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Calculating carbon budgets for agricultural crops

A new study has combined measurements of carbon dioxide (CO_2) fluxes with estimates of other greenhouse gas (GHG) emissions from farming operations for 15 European crop sites over several years. It estimated that the sites lost on average 138g of carbon per m^2 per year. The total GHG balance (including non-CO_2 emissions) was equivalent to an average carbon loss of 203g of carbon per m^2 per year.

Land can emit or absorb carbon and the full carbon budget determines whether land is a sink or source of CO_2. Agriculture affects GHG emissions by disturbing the soil and removing part of the crop, but also through fuel used by machines, fertiliser production and use, as well as irrigation.

The study, conducted under the EU CarboEurope-IP project[1] calculated the net ecosystem carbon budgets (NECBs) of 15 European crop sites. NECB is the sum of 1.) the net ecosystem production (NEP), i.e. the CO_2 exchange between atmosphere and land which was measured with the eddy covariance method and, 2.) carbon input (gain) as organic fertiliser (manure, sugar beet lime), seeds or tubers and 3.) carbon exported (loss) in the biomass at harvest or during fire.

The net ecosystem carbon budget is positive when more carbon is lost than gained, and negative when more carbon is gained than lost, i.e. soil carbon is accumulated. Researchers also estimated the emissions from field operations, such as fuel for machinery and N_2O emissions caused by fertiliser application. Adding those emissions to the NECB allowed the annual GHG budget to be calculated at each site.

There was a large range in NECBs, spanning from -258 g of carbon per m^2 per year for a rice crop in Spain, to 645 g of carbon per m^2 per year for a combined fennel and maize crop in Italy. 70 per cent of the sites had net losses, i.e. carbon removed by harvest was higher than the sum of NEP and carbon inputs. The rice crop had the most negative NECB (biggest carbon gain), even when methane emissions were considered. This could be due to the water covering the ground, which reduces respiration (production of CO_2) by the soil.

At the other end of the scale, the bi-annual harvesting of the maize and fennel crop meant a high carbon removal and therefore a high positive NECB. Pea and sunflower crops also had a high NECB (400g per carbon per m^2 per year). The short growing season means that there are long periods of bare soil or limited vegetation cover which increases net annual carbon loss in the absence of photosynthesis.

The contribution to emissions from field operations represented only 7.6 per cent of the total GHG budget. On average, emissions caused by fertilisers represented 76 per cent of emissions from field operations.

The study makes some recommendations for farmland management. For example, reducing the amount of fertilisers and pesticides could slightly improve the GHG budget and reducing periods of bare ground (periods without growing vegetation) could significantly improve the crops' GHG budget -use of intercropping or change in crop rotations could therefore be considered.

Again, GHG budgets varied dramatically for different crops, management regimes and sites. Therefore more long-term study is needed, in particular to assess the effect of different management regimes for each crop species, in order to provide specific estimations of budgets per crop and management regimes to inform policy.

1. CarboEurope-IP was supported by the European Commission under the Sixth Framework Programme. See: www.carboeurope.org

Source: Ceschia, E., Béziat, P., Dejoux, J.F. *et al.* (2010) Management effects on net ecosystem carbon and GHG budgets at European crop sites. *Agriculture, Ecosystems and Environment.* 139:363-383.
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