil samples originate from the "Comparing experiment of organic and mineral fertilisation" long-term field experiment in Keszthely, Hungary. The investigated soil type is a sandy loam textured Eutric Cambisol (soil type FAO), Alfisol (soil type USDA). In this paper addition of farmyard manure (0kg N + 0kg P + 0kg K + 6 x 17,3ha t^{-1} in 2 parts during 5 years) has been investigated and compared to a not fertilised treatment (0kg N + 0kg P + 0kg K) as a reference. Both sites have been tilled by autumn ploughing to 25cm depth. Soil samples were taken from two different depth layers (0-20 cm and 20-30 cm) according to the depth of fertilisation. The experiment was set up in the 1960's. Crop rotation was sugar beet – maize – maize – winter wheat – winter wheat. Samples were taken from the maize field, first when maize was at the stage of 6-8 leaves, secondly after harvest, but before stubble breaking.

 DOI: 10.1556/CRC.35.2007.2.83

Method

Air dry soil were dry sieved in a 7mm sieve, parts bigger than this size were manually broken with a mortar to reach this size. Two different pre-treatment methods were investigated. (1) ±300g-s of air dry soil was rapidly immersed in tap water for 5min (Slaking (S)). (2) ±300g-s of air dry soil was capillary wetted to field capacity and left overnight to weight equilibrate (Capillary (C)). After the pretreatments each sample was wet sieved for 2min in an analytic sieve shaker machine with the following aperture sizes: 2mm, 250μm, 53μm. Therefore we got 4 fractions: (1) the >2000μm large macro-, (2) the 250-2000μm small macro-, (3) the 53-250μm microaggregates, and (4) the <53μm silt and clay fraction. All fractions were dried at 60^{o}C and weighted.

Results and discussion

Soil samples were taken from four plots of each treatment and depth layer. Different pretreatment methods were done in triplicates. In this paper we present our result before the sand correction. Data were analysed as an F-probe and later with 2 sampled T-probe. Statistical significance determined at $P < 0.05$. In the case of farmyard manure addition values were significantly different from the corresponding ones at the Slaking (S) pretreatment only in the 53-250 μm microaggregate fraction and the <53 μm silt and clay fraction in the upper layer; and at the Capillary (C) pretreatment only in the <53 μm silt and clay fraction in the lower layer at 0.05 significance level. Figure 1-4. show the amount of soil dry matter in the isolated fractions for each treatment and depth layer respectively.

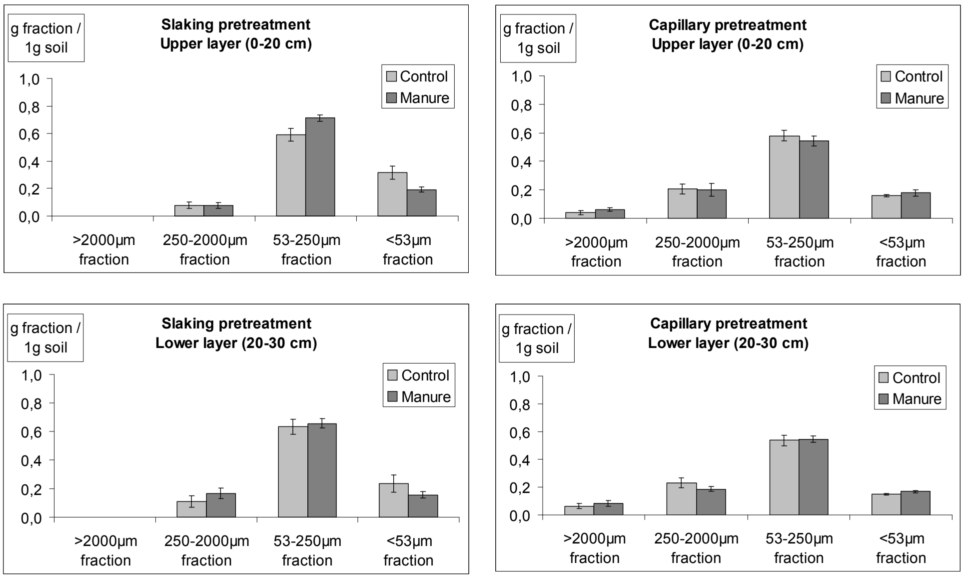

Figure 1-4. Size fractions (g fraction 1 g^{-1} soil, and the standard deviation at P>0.05) obtained by the different pretreatment methods of the investigated treatments in the upper (0-20 cm) and the lower (20-30 cm) depth layers.

Table 1. shows the changes in dry matter amount of fractions for the effect of farmyard manure treatment (in the % of the Control treatment).

Table 1. Changes in dry matter amount of fractions as the result of farmyard manure treatment (in the % of the Control treatment)

Pretreatment	Layer	>2000 µm fraction	250-2000 µm fraction	53-250 µm fraction	<53 µm fraction
Slaking (S)	Upper (0-20cm)	0	-1.84	20.87	-39.02
	Lower (20-30cm)	0	50.36	3.76	-33.80
Capillary (C)	Upper (0-20cm)	51.08	-1.96	-6.06	11.86
	Lower (20-30cm)	30.73	-19.16	1.24	11.73

In the case of Slaking (S) pretreatment incorporation of farmyard manure has changed the ratio of the 53-250µm microaggregate fraction (+20.87%) and the <53µm silt and clay fraction (-39.02%) in the upper layer. The changes of the lower layer were not significantly different. The amount of >2000µm large macroaggregate fraction was negligible in both depths. In the lower layer the amount of 250-2000µm small macroaggregate fraction has grown with 50.36%, but this data is questionable because of the high standard deviation.
In the case of Capillary (C) pretreatment changes caused by farmyard manure addition is less well pronounced, namely they are not significantly different at the $P > 0.05$. The >2000µm large macroaggregate fraction has grown with 30.73% in the lower layer and with 51.08% in the upper layer. The 250-2000µm small macroaggregate fraction has decreased by 19.16% in the lower layer, but significantly has not changed in the upper layer. The 53-250µm microaggregate fraction has not changed significantly in either layer. The <53µm silt and clay fraction has increased with 11.73% in the lower and with 11.86% in the upper layer.

Conclusions

Two different pretreatment methods were investigated by wet sieving. According to our results contrary to the higher disrupting effect of the Slaking (S) pretreatment, this method was more sensitive to the changes of the water-stability of aggregates caused by addition of farmyard manure. Despite the total disruption of >2000µm large macroaggregate fraction, significant different changes were indicated in the 53-250 µm microaggregate fraction and the <53 µm silt and clay fraction. The adding of farmyard manure has increased the amount of microaggregate fraction (+20.87%) and decreased the <53 µm silt and clay fraction (-39.02%) in the upper layer. The explanation of these results is that addition of farmyard manure stimulates the activity of microbes, which produce mucilage substrates. Therefore mineral particles are bound together making aggregates and the water-stability of existing aggregates increases. The amount of >2000µm large macroaggregate fraction was negligible in both depths because the binding agents of this fraction are more soluble, therefore could not withstand the high disruptive force. In the lower layer the increase of 250-2000µm small macroaggregate fraction is well pronounced (+50.36%) but it is questionable because of the high standard deviation. This is the result of the pretreatment, because the >2000µm large macroaggregates dispersed into smaller macroaggregates.
The Capillary (C) pretreatment changes caused by farmyard manure addition is less well pronounced, namely they are not significantly different at the $P>0.05$. These results are

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surprising, because of the less disruptive force higher differences in the water-stability were excepted. Remarkable are the changes in the amount of the >2000μm large macroaggregate fraction. In contrast to the Slaking (S) pretreatment, with this method the amount of this fraction was sizeable. It has increased with 30.73% in the lower layer and with 51.08% in the upper layer compared to the control treatment. Increase of the >2000μm large macroaggregate fraction, the 250-2000μm small macroaggregate fraction was less (with 19.16% in the lower layer), because more large aggregate remained intact to the effect of the less disruptive force. The amount of 53-250μm microaggregate fraction has not changed in consequence of the addition of farmyard manure. The <53μm silt and clay fraction has grown with ≈12% in both depths.
Summing up our results: appropriate detection of aggregate-stability with this new method is hopeful. Further investigations are needed to finish it with the sand correction, and to investigate other different factors affecting water-stability of aggregates.

Acknowledgements
This research was supported by the grant 'Precision agriculture' (OTKA TS 049875) from the Hungarian Scientific and Technology Fund. We would like to thank to Dr. Tamás Kismányoky and Dr. Sándor Hoffmann to let us the sampling permitted. We gratefully thank Dr. Zoltán Tóth, Mr. Tamás Zsittyán, Mr. László Radimszky and Mr. László Ködöböcz for their efficient and essential support at sampling.

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