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The potential of agricultural practices to increase C storage in cropped soils: an assessment for France

Claire Chenu (1), Denis Angers (2), Aurélie Métay (3), Caroline Colnenne (4), Katja Klumpp (5), Laure Bamière (4), Lenaic Pardon (6), and Sylvain Pellerin (7)

(1) AgroParisTech, France (chenu@grignon.inra.fr), (2) Agriculture and Agri-Food Canada, Québec Canada, (3) Supagro Montpellier, France, (4) INRA Grignon, France, (5) INRA Clermont, France, (6) INRA Paris, France, (7) INRA Bordeaux, France

Though large progress has been achieved in the last decades, net GHG emissions from the agricultural sector are still more poorly quantified than in other sectors. In this study, we examined i) technical mitigation options likely to store carbon in agricultural soils, ii) their potential of additional C storage per unit surface area and iii) applicable areas in mainland France.

We considered only agricultural practices being technically feasible by farmers and involving no major change in either production systems or production levels. Moreover, only currently available techniques with validated efficiencies and presenting no major negative environmental impacts were taken into account. Four measures were expected to store additional C in agricultural soils:
- Reducing tillage: either a switch to continuous direct seeding, direct seeding with occasional tillage once every five years, or continuous superficial (<15 cm) tillage.
- Introducing cover crops in cropping systems: sown between two cash crops on arable farms, in orchards and vineyards (permanent or temporary cover cropping) .
- Expanding agroforestry systems; planting of tree lines in cultivated fields and grasslands, and hedges around the field edges.
- Increasing the life time of temporary sown grasslands: increase of life time to 5 years.

The recent literature was reviewed in order to determine long term (>20yrs) C storage rates (MgC ha-1 y-1,) of cropping systems with and without the proposed practice. Then we analysed the conditions for potential application, in terms of feasibility, acceptance, limitation of yield losses and of other GHG emissions.

According to the literature, additional C storage rates were 0.15 (0-0.3) MgC ha-1 y-1 for continuous direct seeding, 0.10 (0-0.2) MgC ha-1 y-1for occasional tillage one year in five, and 0.0 MgC ha-1 y-1 for superficial tillage. Cover crops were estimated to store 0.24 (0.13-0.37) MgC ha-1 y-1 between cash crops and 0.49 (0.23-0.72) MgC ha-1 y-1 when associated with vineyards. Hedges (i.e 60 m ha-1) stored 0.15 (0.05-0.26) Mg C ha-1 y-1. Very few estimates were available for temperate agroforestry system, and we proposed a value of 1.01 (0.11-1.36) Mg C ha-1 y-1for C stored in soil and in the tree biomass for systems comprising 30-50 trees ha-1. Increasing the life time of temporary sown grassland increased C stocls by 0.11 (0.07-0.22) Mg C ha-1 y-1.

In general, practices with increased C inputs to soil through additional plant biomass (agroforestry, hedges and cover crops) resulted in higher additional C storage rates, while the reduction of soil organic matter mineralisation through reduced tillage seemed less effective. When applied to the French agricultural sector, excluding areas with soils with major technical constraints or negative environmental consequences (e.g. poorly aerated soils with high N2O emissions), the measures considered here allowed to increase French soil C stocks by 0 to more than 1 Tg C y-1. However, our estimates are associated with high uncertainties, due to the high variability in soil C storage associated with pedo-climatic conditions and cropping systems, and on the very few studies available for some practices such as agroforestry under temperate conditions.