Geophysical Research Abstracts
Vol. 15, EGU2013-10679, 2013
EGU General Assembly 2013

Greenhouse Gas Emissions Associated With Establishing Energy Crops

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Land-use change to biomass crop production can contribute towards meeting both national and international renewable energy and emissions targets. As a carbon-neutral fuel stock, these crops have the capacity to mitigate GHG emissions through the substitution of fossil fuels. However, studies have also provided evidence of carbon sequestration in vegetative and soil reservoirs in these ecosystems. Realisation of this mitigation potential is, however, dependent on suitable crop selection and thorough assessment of the emissions and sinks associated with biomass crop cultivation.

The aim of this research was to assess the GHG implications of land-use change to biomass crops by quantifying carbon dioxide (CO_2) and nitrous oxide (N2O) emissions both during the initial land conversion phase and in the newly-established plantations. Field-scale stands of Miscanthus $\times$ giganteus and Reed Canary Grass (RCG; Phalaris arundinacea) were established on land previously under permanent pasture in 2009 and 2010 respectively in the south-east of Ireland. CO_2 uptake and release was measured at the ecosystem scale by two open path eddy covariance systems, while N2O fluxes before and after cultivation were sampled using the static chamber technique.

Short-term tillage-induced carbon emissions were found to be high immediately after ploughing but transient in nature, reducing to background levels within a matter of hours. Results suggest that longer term losses could be limited to approximately 2 t CO_2 ha-1 provided the fallow period is minimised. A more sustained release of N2O was observed after soil cultivation, resulting from increased availability of organic N for mineralisation by soil microbes. Development was initially slow in the Miscanthus stand, however by the third year, the crop had begun to mature and had switched from a net GHG source in the first year of establishment to a net sink of over 10 t CO_2 ha-1 yr-1. More rapid establishment of RCG facilitated the development of a dense canopy in its first year and correspondingly high net CO_2 uptake, which increased further in the second year to a value close to that of year-3 Miscanthus. However, continued development of the Miscanthus crop to full maturity and maximum biomass yields is expected to enhance further the superior GHG sink strength of Miscanthus relative to RCG. This research highlights the high GHG efficiency of perennial biomass crops, which, combined with fossil fuel displacement during combustion, may present opportunities in the future for offsetting emissions in the agricultural sector.