VENETO AGRICOLTURA

EXPERIMENTATION 1

Holistic Flexible Conservation Agriculture Sustainable Agriculture

According to a Joint Research Centre (JRC) survey (JRC 2024), at least 63% of EU soils are affected by degradation processes, with overall EU-wide soil erosion amounting to 1 billion tonnes per year, the equivalent of approximately 250,000 hectares when the upper layer of top soil (40 cm) is considered. Furthermore, nutritional imbalances now affect 74% of soils, with an estimated 70 million tonnes of organic carbon being lost from cultivated soils across the EU and UK between 2009 and 2018. The cost of lost productivity due to degradation of EU land is estimated at € 1.2 billion per year. Italy's soil organic carbon is also decreasing rapidly. In the Veneto region, levels have dropped below 1,5% in most of its cultivated land (ARPAV 2025). This alarming scenario is mainly due to unsustainable conventional agricultural practices that decrease potential soil productivity, i.e. fertility, cultivation cycle by cultivation cycle. Herbaceous crops (e.g. cereals, oilseeds, legumes, potatoes, sugar beets) cover a large part of Europe's cultivated agricultural land and play an essential role in human nutrition, in feed for agricultural livestock, and as a source of raw materials for industrial purposes (e.g. starch, biofuels). Today, European farmers still rely strongly on conventional ploughing-based agriculture (CONV) to farm the main herbaceous and vegetable crops. There is an equally strong reliance on pesticide use, despite concerns arising over its effects on both the environment and human health. This concern is reflected at European level by the Farm-to-Fork strategy, Directive 2009/128/EC, and the new Common Agricultural Policy (CAP), all of which back a new sustainable approach to agricultural practices.

Conventional agricultural practices have been producing abundant food for decades, thus helping to achieve major social and economic objectives. However, as scientific research (e.g. Abdallah *et al.* 2021; Neal *et al.* 2017) and the effects on soil properties across millions of conventionally cultivated hectares have demonstrated beyond any doubt, conventional agriculture has caused a progressive reduction in the soil's organic matter (OM) content. This reduction has accelerated where the OM cycle has been interrupted, i.e. OM has not been returned to the soil by the civil and/or livestock sector. This has had negative consequences both on agriculture's sustainability, the core one being an inability to maintain the soil's potential fertility, and on the environment, with more carbon dioxide being released into the air.

Silty soil without ploughing in the last 11 years and without any tillage in the last 5 years, covered and nourished by living roots continuously, May 2023.

Unfortunately, initiatives to reduce the negative impact of conventional practices on soil fertility and biodiversity have yet to lead to widespread implementation of conservation/sustainable agricultural practices.

Some agronomic practices and innovative techniques, however, may be able to reverse this trend. One approach may be able to reverse the trend of soil organic carbon reduction completely, as it uses holistic packages of multiple practices which, when combined, stop carbon losses and sequestrate carbon emissions.

Holistic processes

To achieve this goal, sustainable cultivation packages can be used to combine a series of strategies designed both to contain or zero carbon loss and sequestrate carbon emissions. The package under study at field scale has been called Holistic Flexible Conservation Agriculture (*Agricoltura Conservativa Flessibile Olistica* in Italian, or ACFO) or Sustainable Agriculture.

A) CONTAINMENT/ZEROING OF CARBON LOSS

This process is based on the combined use of:

1. **Precision agriculture**, which needs to become the basis for any decision on agricultural practices. Precision agriculture pinpoints homogeneous areas with associated forecasting models, providing a continuous stream of information regarding what the plant-soil system needs so that the variable rate application of the main production factors (e.g. nutrients, seeds, control agents for harmful organisms, irrigation) can be performed efficiently (Gobbo *et al.* 2020, 2022);
2. **Crop rotations** that are effective in local pedo-climatic conditions, thus helping to mitigate the effects of climate change; dicotyledons and monocotyledons, autumn-winter crops as herbaceous plants for livestock farms; crops with the least water consumption per unit of dry matter produced; and crops with greater salinity tolerance (e.g. crops used on coastal farms). Effectiveness will be evaluated in terms of costs, water consumption, energy balance, environmental impact, and reduced pesticide use in general, considering the rotation as a whole, not the individual crops;
3. **Advanced Integrated Pest Management (IPM)**, exploiting i) agronomic/alternative practices to increase ecosystem biodiversity (Implementation of the Prevention principle according to Directive 2009/128/EC, Annex III); ii) DSS*-based advice from the Herbaceous Crops Bulletin (HCB) and the associated in-farm monitoring, to minimise the use of synthetic chemicals

Combining rolling of the cover, minimum tillage (disc harrow) and drilling, April 2023.

in crop protection without any negative impact on yield. Focus will be placed on interventions that can negatively impact soil biodiversity (e.g. use of soil insecticides) and the evolution cycles of organic matter. These cycles are to be promoted and steered towards the formation of stable compounds (*based on Holistic forecasting models for crops, diseases and pests as described in Furlan et al. 2021b);

4. **Flexible conservation/sustainable agriculture**, including crop rotation (see above), also adopted in the Conventional package, plus **continuous soil coverage both with cover crops and crop residues**, no-tillage or reduced tillage, with shallow depth and the avoidance of soil layer inversion in all cases. When required, deeper intervention can be carried out to decompact soil, while avoiding OM exposure to oxidation.

Long-term field data indicate that this package has the potential to halt/slow carbon losses from agricultural soil (Camarotto *et al.* 2020; Furlan *et al.* 2021a; Piccoli *et al.* 2017; Morari et al. 2019; V.V.A.A. 2019) and induce an improvement in the biodiversity of agricultural soil (Pittarello *et al.* 2022). The results of the LIFE+ AGRICARE project, which combined precision agriculture with the three basic techniques of conservation soil management (minimum tillage, no-till seeding and strip-tillage) and their long-term simulation have confirmed the project's potential for reducing climate-altering gases and for improving soil carbon (V.V.A.A. 2017 and 2019).

"Biomax" cover crop - high biodiversity, high biomass - and wheat direct drilling, October 2022.

B) ADDITIONAL CARBON SEQUESTRATION

No-till or reduced tillage give the most important results and are designed to reduce or avoid physically soil disturbance. Occasional destruction of aggregate exposes organic matter to rapid microbial oxidation, breaks the microaggregates, and exposes them to oxygen, releasing carbon dioxide trapped into soil. Furthermore, when soil biology is exposed to oxygen, higher temperatures, solar radiation and direct predation, it decreases significantly when disturbed by frequent, deep, intensive tillage (Reicosky, 2019). Once the agronomic practices that slash/zero OM losses are applied, thus allowing OM to rise slowly, three main strategies should be used to pursue a positive accelerated carbon balance, i.e. the progressive accumulation of carbon in the soil until it reaches the characteristic balance point for each type of soil in a local climate zone:

B1. INTENSIVE ADOPTION OF COVER CROPS

As reducing tillage is not enough to increase the soil's organic carbon, it is essential to promote its return by intensifying fixation with photosynthesis in fields (Chenu, 2017). Soil always needs to be kept covered, with the presence of living roots and plants for as long as possible. Cover crops produce large amounts of biomass, meaning that they can fix carbon dioxide at times when cash crops are not being used. By doing so, soil biology is fed with root exudates and rhizodeposition, maintaining it as constant as possible. Moreover, the roots can host nitrogen-fixing bacteria, or catch and recycle both soluble nitrogen, which is prone to leaching, and all the other nutrients, making them available for future plants (cash crops) after they have decomposed. The benefits of cover crops do not end here, but these are the main reasons why planting cover crops is important, especially ones that restore soil carbon and regenerate the soil's biological fertility. It has been demonstrated frequently that cover crops containing combinations of different species, or rather different botanical families, provide better and more stable results.

B2. APPLICATION OF GOOD ORGANIC MATTER (closure of carbon cycle)

The OM to be returned or added to the soil must be high quality, i.e. made up of stable molecules that guarantee the activity of soil biology which, on the one hand, enable slow-release and high efficiency nutrients for crops and, on the other, a dynamic balance in the carbon cycle whereby slow evolution leads to accumulation.

B3. AGROFORESTRY

A modern approach to the coexistence of trees and herbaceous crops can guarantee a constant and objectively verifiable accumulation of carbon. Planting short-cycle tree essences, such as poplar and paulownia, with a density of about 50 plants/ha can guarantee significant annual carbon accumulations in the Veneto plain, i.e. on Veneto Agricoltura's three pilot demonstration farms. Although there are still no significant long-term studies on the Veneto-Po valley environment, the bibliography on results in similar conditions indicates that carbon accumulations would be appreciable.

The presence of trees and shrubs, often at the edges of fields, gives complexity to the agroecosystem and contributes to biomass production.

The largest long-term experiment on the future of Europe's agriculture

Based on the aforementioned scientific approach, the cultivated land of pilot farms is divided into two parts (300 ha each) corresponding to each of the treatments under study. About 50% is placed under HOLISTIC FLEXIBLE CONSERVATION/SUSTAINABLE AGRICULTURE (ACFO); the other 50% under ploughing-based CONVENTIONAL AGRICULTURE (CONV) in a randomised block experimental layout. The blocks are the homogeneous areas pinpointed with the basics of the precision farming approach.

The sustainable package (ACFO) comprises:

1. PRECISION FARMING, variable rates for all production factors, including water;
2. SUITABLE ROTATION, (as complex and diversified as possible);
3. CONTINUOUS SOIL COVERAGE, with cover crops chosen according to soil conditions and agronomic needs (e.g. nitrogen fixation, biomass production to outcompete weeds or biocidal species when soil pest reduction is needed, avoiding pesticide impact on biodiversity);
4. NO CROP-RESIDUE REMOVAL, crop residues are kept on the ground as coverage;
5. NO PLOUGHING (minimum or no tillage), according to crop and actual soil conditions; no-till seeding wherever and whenever possible, in particular for cereals and soybean and also for cover crops in order to promote quick installation;
6. SOIL DECOMPACTION, with machines suitable for reducing soil density without exposing OM to oxidation, whenever needed; maintenance of crop residues at constant levels, i.e. straw will only be removed if necessary, and organic matter will be returned to the soil with manure;
7. ADVANCED IPM, as described above, resulting in no or negligible use of synthetic chemical soil insecticides (including coating seed insecticides) and progressive reduction of synthetic chemical fungicides;
8. INCREASE IN ECOSYSTEM COMPLEXITY in farms, both in fields and outside fields, with wood and herbaceous plants in uncultivated fields or field margins, and with the use of microbial consortiums to increase nutrient availability and reduce the risk of parasite damage;
9. SEVERE RESTRICTIONS ON GLYPHOSATE, with use of minimum tillage to clean seedbeds and or pre-emergence herbicide in rotation with post-emergence treatments to keep crops clean;
10. CULTIVATION PRACTICES TO PREVENT SOIL COMPACTION, starting from the crop cycle, to reduce the risk of soil damage, e.g. choice of early corn hybrids to avoid harvesting on wet ground, combine-harvesters with tracks;
11. WATER MANAGEMENT, according to the principles of precision irrigation (Furlan *et al*. 2020);

Whenever possible, carbon incorporation will be accelerated with:

12. AGROFORESTRY (H2020 Proget Earthone, Sasse Rami pilot farm);
13. INNOVATIVE FERTILISATION (organic fertilisers to close C cycle).

Under cover (crop) direct drilling on an organic farm, May 2023.

The Conventional Package (CONV)

Conventional means "in accordance with what is generally done", so it is the standard and most common way farmers practice agriculture. Soil tillage, and in particular ploughing and other mechanical tillage to prepare seedbeds, is the most common way of preparing soil to host a new cash crop. Mineral fertilisers are used to sustain crop nutrient needs in order to boost productivity and development, while other inputs (insecticides, fungicides, herbicides) are the only means utilised to protect crops from harmful organisms that can cause yield loss due to competition or direct crop damage, which is sometimes intensified by a lack of crop rotation and diversification. The soil is left bare between cash crops, often for several months, sometimes even 9 or 10. At times it is not even covered with (cash) crop residue, as this too is sold. During this period, soil tillage is carried out. The vast majority of practices and investments are focused on a rapid return for the next cash crop and there are no specific maintenance actions for a farmer's most important capital: (fertile) soil.

In order to comply with legislation, including the general need to reduce the impact of agricultural practice, the conventional agriculture package (CONV) shares some features with ACFO management, in particular IPM implementation, which has been compulsory since 2014, and crop rotation, which is one of its main pillars. This makes the CONV system already advanced for many European farms, but it is still distinguishable from a sustainable approach.

Therefore, the CONV treatment package comprises:

1. PRECISION FARMING, variable rates for all production factors including water (as in ACFO);
2. SUITABLE ROTATION (as complex and diversified as possible, as in ACFO);
3. BARE SOIL, after harvest no cover crop is sown, but sometimes residues are maintained until the first tillage operation, which is frequently the one mentioned in the next point;
4. PLOUGHING, or sometimes minimum tillage, according to crop and actual soil conditions, in particular for cereals and during wet autumns; harrowing and hoeing in order to prepare seedbeds;
5. RESIDUE REMOVAL, when marketable (e.g. cereal straw after harvesting);
6. ADVANCED IPM (as described above and in the same way as ACFO) resulting in no or negligible use of synthetic chemical soil insecticides (including insecticide-coated seeds) and progressive reduction of synthetic chemical fungicides;
7. WATER MANAGEMENT, according to the principles of precision irrigation (Furlan *et al*. 2020);
8. STANDARD FERTILISATION, with inorganic fertilisers but considering problems of salinisation.


Decompactor.

ASSESSMENTS

The assessments must be carried out on ACFO/CONV plots in selected homogeneous areas (each homogeneous area comprises both ACFO and CONV fields).

ANNUAL

- Monitoring population levels of wireworms and other soil pests (larvae and adults) with specific traps according to ECB instructions;
- Data collection with other traps (as per ECB network);
- Observations of phytophagous diseases, as per bulletin protocols;
- Stand of maize and other main crops;
- Wheat disease surveys;
- Weed monitoring;
- Monitoring mycotoxin content of maize, winter wheat and sorghum grain;
- Penetrometer soil assessment to evaluate compaction;
- Yield assessment;
- Biomass of cover crops and modeling of nutrient content with the 'Methode Merci' to be validated with chemical analysis of biomass composition;
- Economic assessments (detailed costs and incomes).

PERIODICALS

Initial state

Chemical-physical soil characterization::

- Carbon/Soil organic matter;
- Bulk density to quantify organic carbon stock;
- Visual Soil Assessment (VSA);
- Water aggregate stability test.

Biodiversity

- Taking soil samples to define the quantity and type of telluric microfauna (arthropods) and earthworms;
- Enzyme and dsDNA activities as an estimate of activity, abundance and functional diversity of soil microbiology.


Sasse Rami farm – Agroforestry.

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