OPTIMISING THE CARBON SINK function of agricultural soils

Increasing carbon stocks in cropped soils can be achieved but requires the activation of several levers, including rotations, green covers during the intercropping season, soil cultivation and crop residue management.

Measures must be taken to reduce greenhouse gas emissions from agricultural activity, but, in addition, the global impact of CO_2 can also be reduced through storing ambient carbon dioxide in cropped soils.

One of the characteristics of plant production is that it captures and processes ambient carbon through photosynthesis. It is therefore a potential tool for storing carbon and reducing the quantity of greenhouse gas (GHG) emitted, if the captured carbon is partly stored in the soil through plant residue incorporation. Through their organic matter, agricultural soils contain two to three times more carbon than ambient air.

In arable crops, carbon capture is directly linked to photosynthesis, and therefore to the amount of biomass produced. In order for the carbon sink function to reach its potential, biomass production must first be enhanced, provided this does not involve increasing inputs which contribute to GHG emissions, and in particular nitrogen fertilisers.

This biomass production comes from associate plants, such as cover crops, as well as from the main crops. Leaf photosynthesis is key for increasing both plant biomass and grain yield. Producing more grain therefore goes hand in hand with producing more plant residue, which is incorporated into the ground to various extents. Once it has been transformed into humus, crop residue helps to store carbon and preserve or increase the amount of organic matter in the soil.

Favourable cropping practices

Green covers and crop residue incorporation are the two main action levers available to make an impact on soil carbon storage. A cover crop stores around 0.24 t of C/ha/year (GHG studies: INRA, Pellerin et al., 2013). Contrary to popular belief, in France, less intensive soil cultivation, as such, does not affect soil carbon storage compared with ploughing *(insert)*. However, it helps to increase the growth period of cover crops in cases where ploughing at the end of winter is not feasible for agronomic reasons, which in turn helps to produce more biomass. Consequently, cropping programmes that include permanent soil coverage increase CO_2 capture at field level and, in theory, help to increase the soil's organic matter content.

The choice of rotation also plays a role. The level of return of nutrients to the soil differs from one crop to another depending on their intrinsic production level, and the practices used (for example, whether wheat straw is removed or not). Likewise, the input of by-products, depending on their nature, must be taken into account, and in particular those classified as organic enrichment, which is the case for many composts.

In livestock farming, the carbon storage function under pastures plays a very important role. Annual storage is around 0.7 t of C per ha (Klumpp K, 2015). Some practices help maximise this fixing

phenomenon. They include avoiding cultivating permanent pastures, prolonging the life cycle of temporary ones, and preserving hedges bordering fields.

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Biomass as an alternative to products from fossil origin

Each year in France, arable crops capture around 250 Mt of CO_2 equivalent over 14 million hectares, which represents about ten times the amount emitted to produce them. Soil storage of part of this absorbed carbon is therefore a strategic decision. In France, work carried out as part of SYPPRE *(1)*, a project involving several institutes, has shown that carbon stocks in cropped soils can be increased, but that this requires the simultaneous activation of several levers, including rotations, green covers during the intercropping season, soil cultivation and residue management.
However, the impact of arable crops on GHG reduction goes much further: an increasingly large part of crop production also helps create "biosourced" products that can replace oil-based ones. This is why ARVALIS works on developing tools that help estimate biomass resources over a production area, combining all sources (harvested crop residue, industrial by-products, forestry products and by-products, organic by-products, etc.) and their different uses, or even potential conflictual uses (reincorporation into the ground, bedding for livestock, etc.). The first tool (CARTOFA) was developed in collaboration with the oil protein crops sector.

(1): Systèmes de Production Performants et Respectueux de l'Environnement (efficient and environmentally-friendly production systems).

2.1 t/ha/year: quantity of incorporated straw leading to the humification of 0.2 t C/ha.

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The impact of reducing soil cultivation is minimal

The analysis of data derived from one of the oldest long-term trials available (monitoring over 45 years at ARVALIS's Boigneville experimental farm, South of Paris) as well as from several international meta-analyses, and recently collated by INRA, shows that the main effect of changing soil cultivation practices, going from frequent ploughing to direct drilling, is the significant stratification of organic matter in the soil profile. It always results in increased carbon levels on the surface (0-10 cm), but also very often leads to decreased carbon levels further down (15-40 cm). Reducing soil cultivation hardly increases overall carbon stocks, if at all, even with direct drilling. Furthermore, if there is a slight increase, it is not irreversible and may be cancelled out in wet years, when organic matter tends to decompose on the soil surface. It has also been possible to demonstrate that going from direct drilling to ploughing, whether the latter is occasional or regular, does not massively depletes carbon stocks in the soil. Although there are good reasons for reducing soil cultivation in certain agronomical conditions, it does not necessarily lead to greater carbon sequestration. However, those techniques facilitate the generalisation of green covers, which, in turn, have a significant impact on carbon storage.