The Impact of Agriculture and Food Systems on Greenhouse Gas, Energy Use, Economics and the Environment

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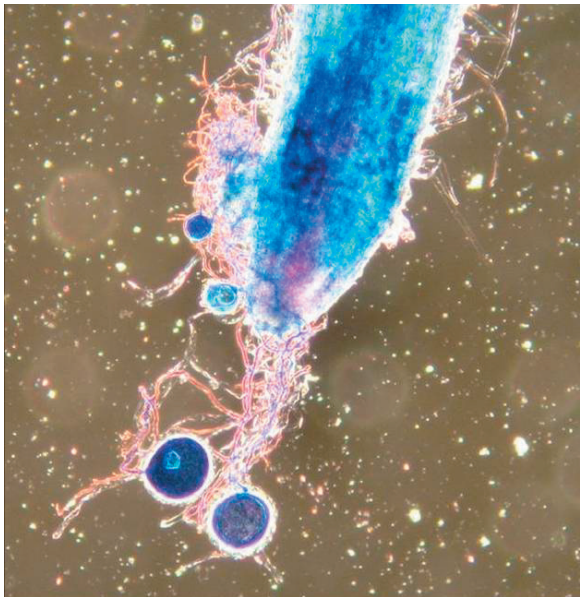
Agriculture and our food system impact global greenhouse gas issues in various ways. Agriculture and food production are major users of fossil fuels. However, organic agriculture has a great potential to sequester carbon, a greenhouse gas, in the soil, thereby reducing the greenhouse gas in the atmosphere. Agriculture can also produce renewable sources of energy which can substitute for the use of the fossil fuels that contribute to the runaway increase in atmospheric greenhouse gases.

Most experts believe the only long-term solution to our energy crisis is the development of alternative fuel resources. However, sequestering soil carbon through improved agricultural practice is an important bridge to a better energy and environmental future for mankind.

The 27-year Rodale Institute Farming Systems Trial® (FST) is the longest running side-by-side comparison of organic and conventional corn and soybean production systems in the United States. Over the years the Institute has teamed with top land grant university and federal researchers and academics to develop our scientific database. The FST has demonstrated the carbon sequestration capacity of organic farming and the biological mechanisms that support it.

The powerful scientific findings from the FST point the way to agricultural and food policy changes which will allow our food and feed systems to more positively contribute to energy management, greenhouse gas reductions, productivity improvement, natural resource conservation and economic returns.

Beneficial Root Fungi



- Extend plant root system
- Produce erosion-resistant carbon enriched soil
- Provide mechanisms for soil biological carbon fixation
- Are maximized by organic and no-till farming practices

In collaboration with the U.S. Department of Agriculture researchers David Douds and Kristine Nichols, The Rodale Institute has shown that organic farming systems can promote beneficial root fungi which secrete resistant glycoprotein that accumulates in soil, improving soil properties and sequestering carbon.

Facts about Organic Agriculture and Carbon Sequestration

- Organic agriculture has a significant ability to sequester large amounts of atmospheric carbon into the soil (over 1,000 kg/ha/yr); this has been precisely measured in the FST. This is equivalent to capturing over 3,500 kg/ha/yr of carbon dioxide. Carbon dioxide is the principle greenhouse gas of global concern for its contribution to climatic change. Moreover, capturing atmospheric greenhouse gas as soil organic matter contributes to improved soil quality and productivity.

Drinkwater, L.E., Wagoner, P. and M. Sarrantonio. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. Nature 396:262-265.

Hepperly, P., Seidel, R., Pimentel, D., Hanson, J., and D. Douds, Jr. 2007. Organic farming enhances soil carbon and its benefits. Pages 129-153 in Soil Carbon Management Economic, Environmental, and Societal Benefits, J. Kimble, C. Rice, D. Reed, S. Mooney, R. Follet, and R. Lal eds. CRC Press, Boca Raton, 268 p.

Pimentel, D., Hepperly P., Hanson, J., Douds, D., and R. Seidel. 2005. Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. Bioscience 55 (7):573-582.

- Conventional no-till agriculture, once considered the “holy grail” of carbon sequestration, can also sequester a significant amount of carbon (370 kg/ha/yr) according to long term studies at Ohio State University and other land grant institutions. However, organic agriculture can improve soil carbon sequestration about 2 to 3 times over conventional no-till agriculture.

Lal, R. 2003. Global potential of soil carbon sequestration to mitigate the greenhouse effect. Critical Reviews in Plant Sciences 22(2):151-184.

West, T.O., and G. Marland. 2002. New carbon flux from agricultural ecosystems: methodology for full carbon analyses. Env. Poll. 116:439-444.

- The Institute has shown that modern compost technology is capable of increasing soil carbon sequestration by more than 2,000 to 3,000 kg/ha/yr. In addition, the Institute has developed an innovative organic no-till system which combines the advantages of both conventional no-till and organic farming to increase benefits over either farming approach. Both these methodologies improve water quality compared to conventional agriculture production systems and methods.

Reider, C., Herdman, W., Drinkwater, L., and R. Janke. 2000. Yields and nutrient budget under composts, raw dairy manure, and mineral fertilizer. Compost Science 8(4):328-339.

Michalak P. 2004. Water, Agriculture and You - A summary of agricultural effects on water quality and health, including results from our long-term trials, FST and CUT. The Rodale Institute, Kutztown, PA. 32p.

- Food and agriculture are major users of the fossil fuels that contribute to pollution and greenhouse gas production. Agriculture production comprises 7% of the total fossil fuel. When processing (6%), distribution (7%), and fiber (4%) are included, the total contribution of food, fiber and agriculture comprises a full 25% of total fossil fuel budget. This is more than the energy used in our national transportation system (21%).

Pennsylvania Environmental Council. 2007. Pennsylvania Climate Change Roadmap. www.pecpa.org/FINAL%20PEC%20Roadmap%20Complete%20Report.pdf.

Pfeffer, D. 2004. Eating fossil fuel. www.fromthewilderness.com/free/ww3/100303_eating_oil.html.

- The FST, in collaboration with Cornell University, has shown that diversified organic agriculture with cover crops can reduce fossil fuel energy by 33 to 50% compared to conventional agriculture systems. The Institute's innovative organic no-till system reduces fossil fuel use by 75% over conventional tillage farming. The Institute's work not only indicates significant opportunity to use agriculture to sequester more carbon, but also its ability to greatly reduce energy use compared to the prevailing technology currently in use.

Pimentel, David. 2006. Impact of organic farming on the efficiency of energy use in agriculture. www.organic-center.org/reportfiles//ENERGY_SSR.pdf. 40 p.

Pimentel, D., Hepperly P., Hanson, J., Douds, D., and R. Seidel. 2005. Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. Bioscience 55 (7):573-582.

- The work of the Institute, in collaboration with U.S. Department of Agriculture Research Service, has shown that organic agriculture can increase carbon to 30 to 45 cm deep in the soil compared to 5 to 10 cm for conventional no-till agriculture. The Institute has shown that the distribution and activity of mycorrhizal fungi correlate highly with soil carbon accumulation and distribution. This is powerful elucidation of the biology behind carbon sequestration in the soil. The Institute's state of the art work uses my corrhizal fungi to regenerate impoverished soils through inoculation methods they have helped to develop.

Douds, D., Hepperly, P., Seidel, R., and K. Nichols. 2007. Exploring the role of arbuscular mycorrhizal fungi in carbon sequestration. American Society of Agronomy Talk and Poster New Orleans Convention.

Hepperly, P., Douds, D., and R. Seidel. 2006. The Rodale Institute Farming Systems Trial 1981 to 2005: Long term analysis of organic and conventional maize and soybean cropping systems. Pages 15-31 in Long Term Field Experiments in Organic Farming. J. Raupp, C. Pekrun, M. Oltmanns, and U. Kopke eds. ISOFAR, Verlag Dr. Koster, Berlin 198 p.

Wright, S., and A. Upadhyaya. 1998. A survey of soils for aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fingi. Plant Soil 198:97-107.

- The FST shows an increase of over 30% in soil organic matter and 15% in soil nitrogen under organic agricultural management over 27 years of testing. In drought years organic corn and soybean yields have exceeded those from conventional management by 28 to 75%.

Lotter, D., Seidel, R., and W. Liebhardt. 2003. The performance of organic and conventional cropping systems in an extreme climate year. American Journal of Alternative Agriculture 18(2):1-9.

- Economic analyses in collaboration with the University of Maryland have shown comparable returns in organic systems even without calculating organic price premium. In recent years, price premiums for organic grains have varied from 35 to 240%, offering great opportunity to wean farmers from price support subsidies.

Hanson, J., Lichtenberg, E., and S. Peters. 1997. Organic versus conventional grain production in the mid-Atlantic: An economic overview and farming system overview. American Journal of Alternative Agriculture 12(1):2-9.

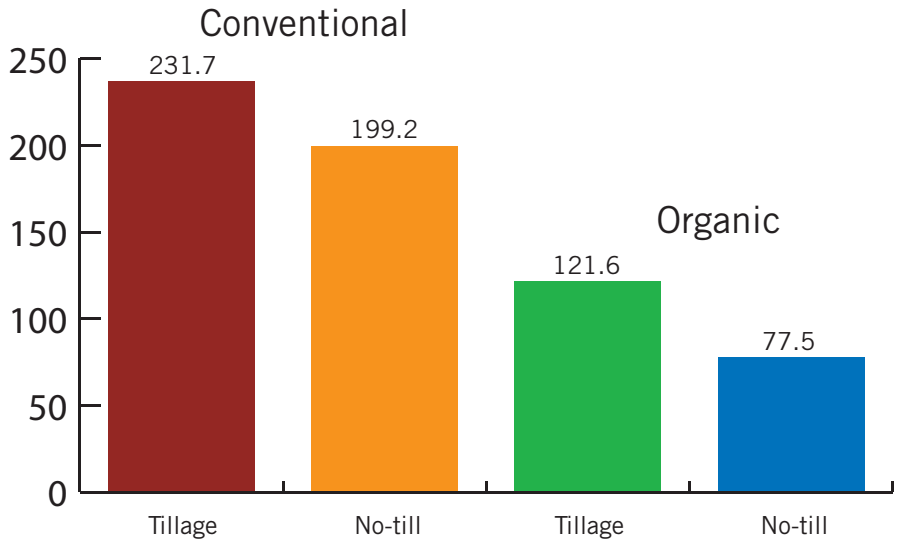
Hanson, J., Johnson, D., Peters, S., and R. Janke. 1990. The Profitability of Sustainable Agriculture on a Representative Grain Farm in the Mid-Atlantic Region, 1981-89. Northeastern Journal of Agricultural and Resource Economics 19(2):90-98.

Hanson, J.C. and W.N. Musser. 2003. An economic evaluation of an organic grain rotation with regards to profit and risk. September 2003. Department of Agricultural and Resource Economics, University of Maryland, Working Paper 03-10.

- Every kilogram of soil organic matter has the ability to absorb 20 times its weight in water. In addition, increased soil organic matter opens the structure of the soil surface, which the Institute has shown increases water percolation 25 to 50% of unimproved soil; reducing the quantity of water passing over the soil surface significantly decreases soil erosion.

Huntington, T. 2006. Available water capacity and soil organic matter. Encyclopedia of Soil Science, Taylor & Francis, 2nd edition. www.informaworld.com.

Energy Used in Different Corn Production Systems
(gallons of diesel per acre)



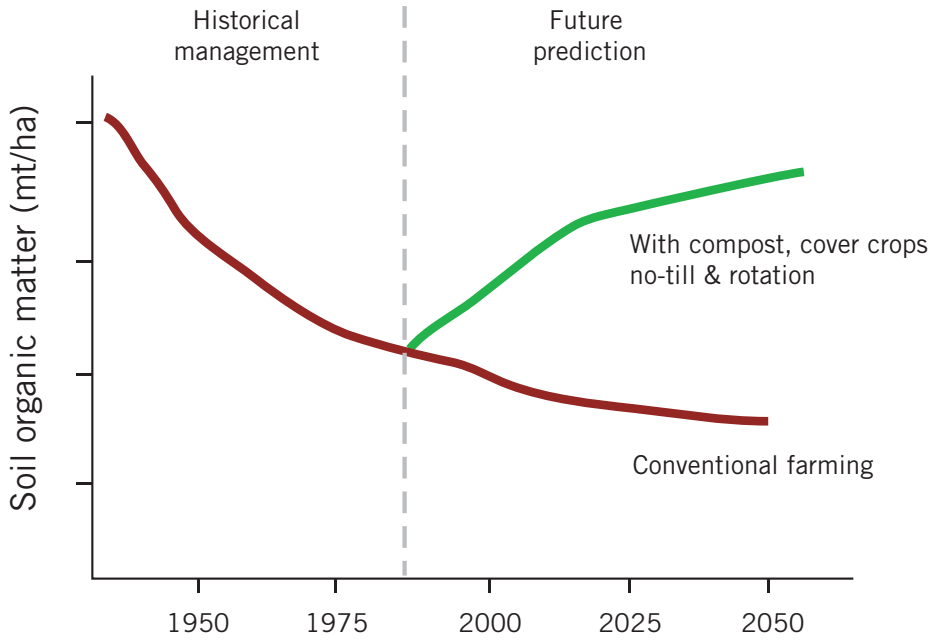
In collaboration with Dr. David Pimentel of Cornell University, calculations from the FST show no-till and organic farming practices work together to greatly reduce the energy or fossil fuel needed to farm corn.

Effects of Different Organic Practices on Soil Carbon

Agricultural Practice	**Increase in Soil Carbon** (kg/ha/year)
• Compost	1,000 to 2,000
• Cover Crop	800 to 1,000
• No-till	100 to 500
• Crop Rotation	0 to 200
• Manuring	0 to 200
• Cover Crop & Rotation	900 to 1,200
• **Compost, Cover Crop, Rotation & No-till**	**2,000 to 3,000** (projected)

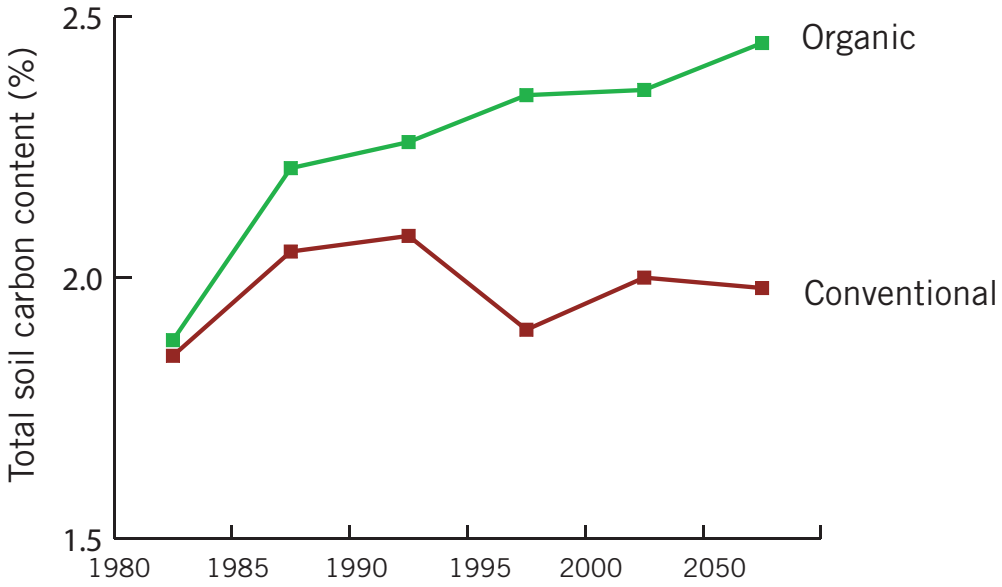
The Rodale Institute shows that different agricultural practices have different potentials to positively influence soil carbon sequestration. Although no-till is an important tool, our work indicates an integrated approach using a spectrum of tools will be more powerful than a single tactic alone.

Organic Agriculture can Increase Soil Organic Matter



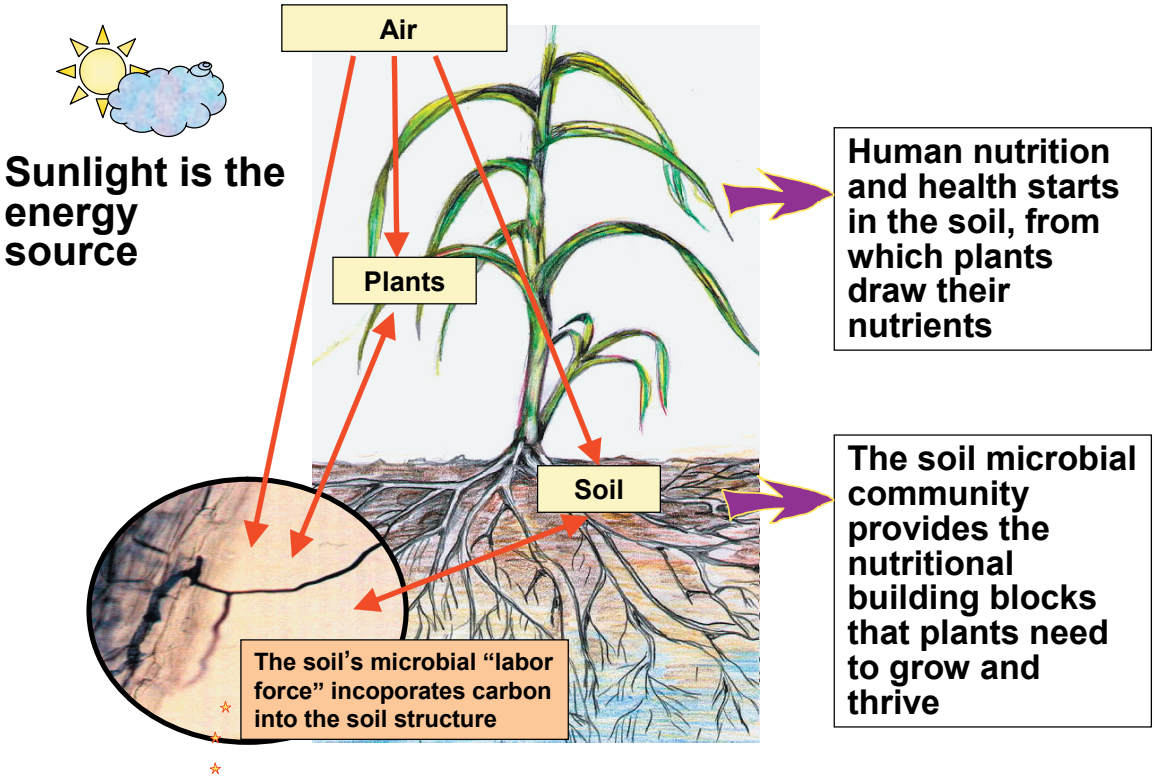
Until the 1950's, agriculture was considered the biggest contributor to the increase in atmospheric greenhouse gas. Current scientific consensus shows that by changing the way we farm, agriculture can become a powerful positive source in reducing the excess greenhouse gases.

Proven Soil Carbon Content Increase in the FST



The tracking of soil carbon changes in the world renowned FST has demonstrated that cover crop practices employed in organic farming systems are a powerful tool for sequestering carbon in the soil, thereby combating increases in atmospheric carbon dioxide.

Plants Equal Proven Carbon Sequestration



Plants and soil are a well-proven mechanism for capturing greenhouse gas from the atmosphere and returning it to soil, where it will improve our production system of food and feed and also conserve and enhance our natural resources. Other mechanisms being proposed, such as sequestration in geologic structures or water resources, are not proven and are likely to have large negative consequences. The Rodale Institute and its partners are uniquely positioned to help provide agricultural solutions that will mitigate runaway greenhouse gas and not endanger the environment.