Management effects on net ecosystem carbon and GHG budgets at European crop sites

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The greenhouse gas budgets of 15 European crop sites covering a large climatic gradient and corresponding to 41 site-years were estimated. The sites included a wide range of management practices (organic and/or mineral fertilisation, tillage or ploughing, with or without straw removal, with or without irrigation, etc.) and were cultivated with 15 representative crop species common to Europe. At all sites, carbon inputs (organic fertilisation and seeds), carbon exports (harvest or fire) and net ecosystem production (NEP), measured with the eddy covariance technique, were analysed. The variability of the different terms and their relative contributions to the net ecosystem carbon budget (NECB) were assessed for all site-years, and the effect of management on NECB was assessed. To account for greenhouse gas (GHG) fluxes that were not directly measured on site, we estimated the emissions caused by field operations (EFO) for each site using emission factors from the literature. The EFO were added to the NECB to calculate the total GHG budget (GHGB) for a range of cropping systems and management regimes. N₂O emissions were calculated following the IPCC (2007) guidelines, and CH₄ emissions were estimated from the literature for the rice crop site only. At the other sites, CH₄ emissions/oxidation were assumed to be negligible compared to other contributions to the net GHGB. Finally, we evaluated crop efficiencies (CE) in relation to global warming potential as the ratio of C exported from the field (yield) to the total GHGB. On average, NEP was negative (-284 ± 228 g C m⁻² yr⁻¹), and most cropping systems behaved as atmospheric sinks, with sink strength generally increasing with the number of days of active vegetation. The NECB was, on average, 138 ± 239 g C m⁻² yr⁻¹, corresponding to an annual loss of about 2.6 ± 4.5 % of the soil organic C content, but with high uncertainty. Management strongly influenced the NECB, with organic fertilisation tending to lower the ecosystem carbon budget. On average, emissions caused by fertilisers (manufacturing, packaging, transport, storage and associated N₂O emissions) represented close to 76% of EFO. The operation of machinery (use and maintenance) and the use of pesticides represented 9.7 and 1.6% of EFO, respectively. On average, the NEP (through uptake of CO₂) represented 88% of the negative radiative forcing, and exported C represented 88% of the positive radiative forcing of a mean total GHGB of 203 ± 253 g C-eq m⁻² yr⁻¹; Finally, CE differed considerably among crops and according to management practices within a single crop. Because the CE was highly variable, it is not suitable at this stage for use as an emission factor for management recommendations, and more studies are needed to assess the effects of management on crop efficiency.