Geophysical Research Abstracts
Vol. 17, EGU2015-12255, 2015
EGU General Assembly 2015

Carbon balance of renovated grasslands: input- or output-driven?

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Temperate grasslands constitute over 30% of the Earth's naturally-occurring biomes and make an important contribution towards the partial mitigation of anthropogenic greenhouse gas emissions by terrestrial ecosystems. In permanent temperate grasslands, biomass production and sward quality can deteriorate over time and periodic renovation activities, involving soil tillage and reseeding, are commonly carried out to halt this decline. Long-term cultivation of agricultural land has been associated with soil aggregate degradation and reduced soil carbon storage. However, the impact of these single tillage disturbances on C cycling in grasslands is less clear.

This study evaluated gaseous and dissolved organic carbon (DOC) losses following a single tillage event by subjecting grassland lysimeters with contrasting soil drainage characteristics to simulated conventional inversion or minimum tillage. Field-scale CO_2 emissions after conventional tillage were also quantified and empirically modelled over short- and medium-term timeframes to delineate the ecosystem response to environmental variables.

Soil moisture was the limiting determinant of ecosystem carbon release following conventional tillage. Freshly-tilled soils were associated with reduced water retention and increased sensitivity to soil moisture, which was particularly pronounced following rewetting events. Significantly elevated but ephemeral CO_2 effluxes were detected in the hours following inversion ploughing, however tillage disturbance did not generate significantly enhanced C emission rates in the medium term. Equally, DOC losses were not significantly amplified by conventional tillage compared with conservative minimum tillage and were predominantly controlled by soil drainage across tillage regimes. Our results suggest that a net ecosystem source of 120 to 210 g C m-2 over an approximately two-month period was most likely a consequence of reduced productivity and C input rather than enhanced soil CO_2 evolution. C emissions from cultivated lands will therefore be minimised by restricting tillage operations and fallow periods to spring or autumn when respiratory losses are reduced and by limiting the length of the fallow period to enhance the compensatory effect of photosynthetic C uptake.