ENERGY USE AND EMISSIONS IN AGRICULTURAL PRODUCTION SYSTEMS

By Vijay Bhosekar, Kris Nichols and Jeff Moyer

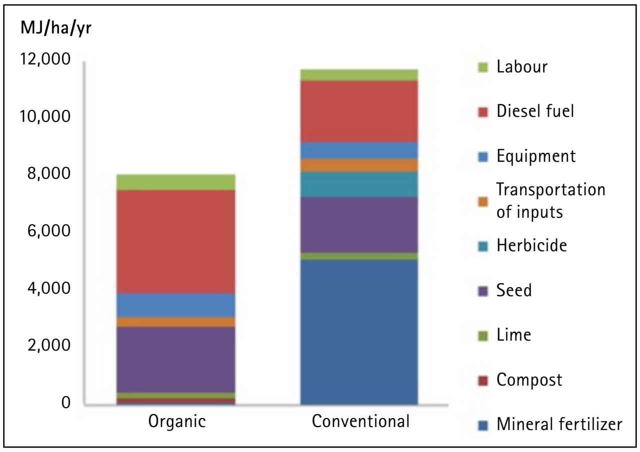
As we face uncertain, extreme weather patterns, increasingly costly oil, lack of water, and a growing population, we will require farming systems that can adapt, withstand or even mitigate these problems while producing healthy, nourishing food. Based on more than 30 years of side-by-side research in our Farming Systems Trial (FST), Rodale Institute has demonstrated that organic farming is best equipped to feed us now and well into the ever-changing future.

As the world's energy crisis continues, smart and efficient use of resources becomes increasingly essential. Currently, conventional agriculture uses an enormous amount of oil for the manufacture, transportation and application of fertilizers and pesticides. These processes release large amounts of greenhouse gas (GHG) into the atmosphere. Figures from the Intergovernmental Panel on Climate Change say that agricultural land use contributes 12 per cent of global GHG emissions.

Table 1 Energy inputs: organic and conventional systems

Inputs	Organic (MJ ha^{-1} yr^{-1})	Conventional (MJ ha^{-1} yr^{-1})
Mineral fertilizer	102	5,052
Compost	121	0
Lime	203	243
Seed	2,302	1,952
Herbicide	0	891
Transportation of inputs	356	437
Equipment	797	614
Diesel fuel	3,631	2,135
Labor	550	390
Total	**8,061**	**11,714**

Figure 1 Energy input comparison between organic and conventional systems



The Rodale Institute engaged in a three-year study (2008–10) comparing energy use in organic and conventional production systems.

Energy Analysis. Overall, the two conventional systems studied had an energy usage of 11,714 MJ per ha/year, 45% higher than the four organic systems studied, at 8,061 MJ/ha/year (Table 1 and Figure 1). Across all organic cropping systems, the single greatest energy component was diesel fuel, which made up 45% of the total energy. The single greatest energy use component across the two conventional cropping systems was nitrogen fertilizer, representing 41% of the total energy.

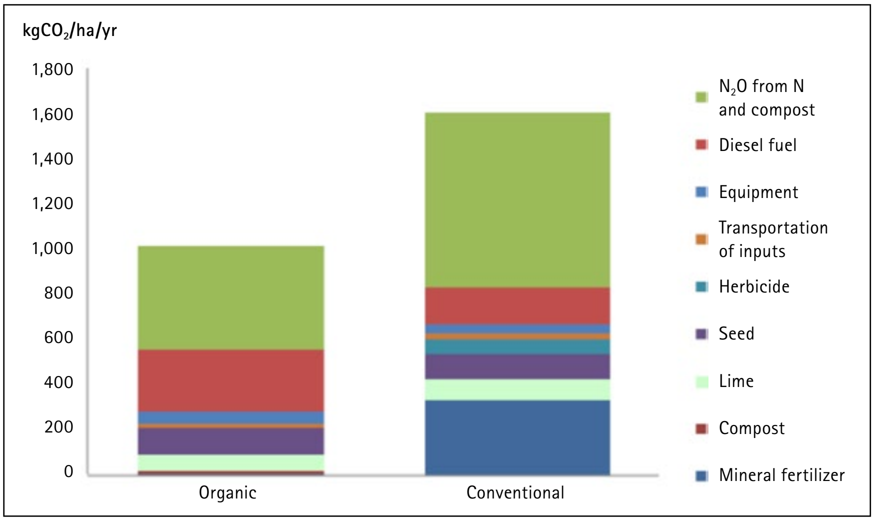
In addition to quantifying the energy requirements of crop production, the ratios between energy inputs and crop outputs were calculated to determine production efficiency. Our results show it took 2.03 MJ to produce 1 kg of dry matter in the organic systems vs. 2.60 MJ in the conventional systems. In other words, production efficiency was 28% higher in the organic systems than in the conventional systems.

Greenhouse gas emissions results. Overall, the two conventional systems had GHG emissions from inputs of 1,601 kg CO_2 equivalents per ha/year, which was 58% higher than in the four organic systems (1,016 kg CO_2 equivalents per ha/year), (Table 2 and

Table 2 Greenhouse gas emissions of inputs from organic and conventional systems

Inputs	Organic (kg CO_2/ha/yr)	Conventional (kg CO_2/ha/yr)
Mineral fertilizer	8	336
Compost	9	0
Lime	75	90
Seed	120	112
Herbicide	0	65
Transportation of inputs	19	23
Equipment	52	40
Diesel fuel	276	162
N_2O from N and compost	458	772
Total	**1,016**	**1,601**

Figure 2 Organic and conventional greenhouse gas emissions from inputs



Energy Use Comparison for Organic and Conventional Production Systems

Inputs

- The organic systems used 45% less energy than the conventional systems.
- Diesel fuel was the single greatest energy sink in the organic systems, representing 45% of the total energy used.
- Nitrogen fertilizer was the single greatest energy sink in the conventional systems, representing 41% of the total energy.
- Production efficiency was 28% higher in the organic systems than in the conventional systems; the conventional no-till system was the least efficient in terms of energy usage.

Emissions

- Conventional systems emit nearly 40% more greenhouse gases (GHG) per pound of crop produced compared to organic systems.
- The conventional systems' biggest GHG emissions came from fertilizer use, fertilizer production and on-farm fuel use.
- The biggest GHG emissions in the organic system came from fuel use and seeds.

Figure 2). Calculating the ratio of GHG emissions between inputs and crop outputs shows that the organic systems emitted 0.25 kg CO_2 equivalents per 1 kg of dry matter produced vs. 0.36 kg CO_2 equivalents per 1 kg of dry matter produced in the conventional systems. This means the organic systems emitted 40% less GHG per crop unit than the conventional systems.

Across all cropping systems, the major GHG input contributor was nitrous oxide (N_2O) emissions, associated with the nitrogen in mineral fertilizer, crop residues, and composting.

N_2O emissions represented 45% and 48% of total emissions in the organic and conventional systems, respectively. The next highest contributors to GHG emissions were nitrogen fertilizer production and on-farm fuel use in the conventional systems and fuel use and seed inputs in the organic systems (Table 2 and Figure 2).

The authors work for the Rodale Institute in Kutztown, Pennsylvania, US. At sixty years, Rodale Institute is North America's longest-running organic studies research facility. Visit: www.rodale institute.org