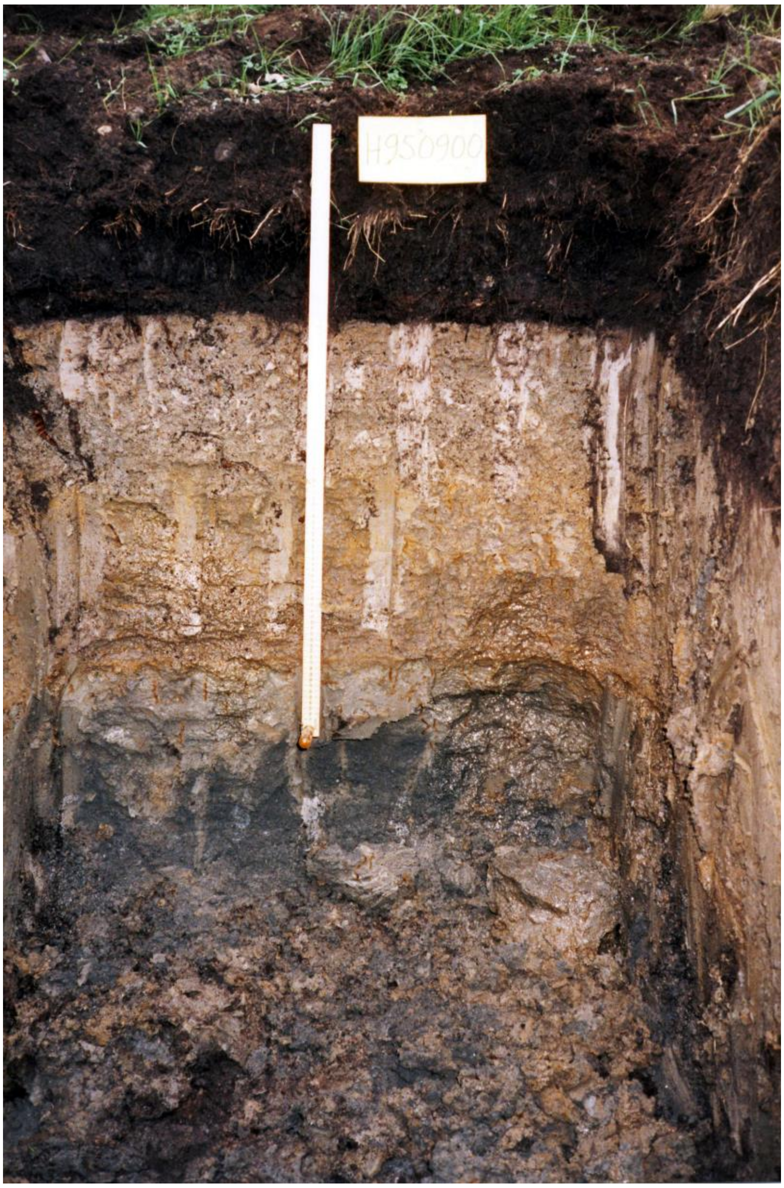
Sequestration Fact Sheet



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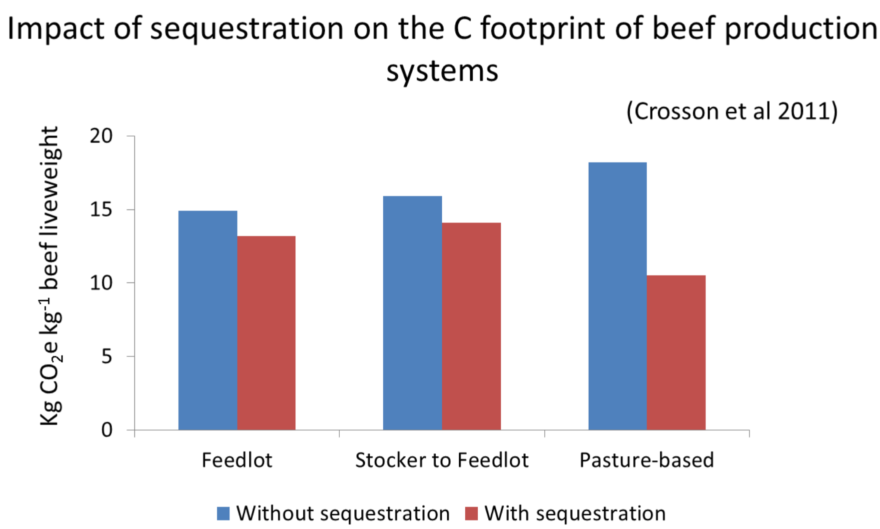
ABOUT SAI PLATFORM

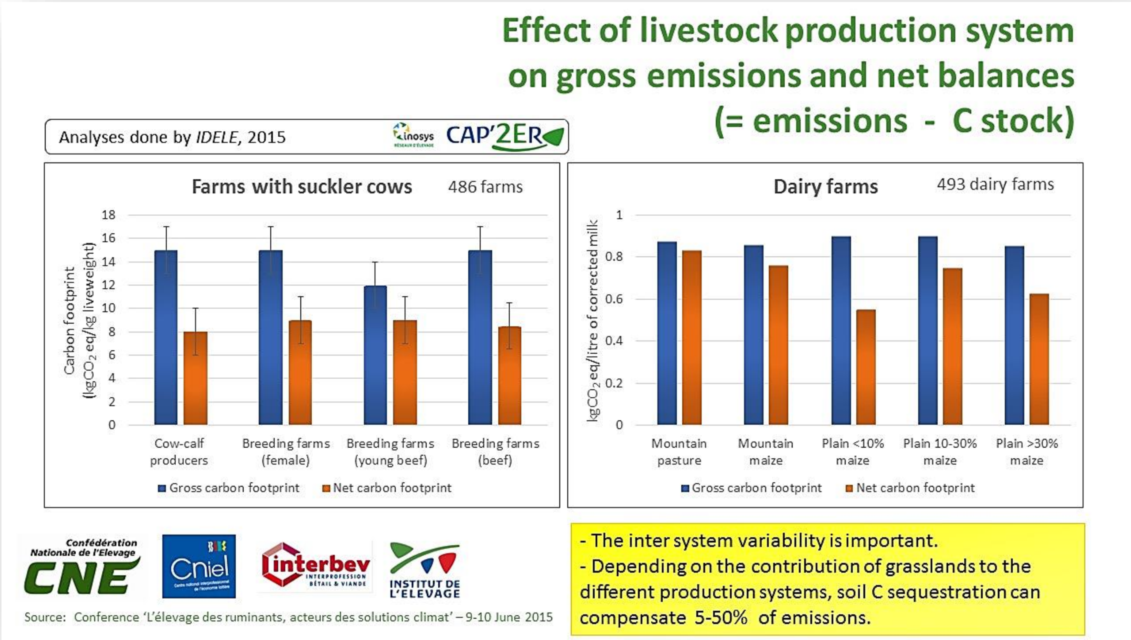
The Sustainable Agriculture Initiative (SAI) Platform (www.saiplatform.org) is the global industry initiative helping food and drink companies to source sustainably grown agricultural raw materials and achieve sustainable production. SAI Platform is a non-profit organization to facilitate sharing, at precompetitive level, of knowledge and best practices to support the development and implementation of sustainable agriculture practices involving stakeholders throughout the food value chain.

Why should I care about improving soil quality?

Good soil quality depends on a proper combination of physical (e.g. soil texture), chemical (e.g. soil pH) and biological (e.g. microbial diversity) properties. Conserving these properties is thus crucial for maintaining good soil health and high soil productivity. High grass yields in the long-term can be only maintained by soils which have the ability to store or sequester carbon (C) and nitrogen (N) in soil organic matter. The accumulation and/or conservation of organic matter in top-soils should be seen as a key management priority mainly because active C and N sequestration in soils determines greater soil fertility, which is then crucial to maintain long-term grassland productivity. Greater sequestration and conservation of C in soils represents an effective long-term insurance policy against climate variability and environmental change. Depending on climate region and management, carbon sequestration in soils can also 'offset' greenhouse gas emissions associated with livestock production. These emissions (methane and nitrous oxide) are difficult to reduce without affecting production. However, increasing sequestration provides more 'room' for the sustainable intensification of agriculture. Furthermore, it has been shown that by including grassland sequestration, the carbon footprint of milk and beef production for pasture-based livestock systems can be reduced by between 33%-50% (Crosson et al., 2011).



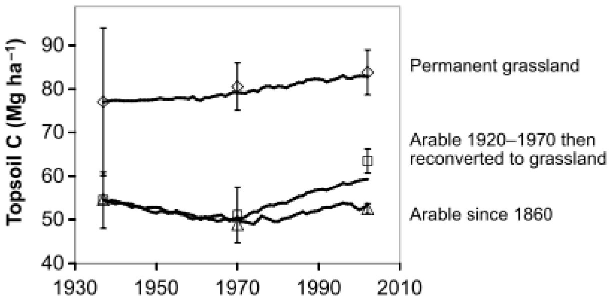
The role of organic matter in soil quality



Why does soil carbon matter for Climate Change? Because there is three times more carbon locked up in soil than in plants or the atmosphere combined. The build-up of soil organic matter is limited by photosynthesis, so increasing SOM is a slow process! The Soil Organic Matter (SOM) reservoir is not permanent but changes through time depending on the net balance between C inputs and losses from soils, which then depend on grassland management. SOM (and particularly organic C) status is important to maintaining good soil quality as it plays a pivotal role in both nutrient availability and soil resilience and physical structure. Basically, SOM acts as a key soil health indicator due to its influence on a host of chemical (e.g. minerals), biological (e.g. micro fauna, microbes) and physical soil properties. Good SOM levels will enhance biological activity, thus improving nutrient availability and soil fertility. Enhanced C sequestration in SOM occurs via the formation of different soil aggregates. The buildup of these aggregates greatly improves soil structure, enhancing infiltration rates, soil water-holding capacity and reducing the risk of soil erosion (water and wind) and nutrient loss.

What are the simple steps in improving soil quality

Because soil quality depends on different soil properties a first step would be to improve soil texture and bulk density by reducing frequent use of heavy machinery, or soil tillage or by avoiding very intensive herbage use resulting either from high stocking rates and/or frequent mowing. Soil biological properties (including the composition and function of soil microbes) could be improved by moderate applications of organic nutrients (animal slurry-manure), of lime (i.e. liming improves soil pH) and phosphorus (i.e. legume). Mixed grass-legume swards will also reduce the inputs of mineral fertilizer, thus maintaining yields and reducing input costs[1].



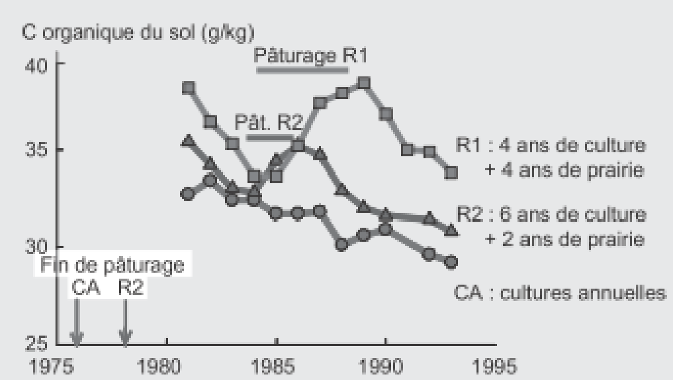


Figure 1 : **Effet à long terme des cultures annuelles et de 2 rotations cultures annuelles - prairie sur les teneurs en C organique dans un essai de longue durée en Argentine** (d'après Studdert *et al.*, 1997).

*Figure 1 : **Long-term effects of annual crops and 2 ley-arable rotations on organic C levels in a long-term experiment in Argentina** (after Studdert et al., 1997).*

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[1] Kätterer T, Bolinder MA, Berglund K, Kichmann H (2013), Strategies for carbon sequestration in agricultural soils in northern Europe. *Acta Agriculturae Scand Section A*, 62, 181-198.
Chabbi et al. (2015), Performances des rotations à base de cultures fourragères en termes de gaz à effet de serre (GES) et bilan de carbone. *Fourrages*, 223, 241-248.

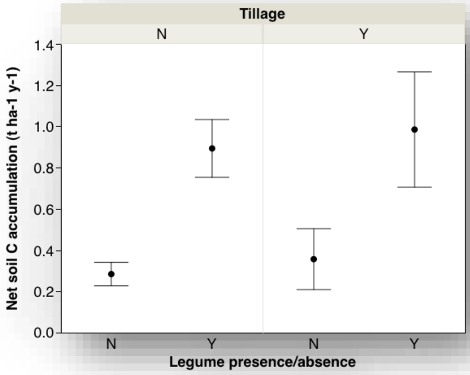

Figure 3. Dependence of net soil C accumulation (i.e. sequestration) to 20 cm soil depth (t C ha-1 yr-1) on legume presence/absence (Yes/No) and on the presence/absence of tillage applications (Yes/No).

Mean soil C accumulation was estimated using literature data from 15 research studies (88 experimental observations) conducted across different agro-ecosystems worldwide (Fornara, 2011).

Pastures influence in soil quality

Pastures play a key role in maintaining soil organic C stocks. The three and a half billion hectares of global pasture are estimated to absorb between 100 and 300 million tonnes of C each year. Temperate grasslands may sequester half a tonne of C per hectare per year. Organic matter levels are primarily influenced by plant productivity and the frequency and extent of disturbance (i.e. grassland ploughing and renovation). Pastures have higher organic matter levels than, say, croplands due to the fact that there is (a) no fallow period with bare soil, (b) soil disturbance is minimized, and (c) vegetation cover is diverse and perennial. This results in a high level of organic matter input from plant photosynthesis (i.e. due to a continuous vegetation cover), via plant litter (dead leaves and roots), allowing the formation of soil aggregates, which physically and chemically protect the organic matter that would otherwise be disrupted by ploughing. Inputs of organic matter from grazing animals and manure spreading also contribute to organic matter buildup in these systems. There is evidence to suggest that grazing pastures sequester more than pastures used for silage/hay production, due to the recycling of nutrients (C and N) by the animals.

What are the real benefits and when will they 'arrive'

The increased accumulation of C in soils brings multiple benefits: (1) promotes and sustains the formation of soil organic matter, (2) increases soil fertility because C binds to key nutrients such as N thus creating larger C and nutrient pools in soils, (3) improves soil structure and soil biogeochemical properties, (4) reduces soil erosion, and (5) maintains soils' ability to sustain quantity and quality of grass yields in the long-term. The benefits of having healthy soils with large organic C and N pools have been known for long time, the challenge now is to 'manage' and 'conserve' these soil C and N pools under increasing demand for plant and animal biomass production. Changes in grassland management - described below - may help stabilizing soil C pools in the short-term (1-3 years) and potentially contribute to soil C accumulation (at least in soil macro-aggregates) in 4-6 years.

What are the four key steps to improving soil quality?

Soil quality could be improved by achieving a ‘right’ balance between C and N inputs to soils. A combination of agricultural practices, which promote the formation of stable soil aggregates, will improve soil quality and sustainability.

1- In permanent grasslands (>5yrs) a key step would be to improve the management of fertilizing materials either organic or inorganic. A first step would be to combine liming treatments either with animal slurry applications (to improve pH and avoid acidification) or with inorganic nutrient fertilization (mainly potash and magnesium and limited N additions). In terms of temporary sown grasslands (<5yrs) and renovation via ploughing, a key step is to increase the time between re-seeding to at least five years, as this will contribute to an organic matter buildup though reduced tillage events.

2- A second step for both grassland types would be to increase the abundance of legume species in the grass sward (e.g. over-sowing, phosphorus application[2]); besides improving forage quality, legumes fix their own N and make it available to other plants. In combination with legumes, a more diverse vegetation cover (>4 species) make grasslands more persistent in terms of climate change, and may provide both a better forage quality and organic matter input.

3- A third step would be to reduce frequency of use of heavy machinery, which could cause high soil compaction and thus ‘reducing’ pore space available in the soil matrix, necessary to transport and accumulate extra C (via soil climate, macro fauna, earthworms, microbes, etc ...). Animal grazing is preferable compared to silage/hay production, due to the nutrient recycling of animals and the reduction in work (25 to 40% of ingested herbage is returned to the pasture in excreta).

4- Finally, the development of pasture management plans perhaps around a 5-7 year-cycle where a combination of different practices (liming, nutrients, grazing, re-seeding) guarantee balanced applications of C and N to soils under moderate (soil) disturbance (avoid high animal stock densities and intensive mowing). A soil-monitoring program including analyses of soil C and N content, soil bulk density and pH should be put in place and run every 2-3 years.

[2] Hogh-Jensen H., Schjoerring J.K. and Soussana J-F. (2002), The influence of phosphorus deficiency on growth and nitrogen fixation of white clover plants. *Annals of Botany*, 90, 745–753.

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