Geophysical Research Abstracts
Vol. 17, EGU2015-10657, 2015
EGU General Assembly 2015

Influence of cover crops and crop residue treatment on soil organic carbon stocks evaluated in Swedish long-term field experiments

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Soil organic carbon (SOC) stocks in agricultural soils are strongly controlled by management. In this study we quantified the effect of cover crops and crop residue management on SOC stocks in Swedish long-term experiments.

Eight pairs of cover crop (undersown ryegrass) vs. no cover crop were investigated in Swedish long-term field experiments (16 to 24 years). Yields of the main crop were not affected by the cover crop. Cover crops significantly increased SOC stocks, with a mean carbon sequestration rate in all experiments (excluding one) of 0.32 ± 0.29 Mg C ha-1 yr-1. Interestingly, this sequestration is similar to that estimated for a U.S.experiment, where ryegrass growth is much less temperature- and light-limited than under Swedish conditions. This sequestration rate is also the same as that recently reported for many other cover crops in a global meta-analysis but less than SOC changes in ley-dominated rotations which under Nordic conditions were shown to accumulate in average 0.5 Mg C ha-1 yr-1 more carbon compared to exclusively annual cropping systems. Thus, originally introduced in agricultural rotations to reduce nitrate leaching, cover crops are also an effective practice to increase SOC stocks, even at relatively high latitudes.

The effect of crop residue treatment was studied in 16 pairs of straw incorporated (SI) vs. straw removed (SR) treatments in six Swedish long-term field experiments. Data series on SOC with 5-28 sampling dates during 27-53 years were analysed using ICBM, a dynamic SOC model. At five out of six sites, the humification coefficient for straw (hlitter; the fraction of straw C that is entering the slow C pool) was much smaller (0–0.09) than the ICBM default h-value for plant material estimated in previous studies (0.125). The derived hlitter-values and thus the stabilization of straw-derived carbon increased significantly with clay content. For an Italian site (with five pairs of SI vs. SR) that was used for model validation we found the best model fits with hlitter-values ranging from 0 to 0.05, increasing with nitrogen fertilization. We explained this with increased substrate use efficiency of microbes due to increasing N availability.

We conclude that i) the efficiency of incorporating straw to increase SOC stocks depends on soil texture and nitrogen availability, ii) using straw for bioenergy production could be a more sustainable and climate-smart option, especially in coarse textured soils, and iii) the introduction of cover crops may be a more efficient strategy for C sequestration in cereal-dominated rotations rather than incorporation of crop residues.