There Are no Differences in Soil Carbon Storage Between Inversion Tillage and Reduced Tillage Systems in Medium-term Experiments in the UK

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Introduction

By inverting the soil, mouldboard ploughing changes many soil properties including bulk density, aeration, drainage, thermal regimes, and the soil biology. These changes, together with the break up of plant residues, may expose previously protected organic matter to oxidation and potentially release CO_2 (Sun et al., 2011). Reduced tillage, through either no till or non-inversion tillage to shallower depths, may limit CO_2 release and help increase the store of carbon in the soil. However, the positive effects of reduced tillage may have been overestimated due to a sampling bias towards the soil surface, the reporting of soil carbon as a concentration without taking into account bulk density, the effect of stone content and the length of time the management practices have been in place.

The objective of this study was to assess the impacts of five tillage treatments on the content and depth distribution of carbon in soils from medium-term experimental plots in the UK.

Materials and Methods

Experimental plots were located in three sites with contrasting soil textures in the UK (STAR, NFS and Mid-Pilmore). The treatments had been in place for between 6-10 years and were, mouldboard ploughing to 20 cm and disking (P), no till (N), min till by shallow non-inversion tillage to a depth of 7 cm (M), compaction by ploughing to 20 cm followed by wheeling with a 8.8 Mg total load (C) and deep plough to 25 cm (D). Soil samples were taken in August 2013 at 5 intervals to a depth of 60 cm. Total carbon was determined on ball-milled soil using a Thermo Flash EA 1112 Elemental Analyser. Statistical analyses were performed with GenStat 18th edition using ANOVA and REML with least significant differences (LSD) at $P<0.05$.

Results and discussion

Bulk density was not significantly affected by tillage treatment in any of the sites. The interaction treatment x depth was significant at Mid-Pilmore. The surface soil of the P treatment had greater bulk density than the M treatment. There were no differences in carbon content between treatments at either the STAR or NFS sites. In Mid-Pilmore, there was greater carbon content in the P treatment compared to the M and N treatments. Carbon content was greater in the surface layers in STAR and NFS. In Mid-Pilmore, the greatest carbon content occurred below the plough layer (Figure 1). The interaction treatment x depth was not significant in STAR and Mid-Pilmore. In NFS, there was greater carbon content in the surface of the D and M treatments compared to the P. These differences in carbon distribution would not be apparent if sampling had been confined to the 20 cm depth of the plough layer alone. The disregard of bulk density in measuring soil carbon has been highlighted by many researchers, but another neglected component of soil that may bias results, is stone content (i.e. > 2 mm). Adjusting bulk density for stone content in Mid-

Pilmore did not change the main conclusion of greater carbon content in the P treatment, but it changed the significance of the treatment x depth interaction. This resulted in the P treatment showing greater carbon content at and immediately below the depth of ploughing compared to the M and N treatments. The C treatment also showed greater carbon content than the M and N treatments at the plough layer. In the sub-soil, the C treatment had lower carbon content than all other treatments. The accumulation of carbon at the plough layer with inversion tillage is a common observation (Gal et al., 2007) and it is attributed to the turning down of crop residue during ploughing. Although our results show no advantages of using reduced tillage for soil carbon storage, there may be other benefits not investigated in this study. For example, the accumulation of SOC in the soil surface with reduced tillage, may increase aggregate stability lowering the risk of erosion and run-off. Other potential benefits include increased water retention, biological activity and nutrient cycling in the soil surface. The preparation of the land is faster and less energetically demanding due to fewer passes, allowing sowing at an optimum time. This is important in the UK where farmers often have a narrow window of opportunity to establish the following crop (Morris et al., 2010). The amount of fuel used in comparison to conventional tillage should also be taken into consideration when assesing the overall advantages of reduced tillage.

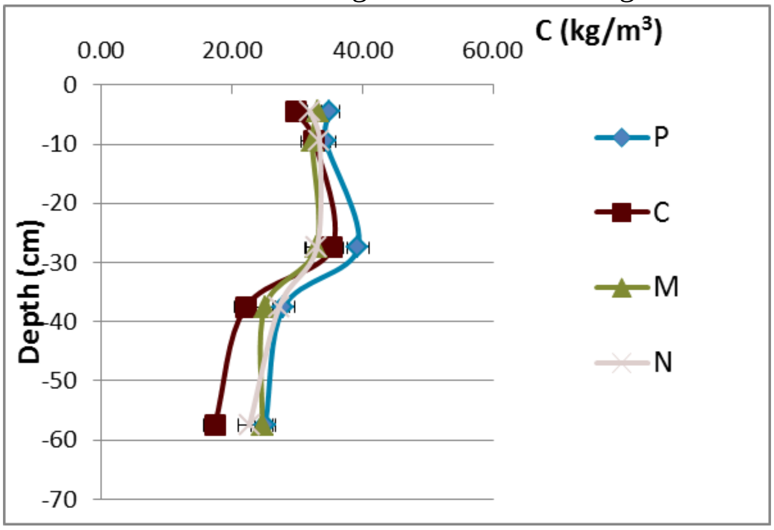

Figure 1: Carbon content by soil depth and tillage treatment in Mid-Pilmore, Scotland, UK.

Conclusions

Carbon content was either not affected by tillage treatment (NFS and STAR) or was greater in conventional inversion tillage than in the reduced tillage systems (Mid-Pilmore). Bulk density at the time of sampling was also not affected by tillage treatment in NFS and STAR. In Mid-Pilmore, the reduced tillage systems showed higher bulk densities than the inversion treatments in the subsoil. We demonstrated that neglecting stone content when quantifying carbon storage in soils can result in considerable differences, so it is important to include. Our results suggest that in the medium term in the UK, reduced tillage practices cannot be recommended as a carbon storage practice, when a soil profile of 60 cm is taken into account.

References

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