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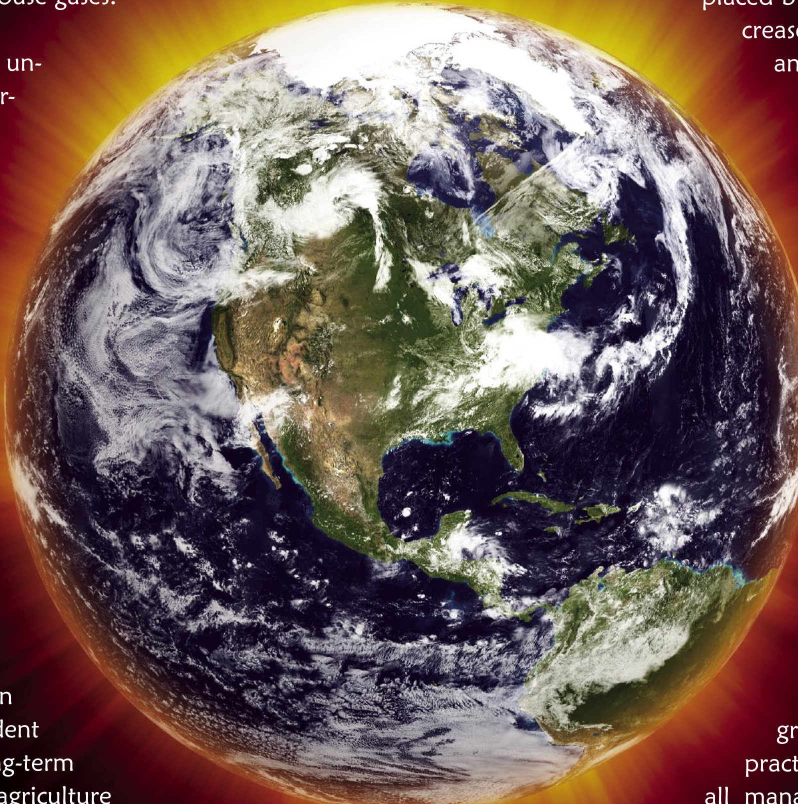
The Organic Farming Response to Climate Change

One of the most powerful tools in fighting global warming sequesters atmospheric carbon, data suggests a new worldwide urgency for the transition from chemical to organic agriculture

by Paul Hepperly, Ph.D.

Organic farming may be one of the most powerful tools in the fight against global warming. Findings from The Rodale Institute's Farming Systems Trial® (FST), which began in 1981 as the longest running agronomic experiment designed to compare organic and conventional cropping systems, show that organic/regenerative agriculture systems reduce carbon dioxide, a major greenhouse gas. This data positions organic farming as a major player in efforts to slow climate change from increases in runaway greenhouse gases.



Besides being a significant underutilized carbon sink, organic systems use about one-third less fossil fuel energy than that used in the conventional corn/soybean cropping systems. According to studies of the FST in collaboration with David Pimentel, Ph.D. of Cornell University, this translates to less greenhouse gases emissions as farmers shift to organic production. The ability of organic agriculture to be both a significant carbon sink and to be less dependent on fossil fuel inputs has long-term implications for global agriculture and its role in air quality policies and programs. The Rodale Institute drew these conclusions in a white paper that was released in 2003.

Organic shows dramatic increases in carbon sequestration

Since 1981, data from the FST has revealed that soil under organic agriculture management can accumulate about 1,000 pounds of carbon per acre foot of soil each year (1,123 kg/ha/yr metric). This accumulation is equal to about 3,500 pounds of carbon dioxide per acre taken from the air and sequestered into soil organic matter. When multiplied over the 160 million acres of corn and soybeans grown nationally, a potential for 580 billion pounds of excess carbon dioxide per year can be sequestered when farmers transition to organic grain systems.

Since the release of this data in 2003, there are new more dramatic findings. Figure 1 shows a more complete assessment of greenhouse gas sequestration in our long-term trial. In our comparison of soil in organic and conventional systems, we found greater levels of soil carbon in organic systems to a depth of two feet, about 60 cm. Conventional no till (or no tillage where plowing is replaced by herbicides) soil carbon increases in just the first few inches and this effect is extinguished at 3 to 6 inches (5 to 10 cm) or before this level, according to published results from several authors doing long-term trials. Organic no till is typically incorporated into organic agriculture production as a supplementary practice to cover cropping, rotation and organic amendment or fertilization.

Our take home message is: (i) non till is great, (ii) cover crops are greater, and (iii) combined practices offer the best overall management systems but need greater verification for their interaction. The data demonstrates that organic farming methods increase stored carbon and retain other nutrients and organically improved soils better hold these nutrients in place for uptake by plants. In the process, organic methods reduce nitrate and other nutrient runoff into streams and water aquifers. These findings can be beneficial to all farmers by helping them to increase crop yields while decreasing energy, fuel and irrigation costs.

The 1995 Kyoto Protocol references the potential of soil to sequester carbon without emphasizing its capacity nor the importance of organic agriculture management for this purpose. Since then, researchers have moved forward strongly

Now in its 27th season, The Rodale Institute Farming Systems Trial® is the longest running comparison of conventional corn and soybean row crop farming to organic production systems of corn and soybean.

with investigations to support agriculture's real potential to sequester carbon. The Rodale Institute's farm manager, Jeff Moyer, has invented and developed an innovative planter and roller for use in an organic no till system. (See at www.newfarm.org and Google "No Till Plus.")

In 2003, The Rodale Institute's findings show that organic grain production systems increase soil carbon 15% to 28%. Moreover, soil nitrogen in the organic systems increases 8% to 15%. Our 2006 deep profile carbon readings on soils receiving compost raises the carbon bar to 40% improvement. The conventional system shows no significant increases in either soil carbon or nitrogen in the same time period. Soil carbon and nitrogen are major determinants of soil productivity.

Why the increase in soil carbon in organic systems?

Why does the soil carbon level increase in organic systems but not in conventional systems when crop biomass is so similar? We believe the answer lies in the different decay rates of soil organic matter under different management systems. In the conventional system the application of soluble nitrogen fertilizers stimulates more rapid and complete decay of organic matter, sending carbon into the atmosphere instead of retaining it in the soil as the organic systems do.

Additionally, soil microbial activity, specifically the work of mychorrhiza fungi, plays an important role in helping conserve and slow down the decay of organic matter. Collaborative studies in our FST with the United States Department of Agriculture (USDA) Research Service (ARS) researchers, led by David Douds, Ph.D., show that mychorriza fungi are more prevalent in the FST organic systems. These fungi work to conserve organic matter by aggregating organic matter with clay and minerals. In soil aggregates, carbon is more resistant to degradation than in free form and therefore more likely to be conserved. Support for this work comes from USDA researchers at the Eastern Regional Research Center and Sustainable Agriculture Research Laboratory in Wyndmoor, Pennsylvania and Beltsville, Maryland. Their findings demonstrate that mychorrizal fungi produce a potent glue-like substance called glomalin that is crucial for maximizing soil aggregation. We believe that glomalin is an important component for carbon soil retention and encourage increased investigation of this mechanism in carbon sequestration. In addition, in organic production systems, increased mycorrhiza fungal activity allows plants to increase their access to soil resources, thereby stimulating plants to increase their nutrient uptake, water absorption, and their ability to suppress certain

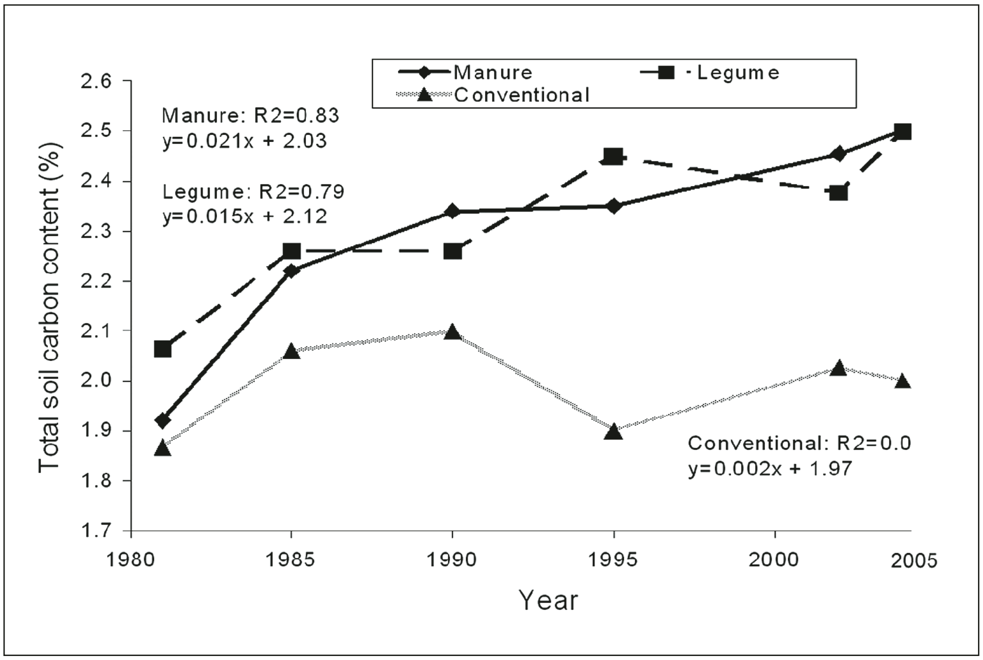


Figure 1: Linear regression of soil carbon rise with time in both organic treatments; while, no increase is found in the conventional system.

plant pathogens. Research shows 12% of the carbon captured in photosynthesis can be shunted to soil mycorrhizae. Synthetic chemical fertilizers and pesticides inhibit mycorrhizae and turn off a key mechanism by which plants naturally feed the soil through their support of beneficial fungi.

Increasing soil organic matter for the soil's carbon bank is a principle goal of organic agriculture. Organic agriculture relies on the carbon bank and stimulated soil microbial communities to increase soil fertility, improve plant health, and support competitive crop yields. This approach utilizes the natural carbon cycle to reduce the use of purchased synthetic inputs, increase energy resource efficiency, improve economic returns for farmers, and reduce toxic effects of fertilizers and pesticides on human health and the environment.

Former U.S. Secretary of Agriculture, Ann Veneman, put it this way: "The technologies and practices that reduce greenhouse gases emissions and increase carbon sequestration also address conservation objectives, such as improving water and air quality and enhancing wildlife habitat. This is good for the environment and good for agriculture."

Background and impact

In 1938, G. Callendar published findings suggesting that the burning of fossil fuels, such as coal, oil and natural gases, would likely increase world temperatures. Since 1958, continuous carbon dioxide measurements on Mount Mauna Loa in Hawaii confirm that carbon dioxide is increasing in the atmosphere at a rate of about 1.3 parts per million (ppm) per year. Atmospheric scientists believe that although several other gases contribute to the greenhouse effect in the Earth's atmosphere, carbon dioxide is responsible for over 80% of potential warming. NASA scientist James Hansen, Ph.D. tracked temperature changes in relation to past carbon dioxide levels and he correlated the 25% increase in carbon dioxide over the last 100 years with a 0.7° C warming of the atmosphere. A number of models have predicted that at current rates of carbon dioxide emission the Earth will warm 2.5° C in the next 100 years.

According to climatic change models, agriculture could be seriously affected by global warming. It is estimated that 20% of potential food crop production is lost each year due to unfavorable weather patterns (drought, flood, severe heat and cold, strong storms, etc.). The deterioration of weather patterns in North America could have devastating effects on world supplies of basic food grains such as wheat and corn. Climate change modelers predict that higher temperatures will generate more extreme weather events, such as severe

Answering The Critics

Upon the release of our original findings, a challenge immediately arose from Rattan Lal, Ph.D. in Ohio and Goro Uehara, Ph.D. in Hawaii (see Lewerenz, 2004). These scientists suggested that our estimates for carbon sequestration were too high, based on their personal research experience on conventional no till and reports in the literature showing conventional no till practice might sequester in soil a maximum of only about 200 to 500 pounds of carbon per year.

Conventional no till emphasizes tillage elimination. It does not, however, generally use live cover crops between cash crops. Under the organic farming systems, however, tillage is commonly used but live cover crops are normally established as the key biological drivers of the organic system. These drivers are what account for the 2 to 4 times greater carbon sequestration than that determined in conventional no till without cover crops as practiced by the critics. In conventional no till the ground can be covered with dead decaying crop residue for 4 to 8 months, while in organic farming cover crops provide live growing plants on the ground virtually all year long.

Veenstra, Ph.D. and co-workers (2006) at the University of California have reported on an experiment in the San Joaquin Valley that evaluated the levels of tillage vs. no tillage and cover cropping vs. without in cotton and tomato cropping systems. This work confirmed our 1,000 pounds of carbon per year soil sequestration level that we obtained under their very different California environment. Moreover, it also confirmed that tillage was of less importance compared to cover crop use in terms of improving soil and increasing carbon sequestration.

sequestration and reduce carbon emissions. While carbon can cycle in and out of soil or biomass material, there are methods for building up what are called soil "humic" substances (also known as organic matter) that can remain as stable carbon compounds for thousands of years.

Before forests and grasslands were converted to field agriculture, soil organic matter generally composed 6 to 10% of the soil mass, well over the 1 to 3% levels typical of today's agricultural field systems. The conversion of natural grasslands and forests around the globe works to elevate atmospheric carbon dioxide levels significantly. Building soil organic matter by better nurturing of our forest and agricultural lands can capture this excess atmospheric carbon dioxide, and preserve more natural landscapes.

droughts and torrential rains. A shift of 1 to 2° C in summer temperatures at pollination season can cause a loss of pollen viability, resulting in male sterility of many plant species such as oats and tomatoes.

As global temperatures rise, the glaciers and polar icecaps will melt, leading to major island- and coastal-flooding. About 50% of the United States population lives within 50 miles of a coastline. As coastlines move inland, uncontrolled carbon dioxide levels will directly affect coastal dwellers. If greenhouse gases continue to increase in the next several hundred years, the rise of global temperature is estimated at 7° C, or almost 15° F, and the sea level would rise over 2 meters, or in excess of 6 feet.

Soil organic matter is the key to sequestration

Agricultural and forest carbon sequestration will reduce the dangers that carbon dioxide currently presents to our atmosphere and world climatic patterns. These benefits will complement energy conservation and emission control efforts.

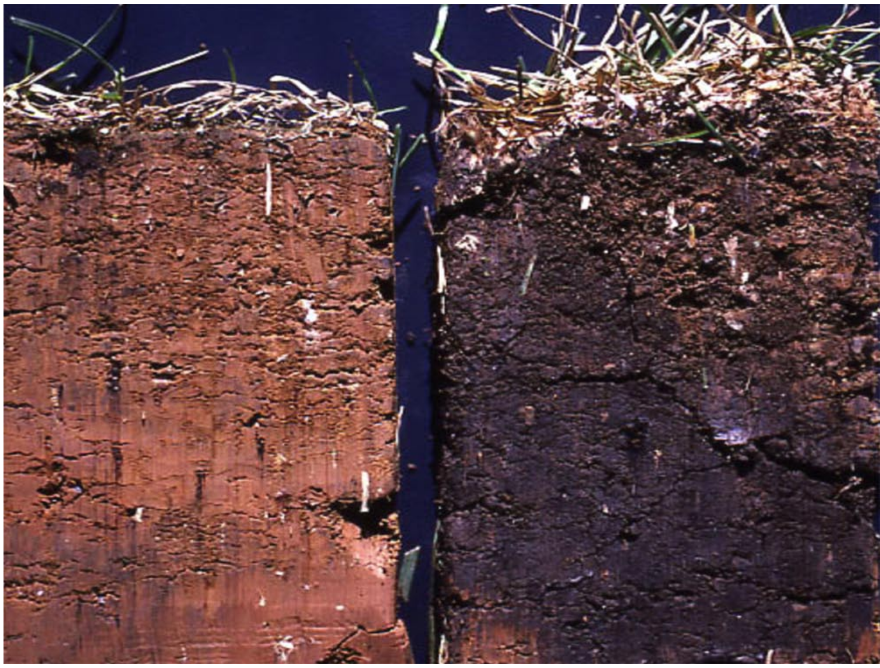
Normal seasonal carbon dioxide fluctuations in the atmosphere demonstrate that plant growth governs major amounts of carbon dioxide, enough to change atmospheric concentration by up to 10 ppm. By increasing plant production, we can reduce carbon dioxide concentrations in the atmosphere. Carbon dioxide levels are minimized in summer when vegetation is lush, and maximized in winter when plants die or go dormant. The fluctuation of carbon dioxide from season to season is about 7 times greater than the yearly average increase in atmospheric carbon from fossil fuel burning and deforestation (1.3 ppm). Plants serve as sinks for atmospheric carbon dioxide. Carbon stored in vegetation, soil, or the ocean, which is not readily released as carbon dioxide, is said to be sequestered. To balance the global carbon budget, we need to increase carbon

Soil, agriculture, and forests are essential natural resources for sequestering runaway greenhouse gases, helping to derail drastic climate changes. The amount of carbon in forests (610 gigatons) is about 85% of the amount in the atmosphere.

Less energy use and consistent yields

With the Institute's organic no till system, we have shown that diesel fuel needs can be reduced by about 75%, as trips through the field are reduced from 9 to 2. We have shown that high consistent yields are possible for corn, soybean, and pumpkins without chemical inputs.

In addition to capturing more carbon as soil organic matter, organic agricultural production methods also emit less greenhouse gases through more efficient use of fuels. Energy analysis of the FST by Dr. Pimentel show that organic systems use only 63% of the energy input used by the conventional corn



Notice the difference in the richness of the soil at 1% (left) and 5% (right) carbon.

In addition to capturing less carbon in soil, conventional agricultural production methods also emit greater greenhouse gases and require the hazardous use of chemical fertilizers and pesticides.

and soybean production system. Dr. David Pimentel's findings show that the biggest energy input, by far, in the conventional corn and soybean system is nitrogen fertilizer for corn, followed by herbicides for both corn and soybean production. In our organic approach, winter annual legumes provide the nitrogen naturally at a small fraction of the chemical cost in all its facets -economically, environmentally and to our health.

Organic systems are economically viable

Organic farming also makes economic sense. In addition to reducing input costs, economic analysis by James Hanson, Ph.D. of the University of Maryland has shown that organic systems in the FST are competitive in returns with conventional corn and soybean farming, even without organic price premiums. Numerous studies point to long term organic corn yield surpassing conventional ones. Perhaps just as important, all our yields have exceeded the country conventional farmer average.

International and state response

Calls for an African Green Revolution based on conventional farming methods will only make matters worse. We are losing ground as the Sahara Desert continues to expand southward because of misdirected land management and it is time to shift the chemical paradigm. In Zimbabwe, the droughts that cause famine are clearly associated with El Nino effects. Unfortunately, problems which are rooted in the soil are now being attributed to lack of synthetic fertilizer, insufficient genetically modified food crop varieties, and lack of pesticide availability. The call for a Green Revolution must be rooted in the soil and not in false hopes and promises based on magical potions with their proven history of health and environmental destruction. We can, and indeed we must, do better.

However, in Europe, scientist consultant groups from Netherlands and Germany have reviewed our findings and use them to incorporate organic farming targets as a part of their greenhouse gas targets for their roadmap and strategies.

In addition, we have been actively involved with Pennsylvania, New Mexico, and Northeast Regional Greenhouse Gas Working Groups. We intend to be at the table to have a positive impact on agriculture and food policies in relation to greenhouse gas issues. This is particularly important because business as usual will not resolve the challenges we have ahead of us.

Conclusion

The presence of sequestered carbon in FST organic field trials is an indicator of healthy soil that has an abundance of carbonaceous matter, in particular the organic material humus. It is humus that enables healthy soils to retain water during periods of drought. Each pound or kilogram of dry soil organic matter can absorb 20 times its weight in water. It is humus that retains mobile nutrients found in soils such as phosphates and nitrates, that would otherwise be lost as runoff to streams and aquifers.

These trials illustrate that economic benefit as well as environmental protection can and should work together hand in hand. The economic benefits are realized by farmers and landowners who see reduced costs for fertilizer, energy and fuels requirement, irrigation needs, and increased crop yields and quality at the same time. It is also economically beneficial to the agricultural business economy, and an environmental benefit to all of us, that specific soil management and tillage practices can help to sequester or retain carbon in the soil – carbon that would otherwise be lost to the atmosphere as a component of the growing greenhouse gas menace.

In conclusion, organic farming can reduce the output of carbon dioxide by 37-50%, reduce costs for the farmer, and increase our planet's ability to positively absorb and utilize greenhouse gases. These methods maximize benefits for the individual farmer as well as for society as a whole. It is a winning strategy with multiple benefits and low comparative risk. These proven approaches mitigate current environmental damages and promote a cleaner and safer world for future generations.

Creating incentives and taking action

While credits for no till farming are now fully established, to elevate the response to climate change we must extend those credits to organic practices, including cover cropping, compost addition, rotation and other methods. There is a continuing need to develop verified methods and real time estimation of sequestration rates. We believe that this can be achieved by utilizing a combination of process- and performance-based standards as a way of confirming and conferring greenhouse gas credits.

Each and every one of us needs to look ourselves in the mirror and ask, "How can I contribute to easing the burden of our collective planetary debt?" In terms of the food system, it can start with consumers consciously eating local organic, producing their own food wherever possible, and even reducing feedlot beef consumption. As individuals, let us start this journey to the future by dedicating ourselves to doing the small things we can do. Then, as a collective, let us work together to do the rest of the job. We can and we must.

Paul Hepperly, Ph.D., the New Farm research and training manager at the The Rodale Institute in Kutztown, Pennsylvania, is an expert in the field of carbon sequestration in organic systems. He grew up on a family farm in Illinois and holds Ph.D. and M.Sc. degrees in plant pathology and crop sciences from the University of Illinois at Champaign-Urbana.

Local Organic: The Best Approach

Part of the problem in our present food system is its centralized nature. Spinach can grow fine in Pennsylvania, but it usually is shipped from California where it is grown on subsidized water shipped hundreds of miles from its source. In the transformation of this inefficient and often unhealthy system of food, we need to engage consumers in the values local organic food resources represent. Combining organic and local is the strongest tandem concept for improving the food system, people's health, and the health of the air, water, and soil.

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