The Climate Benefits of Organic Agriculture

CalCAN
California Climate & Agriculture Network

CALIFORNIA AGRICULTURE is uniquely vulnerable to the effects of climate change. Climate scientists predict that California will experience in the coming years more severe water shortages, increasingly erratic weather, new pest pressures, increased stresses on livestock, and a loss of winter chill hours – all of which can hamper food and fiber production in the state[1].

Much is at stake. California is the fifth largest producer of food in the world; its 75,000 farms and ranches produce more than 400 different crops, generating $35 billion a year in revenues. To keep agriculture viable in California in the coming decades, the worst impacts of climate change must be averted.

Organic farming and ranching practices have an important role to play by enhancing resilience to the coming climate changes, reducing greenhouse gas (GHG) emissions, and storing carbon in soils and woody biomass.

What is Organic Agriculture?

Organic agriculture is a system of land management and food production that replicates natural ecosystems to maximize the performance of renewable resources, enhance beneficial organism populations, and maintain and replenish soil fertility. It is based on minimal use of off-farm inputs and does not utilize genetically modified organisms or synthetic pesticides, herbicides, or fertilizers. Organic livestock production requires considerable pastureland access and prohibits the use of synthetic foodstuffs, growth hormones and antibiotics.

Organic Agriculture in California

In the U.S., organic production has been one of the fastest growing sectors of agriculture for over a decade, with sales approximately doubling each year. According to the U.S. Department of Agriculture (USDA), national organic food sales have increased from $3.6 billion in 1997 to a projected $25 billion in 2010, and the number of acres in organic production doubled in each of the last two decades[2].

The birthplace of modern organic agriculture, California is home to about 20 percent of the nation's organic farms and generates 36 percent of the sales in organic products. It remains the leading state in certified organic agricultural land, with more than 2,700 operations comprising more than 470,000 acres of crop, pasture and range land[3].

Agriculture and Climate Change

According to a 2008 inventory of California's GHG emissions conducted by the California Air Resources Board, California agriculture contributes approximately six percent of the state's GHG emissions, more than half of which comes from livestock and a quarter from fertilizer use.

The science of agriculture and climate change is still relatively new and California-specific research on organic agriculture and climate change is limited. Many complex relationships and variables such as soil type, regional climate, cropping system, and timing and combinations of on-farm practices play a part in the potential for reducing GHG emissions and mitigating climate change.

There are three general ways in which agriculture can mitigate climate change:

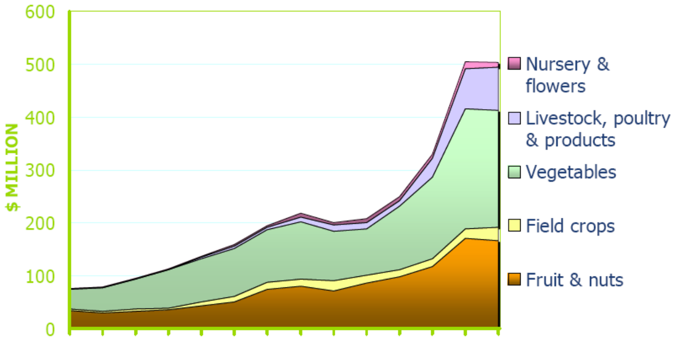
1. Reduce on-farm fossil fuel energy use
2. Reduce the embodied energy of agriculture inputs
3. Remove carbon dioxide (CO_2) from the atmosphere and sequester (or store) carbon in soils and woody biomass

To get a complete picture of a farm's carbon footprint and the opportunities to reduce GHG emissions and sequester carbon, it

Cal Poly Organic Farm

USDA NRCS

Growth in California Organic Sales 1992 - 2005



Source: CDFA Organic Program. Compiled by Karen Klonsky, Agricultural & Resource Economics, UC Davis.

California Agriculture by the Numbers

	California	% of U.S.
All California Agriculture[a]:		
Number of farms and ranches	81,500	< 4%
Average farm size	312 acres	418 acres
Acres of farm/ranch land	25.4 million acres	2.75%
Value of cash farm receipts	$36.2 billion	11.2%
Organic Agriculture[b]:		
Acres of organic farm/ranch land	470,903 acres	12%
Number of organic farms	2,714	19%
Organic product sales	$1.15 billion	36%

[a] Source: USDA National Agricultural Statistics Service, 2008.
[b] Source: USDA National Agricultural Statistics Service Organic Production Survey, 2008.

is important to consider agricultural practices as integrated parts of the whole system. In biological systems such as agriculture, altering one practice to reduce GHG emissions may lead to the unintended consequence of increasing GHG emissions elsewhere in the system.

Climate Benefits of Organic Agriculture

The following provides a summary of the research on certified organic farming systems as well as an overview of some techniques commonly used in organic production.

A. Organic Soil Management Techniques

Organic farming systems use soil management practices that offer the best opportunities to reduce GHG emissions, build soil organic carbon (SOC) and sequester atmospheric carbon. Among the most promising are: reduction/elimination of synthetic nitrogen fertilizer applications; use of organic fertilizers and cover crops; and, conservation tillage[4,5]. A 2008 study funded by the California Energy Commission found that these practices are particularly effective when used in combination[6].

Numerous studies show that organic agriculture offers great potential to sequester significant amounts of carbon[7,8,9,10,11,12]. A review of nine long-term studies found that organic systems improve key indicators of soil quality including SOC and nitrogen content[13]. A Central Valley study looking at alternative practices for seven different crops found that organic farming systems sequestered the most carbon[14].

Research has shown that tillage increases CO2 emissions from soil. In spite of the fact that organic farming typically utilizes tillage for weed control and to incorporate cover crops, organic production appears to sequester greater net amounts of carbon compared to conventional systems. Data collected at Morrow Plots, the oldest continuous corn experimental site in the country, found that after 40 to 50 years of synthetic nitrogen fertilizer applications, the net soil carbon content declined despite the incorporation of large amounts of carbon from crop residues[15].

When examining the net impact of farming systems on GHGs, emissions of nitrous oxide (N2O), a potent GHG, must also be evaluated. The use of nitrogen fertilizers and soil amendments — whether synthetic or organic — can result in N2O fluxes after rainfall or heavy irrigation. The data suggests that N2O emissions

"Carbon sequestration and GHG emission reductions are possible [in agriculture], but there is no single land management practice or change in inputs that could mitigate the carbon released from agricultural practices... Therefore, it is only the integration of different management strategies that shows considerable potential for carbon mitigation as well as provides important cobenefits to ensure the future sustainability of California agriculture."

— Emma C. Suddick et al., 2010.
Advances in Agronomy, Vol. 107. pp 123-162.

are much higher in conventional system after applications of synthetic nitrogen fertilizer compared to organic treatments, and that N2O fluxes can be reduced by avoiding heavy irrigation after organic fertilizer application in the spring[16] or by using subsurface irrigation instead of furrow irrigation[17].

More research is needed to examine which combinations of cover cropping, reduced tillage and irrigation practices have the greatest ability to sequester carbon at the greatest depth and for the longest duration in order to maximize the climate benefits and minimize N2O emissions.

B. Reduced Reliance on Fossil Fuels
Organic practices can reduce GHG emissions due in large part to the elimination of fossil fuel-based synthetic pesticides and fertilizers. A review of literature by the United Nations Food and Agriculture Organization found that organic agriculture production uses 30 to 50 percent less energy than comparable conventional systems[18]. Results from a 22-year study in the U.S. found that organic corn systems use inputs with 28 to 32 percent less embedded fossil fuel energy than conventional systems[19].

A study in Maryland by the USDA Agricultural Research Service found that an organic system helped reduce total GHG emissions while the no-till and chisel till systems contributed to it, even when adjusted for yield differences[20]. This was due primarily to greater carbon sequestration in the organic soils and secondarily to lower energy inputs. A Canadian study found that on average the organic production of corn, canola, soy and wheat consumed 39 percent of the energy and generated 77 percent of the GHGs compared to their conventional counterparts[21].

C. Organic and Pasture-Based Livestock Management
The methane emissions generated by livestock digestive processes and manure management account for approximately half of California agriculture's GHG emissions[22], which makes this sector an important one to understand. Livestock-related emissions come from a combination of gases emitted directly from the animals (enteric fermentation), from manure management, and from the emissions associated with the feed, energy and water use during production.

Data on Organic Agriculture & Carbon Sequestration

- In a twelve-year California study of organic farming practices, carbon sequestration was improved by 36 percent with the use of green manures and animal manures even though tillage was increased compared to conventional systems[23].
- An eight-year California study found that SOC increased 19 percent in organic and low input systems, as compared with 10 percent in conventional soils with synthetic fertilizers[24].
- After 23 years, organic management practices increased soil carbon by 15 to 28 percent and increased soil nitrogen by 8 to 15 percent[25].
- A nine-year USDA study found that organic production sequestered more carbon than no-till systems at all soil depths up to 30 cm[26].

Sustainable management of rangelands — which cover half of the total land area of California[27] — can be an effective tool for carbon sequestration and GHG emission reductions. Cattle grazing can increase above ground productivity of vegetation and species richness[28], which is frequently correlated with increased carbon in the soil[29]. Grazing has also been found to increase the rate of soil carbon sequestration[30,31]. In a study modeling the impacts of various dairy and beef management practices it was estimated that intensive grazing and rotation through paddocks increased carbon sequestration by 10 percent, and increased to 15 to 30 percent when combined with improved production efficiency and no-till feed production[32].

Livestock grazed on high quality forage or a diet containing plants typically found in pastures may emit less enteric methane[33,34,35,36]. Studies comparing the energy inputs required for different livestock management systems also suggest that conventional feedlot livestock require twice as much fossil fuel energy compared to grass-fed livestock due in large part to the use of synthetic fertilizers and pesticides used to produce the feed crops[37].

Altering livestock waste management practices can also reduce GHG emissions. Manure lagoons or slurries often produce N_2O and methane[38], two potent GHGs, as the result of the anaerobic decomposition of manure. When manure is applied to the land instead of stockpiled or stored in large ponds or lagoons, methane emissions can be reduced[39]. Because animal manures contain about 40 to 60 percent carbon, its application to land can increase the soil organic matter content and enhance soil carbon sequestration[40].

Enhanced Resilience of Organic Agriculture

Organic agriculture appears to be less vulnerable to some of the uncertain conditions caused by climate change compared to conventional systems[41]. As summarized in a report by University of California researchers[42] and other research[43,44,45], improving soil organic matter by using practices such as cover cropping, organic fertilizers and reduced tillage have many benefits that increase resilience, including:

- Increased soil fertility
- Reduced soil erosion
- Improved water infiltration (which improves water conservation and limits the impacts of flooding)
- Decreased reliance on fossil fuel-based fuels and inputs such as synthetic fertilizers (which also decreases cost)
- Increased habitat for beneficial insects (reducing the need for pesticides)

Diversified farming systems that incorporate crop rotations, multiple cultivars, and cover crops have traditionally been a hallmark of organic farming. These practices not only protect and enhance the fertility of the soil, break pest cycles, and build soil organic matter, but also protect farms from yield losses or crop failures[46,47] that may increase due to changes in climate or the extreme weather events expected to characterize future climate change impacts.

All of these enhancements to resilience also have positive impacts on environmental and public health.

Summary

Organic agriculture is part of a toolkit of climate solutions, and can help reduce GHG emissions, enhance a powerful resource for sequestering carbon, and provide many additional environmental co-benefits.

To support the climate benefits of organic agriculture, research, technical assistance and financial incentives are needed:

- More California-specific research is needed on agriculture and climate change issues, specifically focused on the relationship of organic and biologically integrated agricultural practices to carbon sequestration, GHG emissions reductions, and risk reduction.
- Producers need adequate technical expertise to put the scientific findings into practice.
- Because it requires time, skill building and money to transition to new production practices, financial incentives must be available to growers who implement specific climate-friendly practices.

These resources must be found to enable California agriculture to remain viable in the face of the coming climate challenges. ■

The California Climate & Agriculture Network

The California Climate and Agriculture Network (CalCAN) is a collaboration of California's leading sustainable agriculture organizations advocating for policy solutions at the nexus of climate change and agriculture. We cultivate farmer leadership to face the challenges of climate change and to serve as California's sustainable agriculture voice on climate change policy.

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February 2011

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