EFFECT OF CULTIVATION SYSTEMS ON THE DISTRIBUTION OF SOIL ORGANIC MATTER IN DIFFERENT FRACTIONS

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Introduction

The most important function of agriculture is to supply food for the population. This role is permanently endangered by the degradation of soil structure and the loss of organic matter. This is the reason why it is substantial to preserve the soil organic matter, because carbon is the most important element of food chain. Some tillage operations may decrease the total soil organic matter (SOM), but detailed changes for different SOM fractions are less well known. Individual SOM fractions may be more sensitive indicators to the changes in management than total organic C (OC) and N. SOM fractions can be isolated and measured by physical fractionation of soil (Cambardella et Elliott (1992), Janzen et al. (1992)). SOM can be protected in aggregates, but conventional or intensive tillage can cause the disruption of these aggregates (Cambardella et Elliott (1994)) which causes loss of OM. Six et al (2000a) found that tillage causes a decrease of C-rich macroaggregates (>250 μm) and a decrease of C-depleted microaggregates (53-250 μm). Under no-tillage the degradation of macroaggregates is diminished, so tillage-resistant microaggregates can be formed, inside of which OM can be stabilized.

In this study we investigated the effect of different tillage treatments compared to a conventionally tilled soil on the OM distribution over several SOM fractions, in order to develop tillage systems for the optimisation of soil carbon cycle.

Keywords: *soil aggregate, organic matter, physical fractionation, tillage*

Methods

Site Description

The soil samples originate from the Józsefmajor field experiment in Hungary (Birkás & Gyuricza (2004)). The investigated soil type is a clay loam textured Lime Chernozem. Four different tillage treatments have been investigated: one no-tillage (Direct Drilling (DD)), two reduced-tillage treatments (Disking (D), Disking + Loosening (D+L)) and as a reference, one conventional tillage treatment (Ploughing (P)). Soil samples were taken from two different depth layers (0-10 cm and 10-20 cm) according to the two most important ranges of plant root nutrient uptake in 2005, three years after setting up the experiment.

Physical fractionation of soil organic matter

Microaggregates consist of decomposition protected OM forms, fine sand, silt and clay. Decomposition unprotected OM forms, coarse and fine sand, silt and clay are found outside of microaggregates but inside of macroaggregates. We measured the quantity of carbon-protecting microaggregates and the ratio of differently protected OM in the soil depending on the tillage treatment. Firstly, microaggregates were separated according to their particle-size with physical fractionation (i.e. wet sieving) (Six et al. (2000a)). Secondly, the mineral-associated OM was separated by density flotation (Six et al. (1998)) from those OM forms that do not have any significant association with mineral particles. Finally, we obtained five soil dry matter (DM) fractions, which contained minerals and OM. There are two fractions of unprotected OM (Coarse sand + Coarse free POM (POM: particulate OM: <53μm) and Light fraction (Fine free POM)), two fractions of protected OM (mineral-associated OM (Heavy fraction <53μm) and intra-microaggregate POM (Heavy fraction >53μm)) and a fifth fraction that contains only minerals (Silt + clay fraction).

Results and discussion

Figure 1 shows the amount of soil dry matter in the isolated fractions for each tillage treatment and depth layer.

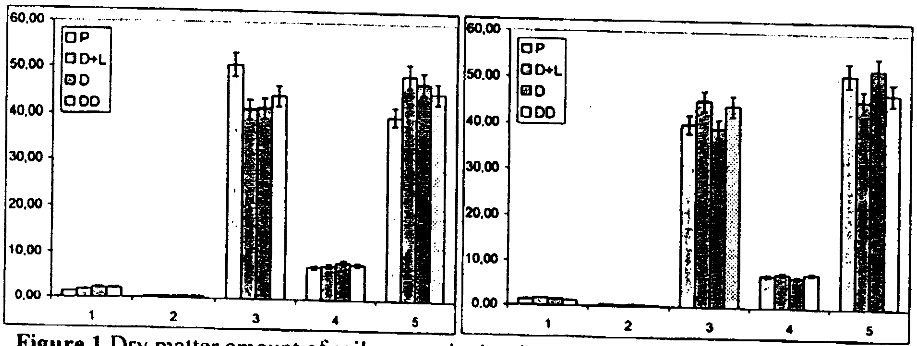

Figure 1 Dry matter amount of soil present in the size and density fractions (g 100 g^{-1} soil, and the standard deviation at P>0.05) obtained by the physical fractionation of the different tillage treatments in the 0-10 cm (left) and the 10-20 cm (right) depth layers. (1: Coarse sand + Coarse free POM; 2: Light fraction (Fine free POM); 3: Heavy fraction <53μm (mineral-associated OM); 4: Heavy fraction >53μm (intra-microaggregate POM); 5: Silt + clay fraction;
P: Ploughing; D: Disking; D+L: Disking + Loosening; DD: Direct Drilling)

For the 0-10 cm depth layer, the largest amount of the Coarse sand and coarse free POM fraction was measured for the D treatment (2.25%), because crop residues rested in the upper layer caused by the low cultivation depth. The least amount of this fraction presented after P (1.45%), because this way of tillage turns the crop residues onto the bottom of the cultivated layer, therefore the more decomposed below-ground layer gets onto the surface, which is lack of fresh, big grained OM. In the 10-20cm layer this fraction was the largest in the case of D+L (1.72%), probably because the 40cm cultivation depth of L carried a part of the crop residues into this depth. Least of this fraction in the deeper layer was found in the case of DD (1.18%), possibly because crop residues were not mixed to this depth by DD.

The largest amount of Fine free POM was present in the upper layer in the case of D (0.61%), because the low cultivation depth does not mix crop residues to the deeper layer. This fraction was the least in the case of ploughing (0.46%), possibly because some parts of the crop residues have been mixed to underlying soil layers and because of the aeration of soil due to tillage which increases the decomposition of this relatively unprotected OM. No clear trend of the effect of tillage operations on the amount of DM in this free POM fraction could be found for the 10-20 cm depth layer.

For the 0-10 cm depth layer, the mineral-associated OM, silt and clay fraction (<53μm heavy fraction) was highest for the P (50.08%) treatment, followed by DD, D and D+L. Six et al. (2002) claimed that the protection of OM by aggregation in less disturbed soils leads to an accumulation of more labile C, but increase of stable C needs longer time. This is the reason why the DM of this fraction was always less in the other treatments compared to P. In the 10-

20 cm depth layer this fraction was more in the case of D+L (45.02%) and DD (44.03%) than P.

For the 0-10 cm depth layer, the intra-microaggregate POM and fine sand fraction (>53μm heavy fraction) was highest for the D (8.43%) treatment, followed by DD, D+L and P. These results clearly indicate an accumulation of intra-microaggregate POM as a consequence of the reduction of soil disturbance under reduced or no-tillage management. A similar trend was found for the 10-20 cm depth layer, but effects of tillage management were less pronounced.

Summing up the microaggregate sized fractions (Light and both Heavy fractions), and the microaggregate-building fractions (the <53μm and >53μm heavy fraction) the cumulated amount of DM was the highest in the 0-10 cm layer for P, followed by DD, D and D+L. The order of the microaggregate sized fractions can be explained with the fact that P causes the most intensive macroaggregate disruption, thus causes the most intensive microaggregate emission. Moreover, the order of the treatments demonstrates the supporting effect of reduced tillage on the microaggregates' formation. In the 10-20 cm layer this fraction has been measured in the order D+L, DD, P and D, which does not demonstrate a trend explainable with the reasons mentioned above. In the 10-20 cm layer the microaggregate-building fraction has been measured in the order D+L, DD, P and D. These orders followed those of the microaggregate-sized fractions, because the DM of the Light fraction (Fine free POM) was so low, that its value did not influence the final results.

Conclusions

These preliminary results indicate that conventional tillage by frequently disturbing the soil structure and making more intensive aerobic microbial breathing decreases OM in soils.

In the surface layer an increasing trend can be realised in the amount of protected OM fractions in the order D+L < D. DD caused less DM of the OM fractions than the two other more OM-decomposing tillage (D+L; D). Furthermore all the three reduced tillage caused less DM of the mineral-associated OM fraction than P, which is the most aggregate disturbing tillage. A similar trend can be realised in the unprotected OM fractions in the surface layer. The differences are that these forms of OM are more than were measured in P. In the subsurface layer the unprotected OM forms were in the highest DM amount in D+L. The protected OM fractions were in the highest DM amount in D+L. Further studies are needed for the optimisation of tillage for decreasing the loss of the most important food chain element from the soil.

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