Union of Concerned Scientists

Agricultural Practices and Carbon Sequestration

FACT SHEET

OCTOBER 1, 2009

One of agriculture's major opportunities to help mitigate the effects of climate-warming gases lies in management of soil to increase organic content, thereby removing carbon from the atmosphere. Many scientists are conducting studies to determine which agricultural practices will in fact sequester carbon. Recent studies, summarized below, demonstrate that a number of biological, soil-based practices employed in integrated systems have great potential to sequester carbon. In contrast, recent studies suggest that no-till, a form of conservation tillage, has environmental benefits such as reducing soil erosion, but may not sequester more carbon than conventional tillage (plowing).

Integrated soil-based practices

The most promising systems for carbon sequestration in soil combine crop rotation and low or no inputs of pesticides, herbicides, and industrial fertilizers. Long-term studies done by the Rodale Institute and others suggest that such systems build (not simply conserve) significant quantities of soil organic carbon through a variety of mechanisms such as enhanced abundance of mycorrhizal fungi. Several studies, including some done over long periods of time, have compared carbon accumulation in organic (plowed) and conventional (plowed) systems[1] and demonstrate that organic systems sequester more carbon than conventional chemical-intensive systems.

In a head-to-head comparison between conventional no-till and organic plowed systems, organic plowed systems sequestered more carbon even though the sampling was restricted to shallow soil, where no-till tends to show carbon accumulation.[2] Although more studies are needed, there are good reasons to believe that organic systems would do at least as well as conventional systems deeper in the soil. Current organic systems typically employ plowing to control weeds, and conventional plowed systems generally sequester more carbon at greater soil depths than no-till (discussed below).[3]

Systems that use crop rotations and green and animal manure have shown higher biodiversity by foregoing chemical pesticides, supplying more diverse habitats,[4] and reducing nitrogen pollution. Systems that integrate livestock and crops, employ perennial pastures, and adopt many of the practices used in organic production (e.g., long crop rotations, leguminous crops and cover crops, manure produced by livestock as fertilizer) also have shown potential for improved greenhouse gas balance, reduced pollution, and higher profitability. Further research on these promising approaches will help optimize their benefits and determine their applicability across geographic regions.

In summary, available data suggest that organic and near-organic farming systems achieve greater carbon sequestration and other benefits compared with conventional systems. Further work, supported by adequate research funding, is needed to realize the promise of these biologically sophisticated production systems.

No-till practices

Scientific evidence accumulated over the last two years has called into question the long-held view that no-till practices result in significant accumulations of carbon in the soil. The most important of these reports are:

- Baker, J.M., et al. 2007. Tillage and soil carbon sequestration—What do we really know? *Agriculture, Ecosystems and Environment* 118:1–5.

This landmark review of the scientific literature found that no-till fields sequestered no more carbon than plowed fields. Most previous studies measured carbon sequestration only down to about 30 cm. For example, a review often used to support no-till as a means to sequester soil carbon cited 140 studies, none of which measured soil carbon below 30 cm.[5] However, the roots of crops—which deposit carbon in the soil—often grow much deeper. In a review paper cited in Baker et al. that examined carbon changes to soil depths greater than 30 cm, most (35 of 51) of the studies found no

significant difference in carbon sequestration between plowing and no-till. In fact, on average, the no-till systems may have lost some carbon over the period of the experiments. In summary, no-till tends to show increased carbon at shallow depths where crop residues are found, but at greater depths plowed soils typically sequester more carbon.

- Blanco-Canqui, H., and R. Lal. 2008. No-tillage and soil-profile carbon sequestration: An on-farm assessment. *Soil Science Society of America Journal* 72:693–701.

This research compared soil carbon between plowed fields and fields managed with no-till practices for up to 30 years on actual farms (as opposed to controlled field tests) in three eastern states, using paired sites on each farm. Most of the sites showed no statistical differences between no-till and plowed fields in soil carbon accumulation when carbon from the entire soil profile (including depths below 30 cm) was measured. Three of the 11 sites had greater soil carbon accumulation in the plowed fields than in the no-till fields. The paper also reviewed 16 studies from around the world that examined carbon sequestration at soil depths greater than 30 cm and found similar results.

- Poirier, V., et al. 2009. Interactive effects of tillage and mineral fertilization on soil carbon profiles. *Soil Science Society of America Journal* 73:255–261.

This study of sites in Quebec, Canada, over a period of three years also found that the amount of sequestered carbon did not differ between no-till and plowing. These authors also found higher carbon accumulation from no-till only where the top several centimeters of soil were measured. When the measurements included the entire soil profile, the higher carbon accumulation in plowed fields at lower depths compensated for the lower amount of carbon near the soil surface. Different fertilization rates did not alter these results.

Summary of the science

The current scientific literature does not support favoring no-till over plowing for carbon sequestration. Recent reviews suggest that under a variety of environmental conditions no-till sequesters no more carbon than plowing. Additional studies with attention to sampling soils deep in the profile and over appropriately long time scales are needed to determine whether the effects of no-till vary depending on soil type, and agricultural system, and local climate. The apparent carbon sequestration advantage for no-till inferred from previous studies likely reflects the tendency to sample carbon only near the soil surface.

---

[1] Drinkwater, L., et al. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature* 396:262–265; Pimentel, D. 2005. Environmental, energetic and economic comparisons of organic and conventional farming systems. *BioScience* 55:573–582; Marriott, E.E., and M.M. Wander. 2006. Total and labile soil organic matter in organic and conventional farming systems. *Soil Society of America Journal* 70: 950–959.
[2] Teasdale, J.R. 2007. Potential long-term benefits of no-tillage and organic cropping systems for grain production and soil improvement. *Agronomy Journal* 99:1297–1305.
[3] Baker, J.M., et al. 2007. Tillage and soil carbon sequestration—What do we really know? *Agriculture, Ecosystems and Environment* 118:1–5.
[4] Gabriel, D., et al. 2006. Beta diversity at different special scales: Plant communities in organic and conventional agriculture. *Ecological Applications* 16:2011–2021.
[5] West, T.O., and W.M. Post. 2002. Soil organic carbon sequestration rates by tillage and crop rotation: A global data analysis. *Soil Science Society of America Journal* 66:1930–1946.

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

National Headquarters
Two Brattle Square
Cambridge, MA 02238-9105
Phone: (617) 547-5552
Fax: (617) 864-9405

Washington, DC, Office
1825 K St. NW, Ste. 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

For more information, please contact Dr. Margaret Mellon at 202-331-5432 or Dr. Doug Gurian-Sherman at 202-331-5436.