LANDMARC
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Organic cropping

Large-scale potential to improve soil carbon storage and reduce soil N_2O emissions in Switzerland

About the initiative

Together with relevant stakeholders, including Agroscope, the Research Institute of Organic Agriculture (FiBL) and partners from the LANDMARC H2020 research project on land-based negative emission solutions, we will explore the long-term and large-scale potential and limitations of organic cropping to provide sufficient and economically viable crop production and to mitigate soil GHG emissions through the improved soil carbon storage and reduction of soil N_2O emissions in Switzerland. Ecosystem, land use and economic modelling research complemented with stakeholder engagement activities will be implemented in the 2021-24 period.

Additional information - Organic cropping

Organic cropping can preserve natural resources from degradation and promote long-term environmental health and economic profitability based on resilient agroecosystems. It is defined as crop production using animal or green manures, or diverse crop rotations with the aim to conserve soil structure and functions as well as biodiversity, improve the sustainability of crop production, and control weeds and pests. The use of agricultural chemicals (synthetic fertilizers, herbicides, and pesticides) is strictly avoided. Instead, animal manures are used, or leguminous cover crops and green manures are integrated into the crop rotation to provide nutrients for the crop and to suppress weeds and pests. This crop production relies in large part on more closed nutrient cycles by returning plant residues and manures from livestock back to the land and/or by integrating perennial plants, mainly grass–clover mixtures or forage legume leys, into the system. It has been often combined with reduced tillage practices to preserve soil fertility, despite known disadvantages such as high pressure from enhanced weed infestation.

As a systems approach, organic cropping can provide many benefits, such as increased biodiversity at different trophic levels, improved soil quality (fertility, structure and soil biological activity) and adaptation to climate change. Numerous studies show that organic cropping can lead to a reduction of soil organic carbon losses or even to higher soil organic carbon concentrations and net carbon sequestration over time and lower soil N_2O emissions compared to conventional systems per hectare.

Nevertheless, organic cropping generally leads to weed management problems, which might require extra labour or an occasional use of a deep inversion tillage, and a delay in soil nitrogen mineralization in spring, which might together contribute to a crop specific yield reduction (by 20% in general). On the other hand, organic products receive a price premium. The adoption of organic cropping might be hindered by a lack of organic manures due to a limited number of animal husbandries in the area. In summary, despite lower yields, organic farming can deliver more ecosystem services and social benefits and could lead to an improvement of rural livelihood.

Focus Area

The long-term ongoing experiment evaluating effects of several agricultural input systems on crop yields and various soil properties was established in 1977 in Therwil, Switzerland (Fig.1, 47°30'9.6" N, 7°32'21.0" E) as a result of a collaboration between Agroscope Reckenholz-Tänikon station and the Research Institute of Organic Agriculture (FiBL). Initially, the main goal was to investigate the feasibility of organic farming systems. Nowadays, the main research questions are related to soil and product quality. The experiment compares farming systems differing with respect to fertilization and plant protection management: a) biodynamic and organic systems fertilized with farmyard manure and slurry at the typical intensity of Swiss organic farms (at 1.2, later at 1.4 LU ha^{-1} yr^{-1}); b) conventional system with the same organic fertilizer input and additional mineral fertilization up to recommended plant-specific levels (on average 149 kg N ha^{-1} yr^{-1}); c) mineral conventional system fertilized with mineral fertilizers, representing a stockless system (on average 125 kg N ha^{-1} yr^{-1}); and d) unfertilized system. The N, P and K inputs in the biodynamic and organic systems are 34-51% lower than in the

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conventional systems. Organic and conventional systems are managed at two fertilization levels, corresponding to 100% and 50% of typical fertilization. Systems are arranged in a split-split-plot design with four replicates. A seven-year crop rotation consists of potatoes (*Solanum tuberosum*), green manure, winter wheat (*Triticum aestivum*), fodder intercrop, white cabbage (*Brassica oleracea*), winter wheat, winter barley (*Hordeum vulgare*) and a two-year grass-clover ley (*Trifolium pratense, Trifolium repens, Dactylis glomerata, Festuca rubra, Phleum pratense, Lolium perennne, Poa pratensis, Festuca pratensis*). White cabbage was replaced with beetroot (*Beta vulgaris*) and soybeans (*Glycine max*), and one winter cereal with silage maize (*Zea mays*) in later years. As fodder intercrops, rye and vetch or sunflower and vetch mixtures are planted. The crop rotation is planted with a temporal shift on three rotation subplots so that three crops are grown simultaneously in each system each year. Soils are managed with conventional tillage and cereal straw is removed. The plant protection in the organic and unfertilised systems is based on mechanical weeding, indirect disease control measures and plant extracts together with bio-controls against insects, while in the non-organic systems herbicides, fungicides and pesticides are applied. Research management and a regular data collection (yields, soil properties) on a plot level allowed development of a long- term dataset spanning 43 years. The experiment is aligned with a network of farmers and local stakeholders, which will provide a valuable asset for the LANDMARC project.

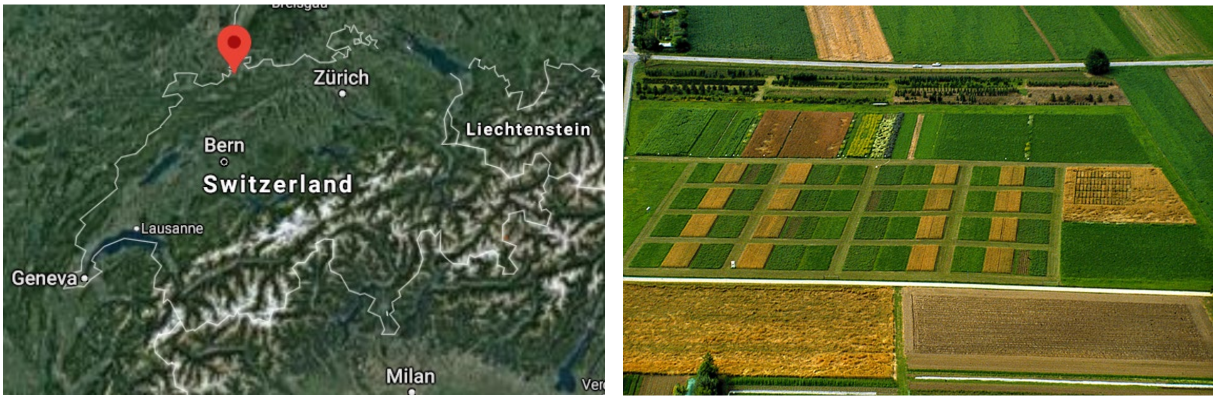

Figure 1: a) Location of the DOK long term experiment in Therwil close to Basel (Switzerland) and b) a photograph of the experiment. Photo credit Paul Mäder (FiBL, Switzerland)

What LANDMARC offers

LANDMARC complements the ongoing work on organic cropping in Switzerland through:

1. **Complementary data collection:** A human systems data for organic cropping (i.e., local contextual data, socio-economic data such as costs, markets, policies, social acceptance, land use competition) will be collected through reviews of scientific literature, local/national databases, survey tools and stakeholder workshops.
2. **Assessment of climate vulnerability/risk and potential effectiveness of large-scale implementation of organic cropping:** A climate risk and sensitivity analysis of organic cropping in Switzerland will be performed based on stakeholder knowledge, locally available data and by analysing the results from the Coupled Model Intercomparison Project, phase 6.
3. **Ecosystem and socio-economic impact assessment of organic cropping**: A qualitative and quantitative exploratory assessment of potential co-benefits and trade-offs related to nationwide scaling-up of organic cropping will be performed through the stakeholder engagement and by employing ecosystem (DayCent), land-use (ALCES, LandSHIFT) and macro-economic (E3ME) simulation models across the medium to long term. The outcomes of these analyses will have implications for the national climate change mitigation policy strategy development.

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