

Organic farming – a key to solving the climate problem

Organic farming has a number of objectives, such as to avoid damage to the environment, to promote biodiversity, to manage attractive landscapes, to keep livestock in a manner that fulfils their welfare requirements, and to produce good food. It also provides a key to solving the problem of climate change: organic farming is an alternative that uses resources sparingly, is climate-friendly, and offers significant scope for climate change adaptation.

Four reasons why organic farming protects our climate:

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1. Organic farming sequesters more carbon in the soil

Arable soils naturally have a major potential for sequestering carbon dioxide (CO₂). However, over the course of the millennia, arable land use has led to a loss of soil organic matter. This loss is largely due to intensive agricultural land use and the use of industrial fertilizers and chemical pesticides.

Organic farming strives to build humus in the soil in order to improve soil fertility. Humus formation increases soil stability and water retention capacity and thus reduces the soil's susceptibility to erosion. Humus provides more favourable conditions for soil organisms and stimulates soil biota. An increased humus content is also an indicator of increased sequestration of atmospheric carbon dioxide in the soil.

Using farmyard manure, slurry, compost, and other organic fertilizers to fertilize the soil can contribute to increasing soil organic matter. Careful soil cultivation also leads to organic matter being stored in the upper soil strata. Moreover, maintaining a continuous green cover of actively assimilating plants causes a continuous flow of assimilates through the plant roots into the soil.

Organic farming combines many of these measures and therefore this production system offers a number of solutions to climate protection. By promoting soil organic matter, atmospheric CO₂ can be sequestered and thus organic farming can contribute to achieving climate objectives. Moreover, humus formation increases the adaptability of agricultural systems to a changing climate.

Research proves that organically farmed soils sequester more carbon

The DOK field trial in Switzerland (Mäder, et al., 2002) compares biodynamic, organic, and non-organic agricultural systems using the same stocking intensity. The biodynamic plots with composted farmyard manure showed the highest soil organic matter contents, and carbon contents have remained stable since the trial commenced (Fliessbach et al., 2007; Mäder et al., 2006). In contrast, the organic plots and the non-organic plots with farmyard manure lost 177 kg and 209 kg carbon/ha/year respectively. The control plots which only received mineral fertilizers (straw removed post-harvest) lost 270 kg kg carbon/ha/year.

Worldwide many field trials have been conducted showing significant differences between soils under organic management and non-organic controls (Marriot and Wander, 2006; Pimentel et al., 2005; Reganold et al., 1987; Reganold et al., 1993, Soil Association 2009). The Soil Association for example has published an extensive study on carbon sequestration in organic farming. The publication compares 39 studies (comprising more than 100 individual comparisons) and concludes that, on average, organic farming shows a 28% higher sequestration rate (carbon storage) than non-organic farming in northern Europe. Globally, organic farming is 20% more effective in this regard (studies in Europe, America, Australasia).

Field trial	Components compared	Carbon gains (+) or losses (-) in kg per hectare per year ¹
DOK Trial, CH, since 1978	Biodynamic, with composted farmyard manure	+42
	Organic, with fresh farmyard manure	-123
	Integrated production, with farmyard manure and mineral fertilizer	-84
	Integrated production, with mineral fertilizer	-207
SADP, USA, since 1994	Organic, no-till	+1829
	Non-organic, no-till	0
Rodale FST, USA, since 1981	Organic, with farmyard manure	+1218
	Organic, with green manure	+857
	Non-organic, with mineral fertilizer	+217
Commercial farms, Bavaria, Germany, data modelled	18 organic tillage farms (median value)	+402
	10 non-organic tillage farms (median value)	-202
Reduced tillage trial, Frick, CH, since 2002	Organic, with ploughing	0
	Organic, with reduced tillage	+879

1) Conversion factor: kg C * 3.67 = kg CO₂

Source: Niggli, U. et al. 2009: Low Greenhouse Gas Agriculture, FAO Rev. 2, 22 pp

Reduced tillage promotes humus formation

Organic farming systems using organic fertilizers can make a similarly valuable contribution to soil conservation and humus formation than non-organic no-till systems (Teasdale et al., 2007; Müller et al., 2007). Moreover, the combination of organic farming and reduced tillage techniques is one of the most effective techniques to enhance carbon sequestration rates. While reduced tillage techniques prove difficult under organic conditions due to weed problems, the long-term reduced tillage trial at Frick has shown that compared to the organic variant with ploughing, 800 kg carbon per year could be sequestered (Berner et al., 2008). A long-term organic trial in Maryland, USA showed even higher carbon sequestration rates (Teasdale et al., 2007).

2. Organic farming uses less energy

Greater efficiency in organic farming

Organic agriculture strongly relies on the farms' own resources and seeks to eliminate, as much as possible, reliance on external inputs. For this reason, organic farming requires significantly less primary energy, and energy use per unit area in organic crop and livestock production is significantly lower than it is in non-organic agriculture (Grönroos et al., 2006; Haas et al., 2001; Lampkin, 2007; Schader et al., 2008). For example, in the DOK trial, the organic systems use 20 percent less energy per yield unit. While this makes organic farming more climate friendly, it does not make it climate neutral.

The use of reduced tillage techniques and the increased use of nitrogen-fixing green manure crops could contribute to a further significant reduction in energy use and CO₂ emissions while increasing yields.

While lower yields per unit area in organic farming systems reduce product-specific energy efficiency (for example, in terms of calories or added value), organic production is nevertheless more efficient than non-organic production in most cases (Ziesemer, 2007). However, this is not true for all agricultural products.

Higher energy consumption in non-organic farming

The increasing consumption of fossil fuels leads to the depletion on limited resources and increases global warming (Pervanchon et al., 2002). For this reason, the farming sector is also subject to reduction targets in terms of its use of primary energy and strives to improve energy efficiency respectively. Indirect energy use plays a particularly important role in this respect, i.e. energy consumed through bought-in products (primarily fertilizers and feedstuffs) which has to be credited to the farming sector (Mack et al., 2007). Industrial nitrogen is particularly significant in this regard.

Industrial nitrogen production consumes great amounts of energy and contributes to climate change

In the early twentieth century a technology was developed which allowed atmospheric molecular nitrogen (N₂) to be processed into a form which could be directly used by plants. However, this process is very energy-intensive. While the use of industrial nitrogen allowed for significant increases in agricultural yields, a large proportion of the nitrogen applied as fertilizer finds its way into the groundwater where nitrate contamination hampers the use of groundwater resources for drinking water and incurs high costs. A further share of the fertilizer nitrogen returns to the air as inert atmospheric nitrogen. However, as part of this process nitrous oxide (N₂O) is generated which as a greenhouse gas has 300 times more impact per unit weight than CO₂. Nitrous oxide is emitted during the production of industrial nitrogen and also from soils following the application of nitrate or ammonium fertilizers.

Organic farming: Industrial fertilizers are not permitted

In organic farming the nitrogen supply to crops is ensured by way of recycled organic matter (such as farmyard manure or compost). This is the reason why in organic farming systems harvest residues are not burned, thus reducing methane and nitrous oxide emissions. Additionally, atmospheric nitrogen can be fixed in the soil with the aid of leguminous plants and becomes available to subsequent crops. Industrially produced fertilizers are prohibited in organic farming and the amounts of nitrogen cycling in organic systems are generally much smaller compared to non-organic systems and, moreover, they are biologically fixed.

Therefore the risk of nutrient leaching or gaseous losses are lower than in systems using industrial fertilizers. While one to two percent of all nitrogen applied is lost in the form of nitrous oxide, the inputs in organic farming are significantly lower than in non-organic systems and therefore these emissions are similarly lower.

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3. Methane: Organic farming has a lesser impact on the environment



The number of animals per holding and the stocking density are limited in organic. Photo: FiBL, Frick

Agriculture is the most significant emitter of methane

Due to the increase in livestock numbers, ruminants have become the world's most significant emitters of methane, accounting for about a third of global greenhouse gas emissions from agriculture (Smith et al., 2007).

Organic farming: Fewer animals per unit area

The number of animals per holding and the stocking density are limited in organic farming, both for ethological reasons and in order to prevent nutrient losses (Olesen et al., 2006; Weiske et al., 2006). Moreover, in dairy farming the breeding focus is on life yield, lowering the ratio of non-productive juvenile phase to total lifetime. As the consumption of milk and meat require significantly more energy (and thus result in higher emissions) than a mostly vegetarian diet, consideration should be given to a reduction in the consumption of meat and dairy products, possibly by way of limits on ruminant production per unit of grassland area. Such a strategy of changed consumption patterns could very favourably be combined with a strategy towards global organic farming.

Organic farming therefore involves a systems approach which encompasses the entire food supply chain and reduces methane emissions as follows:

- Lower stocking density per unit area (rationale: ethologically sound livestock husbandry, avoiding eutrophication, feed).
- Increasing the amount of roughage fed and reducing the proportion of compound feeds in the ration (rationale: feeding in a way that fulfils the animals' welfare requirements; livestock health management based on prevention; prolonged period of utilization; reduced feed imports; see also FiBL's "Feed no Food" project).
- No competition between feeding ruminants and human nutrition.
- Reduced proportion of meat and milk in human nutrition (rationale: health and well-being).

While feeding energy-rich compound feeds can reduce emissions per kilogram of milk or meat (Beauchemin and McGinn, 2005), it must be borne in mind that ruminants can utilize roughage on grasslands that are not suited to other types of agricultural uses.

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4. Weather extremes: Organic farming is better adapted



The Swiss DOK trial clearly shows that soils under organic management (above) are more water-retentive than soils under non-organic management (below). Photos: FiBL, Frick



Organic farming aims at closed materials cycles and the efficient use of natural resources. Numerous studies verify that organic farming improves soil fertility and soil stability (Breland and Eltun, 1999; Esperschütz et al., 2007; Fliessbach et al., 2007; Mäder et al., 2002; Oberson et al., 1993; Oberson et al., 2007; Oehl et al., 2004a; Oehl et al., 2003; Wander et al., 1995). Soil biomass and biological activity are important for the mineralization of nutrients and the diversity of symbioses with plants, and it makes the production systems independent of external inputs.

Soils with an increased humus content and a preferably permanent soil cover of living or dead plant biomass are less susceptible to water erosion and to drying out in hot weather. Moreover, a high humus content increases the water-retention capacity of the soil and can thus help to bridge dry periods (Pimentel et al., 2005). The ability of soils under organic management to retain water can also help regulate flooding. Healthy fertile soils also increase crop plants' resistance to pests and diseases. If the adverse impacts of climate change on agriculture come to pass as predicted (increased water shortages, increase in weather extremes, increased pressure from pests and diseases) organic farming will represent an optimum adaptation strategy.

The potential of organic farming as a climate change adaptation strategy also includes socio-economic aspects. Diversified farm systems with their resultant lower risk of complete loss of

harvests are an inherent part of the organic farming strategy. Lower inputs also entail a lower risk of farmer indebtedness. Moreover, organic products attract higher prices in the marketplace, further increasing income security. These are advantages which are of particular significance to small farmers in developing countries.

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Background

1. Agriculture and climate

At the global level, agriculture contributes about ten to twelve percent to climate change. The main sources of GHG emission are nitrous oxide from nitrogen fertilizer use, methane from ruminants and rice paddies, methane and nitrous oxide from the burning of crop residues and improper manure management, carbon dioxide from the production of fertilizers and pesticides and the clearing of forests for tillage farming and livestock grazing as well as for the production of feedstuffs for livestock.

The mechanization of farming, such as the use of agricultural machinery, also consumes a lot of energy and therefore impacts on the climate. Additionally, intensive soil cultivation reduces the soil humus content and thus reduces the quantity of carbon agricultural soils can store.

Organic farming: Climate friendly

Organic farming as a climate change mitigation and adaptation strategy has the following benefits:

- Increased carbon sequestration in soils
- Reduced energy consumption
- Reduced nitrogen inputs and resultant reduction in emissions of nitrous oxide
- Avoidance of burning of crop residues
- Optimum livestock management with lower stocking densities
- Better soil quality and soil fertility with resultant reduced soil erosion and increased water retention capacity
- Diversified management systems with resultant lower risks.

There is still much scope for optimization in organic farming in terms of yields, CO₂ emissions, and humus formation, all of which require research and advisory services. Given these benefits of organic farming, it is important that the promotion of organic systems be further extended and intensified through research and development as well as practical application.

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2. Organic farming: Need for development

No-till systems are more beneficial than ploughing when it comes to reducing soil erosion and increasing carbon sequestration in soils. However, the disadvantage of non-organic no-till systems is that they require more inputs in terms of herbicides and chemical nitrogen fertilizers in order to maintain the yield levels of non-organic systems involving ploughing. A further disadvantage is that organic fertilizers can not be recycled onto such lands. Organic cropping systems with reduced soil cultivation would appear to be a most favourable solution which should urgently be developed to the point of practical application (Berner et al. 2008).

Despite the fact that much progress has been made, problems resulting from pests and diseases are still a major reason for lower yields. This problem must now be addressed with force through crop breeding efforts. Plant breeding under the special conditions of organic farming systems results in well-adapted, highly nutrient-efficient crop plants and can significantly increase yields (Reid et al., 2009; Lammerts van Bueren et al., submitted). Moreover, the possibilities of organic plant protection are not yet fully being utilized. The introduction of new products often fails due to the high costs of development and registration.

Weaknesses in livestock production which impact on energy and greenhouse gas emissions balances require improvements to be made in the areas of breeding, management, feeding, and animal health. For example, it is a challenge to provide optimum nutrition with on-farm feed production (amino acids, minerals, trace elements) while non-organic livestock can simply be given supplementary feeds from synthetic sources. Many holdings do not have prophylaxis strategies for livestock in place and veterinarians do not tend to support organic farmers in this regard. Sub-clinical udder problems for example cause unnecessary milk yield reductions in dairy herds (Sundrum 2007). The transnational [ANIPLAN](#) research project is now addressing the problem of udder diseases. Further progress can also be expected in livestock breeding efforts focussed on the special conditions prevailing on organic farms. The year 2009 saw the commencement of the first major European research project ([LowInputBreeds](#)) in this field.

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3. References

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