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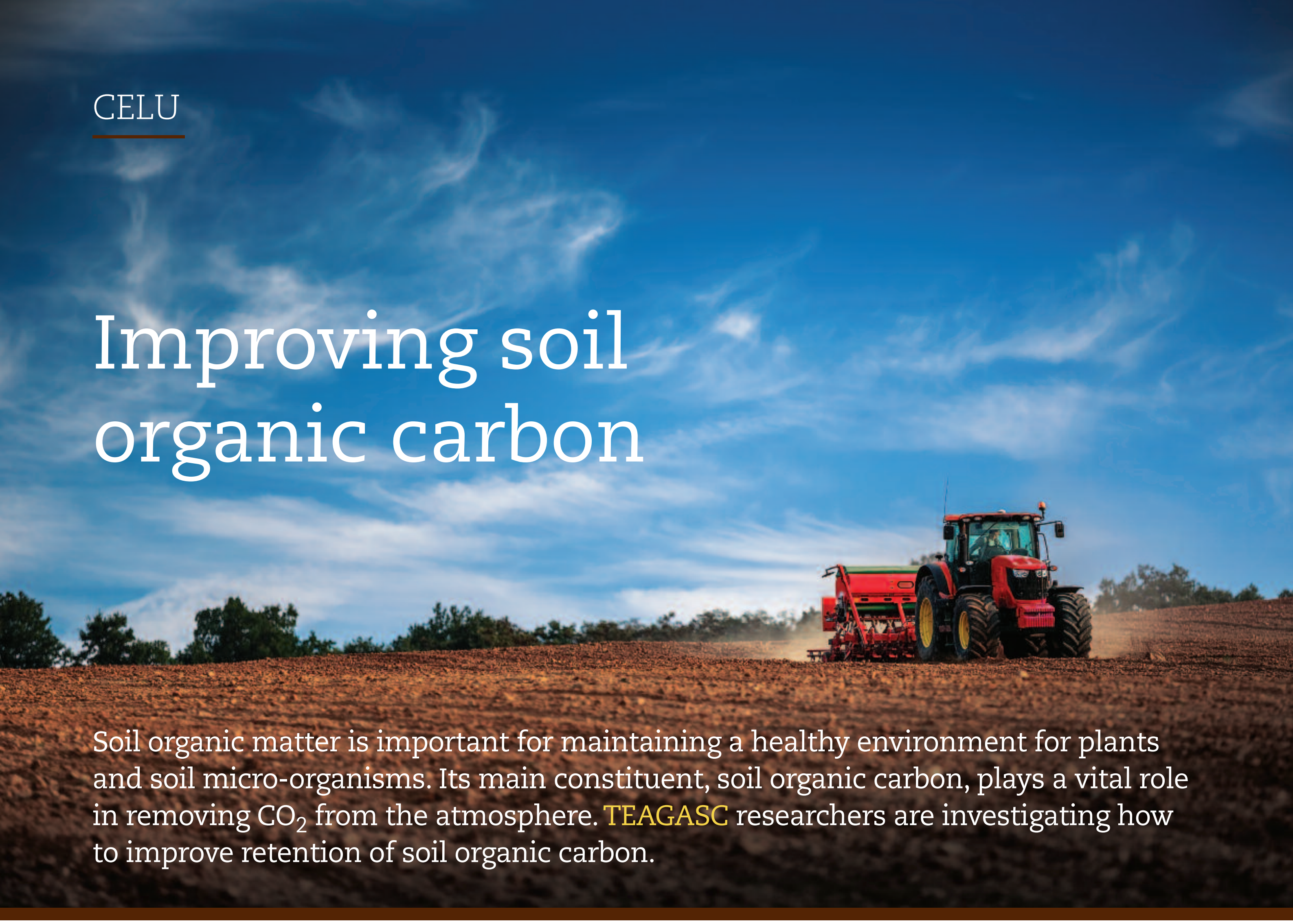

Improving soil organic carbon

Soil organic matter is important for maintaining a healthy environment for plants and soil micro-organisms. Its main constituent, soil organic carbon, plays a vital role in removing CO_2 from the atmosphere. TEAGASC researchers are investigating how to improve retention of soil organic carbon.

Why care about soil quality?

Soil organic matter (SOM) forms due to the decomposition of plant and animal residues that enter the soil system. These inputs include leaf and straw residues, root material, soil biota, and any applied animal manure. Soil organic carbon (SOC) is the main constituent of SOM, accounting for 50% of the total, and sequestration of carbon (C) in soils plays a vital role in removing CO_2 from the atmosphere. Indeed, global soils contain 2,200 billion tonnes of carbon, three times the amount in the atmosphere. SOM is also rich in nutrients such as nitrogen (N), phosphorus (P) and sulphur (S), and in micronutrients, and SOM increases have been positively related to soil fertility and agricultural productivity potential. SOM/SOC consists of an active labile pool, which is readily available to soil organisms, and a passive pool (humus), which is hard to decompose. Sequestration of C occurs when there is a build-up in the passive pool, while the labile pool is most associated with the nutrient effects of SOC.

Role of SOM in plant productivity

The role of SOM in enhancing plant productivity can be classified into three broad categories: biological, physical, and chemical. SOM contributes soil nutrient retention by increasing the cation exchange capacity (CEC), which determines a soil’s ability to retain positively-charged plant nutrients. Thus, SOM can act like a slow-release fertiliser. SOM also plays a key role in soil aggregate formation, which reduces soil bulk density and compaction. As a result, it also increases the soil's water-holding capacity. SOC also provides an energy source for soil microbes and fauna. These are vital for decomposition and soil nutrient cycling.

Increasing organic C in croplands

Cropland soils generally store less SOC than grassland because cropland has greater disturbance from cultivation, a lack of organic manure being returned to the system, has a winter fallow period and, as a consequence, has less root and shoot material returned to the soil. Changes in SOM/SOC are not linear and reach a new equilibrium over time (**Figure 1**). In other words, accumulation of SOM/SOC is finite. Some examples of management options to increase organic carbon C in croplands are:

Cover crops/rotations

Crop rotations can include cover crops, perennial grasses and legumes that maximise soil C inputs and maintain a high proportion of active C.

Straw and manure incorporation

Straw incorporation increases SOC, as organic matter is directly inputted back into the soil. **Figure 1** shows that for 4t straw incorporated over 20 years, a 7-17% increase in SOC (top 15cm only) has been observed (depending on whether reduced tillage was also applied). Manure inputs will also build SOC stocks, particularly farmyard manure.

Reduced/minimum tillage

The concept of reduced tillage is that aggregates are disrupted less, leading to reduced SOC loss. However, while SOC levels in the top 30cm are increased, there is increasing evidence that ploughing may simply redistribute SOC over a greater depth profile.

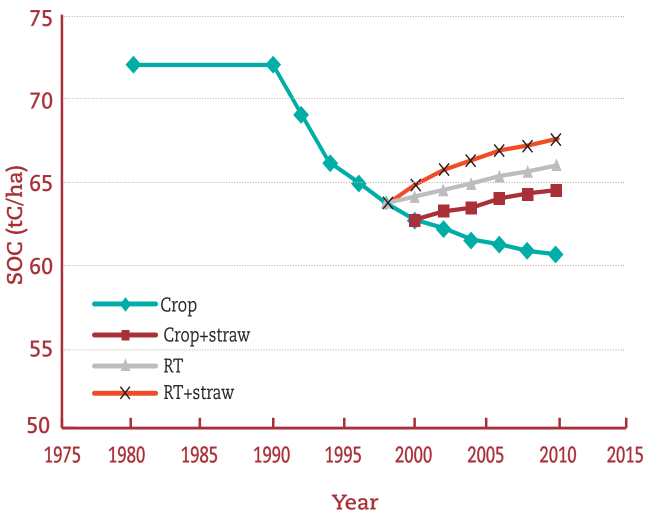

FIGURE 1: Impact of grassland conversion to cropland and subsequent impact of management on soil organic carbon.

Increasing organic carbon in grassland

Soil quality in grasslands could be improved by achieving a 'right' balance between C and N inputs to soils. A combination of agricultural practices that promote the formation of stable soil aggregates will improve soil quality and sustainability. Some management options include:

- In permanent grasslands (>5yrs) a key step is to improve either organic or inorganic fertiliser management. A first step would be to combine liming treatments with either organic and/or inorganic nutrient fertilisation (N, P, K, Mg, etc.). 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 build-up though reduced tillage events.
- Increasing the abundance of legume species in some grass swards can improve sequestration and forage quality, and reduce inorganic N inputs. In combination with legumes, a more diverse vegetation cover (>4 species) can make grasslands more resilient in terms of climate change, and may provide both a better forage quality and organic matter input.
- A third step is to reduce frequency of use of heavy machinery, which could cause high soil compaction and thus 'reduce' pore space available in the soil matrix, which is necessary to transport and accumulate extra C (via soil climate, macro fauna, earthworms, microbes, etc.). Animal grazing is preferable to silage/hay production, due to the nutrient recycling of animals and the reduction in work (25-40% of ingested herbage is returned to the pasture in excreta).
- Finally, the development of pasture management plans, perhaps around a five- to seven-year cycle, where a combination of different practices (liming, nutrients, grazing, reseeding) guarantee balanced applications of C and N to soils under moderate (soil) disturbance (avoid high animal stock densities and intensive mowing). A soil monitoring programme including analyses of soil C and N content, soil bulk density and pH should be put in place and run every two to three years.

Summary

- Soil organic matter (SOM) and soil organic carbon (SOC) levels in arable systems are lower compared to grassland systems due to ploughing and fallow periods.
- Improving SOM will increase aggregate stability, and reduce compaction, erosion and nutrient leaching, as well as increasing soil fertility by improving nutrient availability.
- Furthermore, carbon sequestration associated with SOM build-up will offset greenhouse gas emissions but is also reversible.

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Authors

Gary Lanigan
Principal Research Officer, Crops Environment and Land Use Programme, Teagasc, Johnstown Castle, Wexford.
Correspondence: gary.lanigan@teagasc.ie

Richie Hackett
Research Officer, Crops Environment and Land Use Programme, Teagasc, Oak Park, Carlow.