



Newsletter of the National Sustainable Agriculture Information Service: A project of the National Center for Appropriate Technology (NCAT)

Finding the Best Ways to Revive and Protect the Living Soil

Thanks to recent research, we are learning more about the diverse biological community that forms the soil, and how to keep that community healthy. This issue of ATTRAnews looks at why soil conservation is important, and how farmers and ranchers across the nation can learn from on-farm research that's taking place around the world.

Soil Organic Matter "Banks" Water for the Future

Rex Dufour, NCAT Technical Specialist

Soil holds water according to its texture. However, the level of organic matter also determines how much water a particular soil can hold.

For every 1 percent of organic matter content, the soil can hold roughly 16,500 gallons of plant-available water per acre of soil down to 1 foot deep. That is roughly 1.5 quarts of water per cubic foot of soil for each percent of organic matter. The graph shows the relationship of organic matter to water-holding capacity.

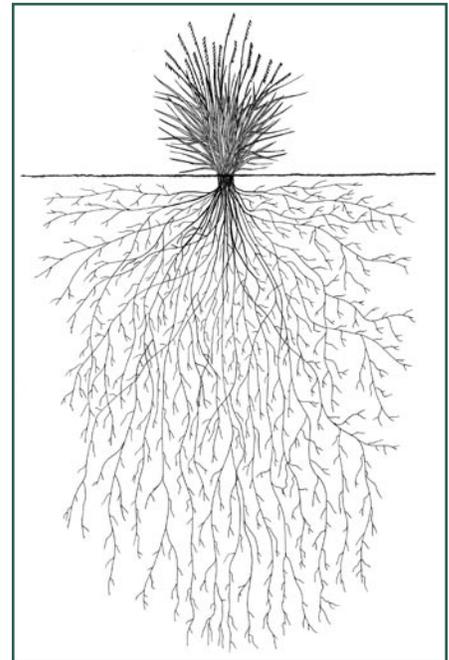
As global warming takes hold, all computer models predict that there will be periods of greater rainfall intensity as well as drought. Farmers can prepare their farmland for this by increasing the percentage of organic matter in their soils. Well-tested techniques to do this are no-till (organic farmers can use roller crimpers!), minimum till, compost

applications, crop rotations, and cover crops and green manures.

All these techniques help build soil health and soil organic matter, which in turn will allow for greater infiltration of the rain that does fall, reducing erosion and increasing the moisture-holding capacity of the soil.

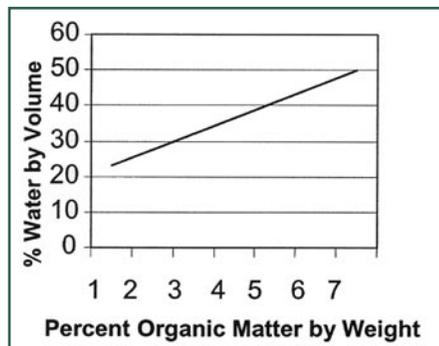
Particularly during low-rainfall years, farmers who have good levels of organic matter in their soils will maintain better yields compared to their neighbors with low soil organic matter and low soil moisture-holding capacity.

Well-managed soils have many other beneficial effects on plant health and on livestock and human health, too. The USDA's Natural Resource Conservation Service (NRCS) has programs such as EQIP, the Environmental Quality Incentive Program, that will pay farmers some of the costs of implementing many of these



Extensive root systems of plants like this Side Oats Grama grass can support a healthy community of soil micro-organisms. Drawing: Dr. James Nardi, University of Illinois at Urbana-Champaign.

soil conservation techniques. Check in your phone book for the nearest USDA Service Center and ask them about their programs.



Graph from Hudson, B. E. 1994. "Soil organic matter and available water capacity." *Journal of Soil & Water Conservation*. Vol. 49 #2.

Find Out More About the Hidden World in the Soil

The Soil Biology Primer is an excellent place to learn about the complex interactions of the soil food web. Written by Dr. Elaine Ingham and others for the Soil Quality Institute of the Natural Resource Conservation Service, the *Primer* is published by the Soil and Water Conservation Society (www.swcs.org). It is available free online:

www.urbanext.uiuc.edu/soil/SoilBiology/soil_biology_primer.htm

Learn more about **Soil Biological Communities** of the arid West at the informative Web site of the Idaho office of the Bureau of Land Management. Great photos of the microscopic fungi, bacteria, protozoa, and nematodes that populate the soil food web: www.blm.gov/nstc/soil

Inside:

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On-Farm ResearchPage 2
University Research ProgramsPage 2

Soil Health, Plant Health,
Our HealthPage 3

Farm Aid Farmer Resource Network ...Page 4
New and Updated PublicationsPage 4

On-Farm Research Open to All

Over the past decade there has been a remarkable increase in research about sustainable soil management and farming systems. University farms are experimenting with various agricultural practices, including organic methods. Farmers and ranchers are also teaming up with researchers to track comparisons on real farms, away from the university setting. Many of the research results are posted on the Internet, so it's possible to learn about promising new directions for experimentation. Here are some Web sites that offer research reports and the results of all this new work.

Midwest Organic and Sustainable Education Service (MOSES) sponsors workshops, a February conference, a Research Symposium:
www.mosesorganic.org/research.html and other projects: www.mosesorganic.org

Organic Center promotes credible peer-reviewed scientific studies about organic production and food safety: www.organic-center.org

Organic Eprints was developed by the Danish Research Center for Organic Farming as an open archive for organic research reports from around the world. Most of these include English abstracts: www.orgprints.org

Organic Farming Research Foundation has raised money and campaigned for more organic research since 1990. Their 2007 National Organic Research Agenda suggests future priorities: www.ofrf.org/publications/publications.html. OFRF-funded project reports can be found at: www.ofrf.org/funded/funded.html

Sustainable Agriculture Research and Education (USDA SARE) provides a searchable database of the thousands of groundbreaking Farmer-Rancher grants and other projects it has funded since 1988: www.sare.org/projects

Universities with Outstanding Organic Research Programs

Center for Environmental Farming Systems, North Carolina State University and North Carolina A&T State University: www.cefs.ncsu.edu

Cornell Univ. Organic Research: www.organic.cornell.edu/research/index.html

Iowa State Organic Ag. Program: <http://extension.agron.iastate.edu/organicag>

University of Minnesota Organic Ecology: www.organicecology.umn.edu

Washington State University Organic Farming Systems & Nutrient Management: www.puyallup.wsu.edu/soilmgmt/SusAg.htm



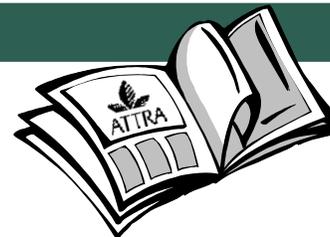
Fungal Hyphae.
Drawing by Dr. James B. Nardi, University of Illinois at Urbana-Champaign.

Root-dwelling fungi secrete a sticky protein known as glomalin through their hair-like filaments, which are called fungal hyphae. Glomalin enhances soil stability by binding soil particles into water-stable aggregates that resist erosion. Scientists are finding that glomalin indicates the presence of the hard-to-track microscopic fungi. See "Using Glomalin as an Indicator for Arbuscular Mycorrhizal Hyphal Growth" by C. Lovelock, S. Wright, and K. Nichols in *Soil Biology and Chemistry* March 2004: www.ars.usda.gov/research/publications/publications.htm?seq_no_115=150316

The National Agricultural Library's Alternative Farming Systems Information Center provides helpful links to many research databases: www.nal.usda.gov/afsic/pubs/intlresearch.shtml

ATTRA Publications about Soil Management

In addition to the publications listed here, ATTRA offers hundreds more that provide general information and specific details about all aspects of sustainable and organic agriculture. They are available to download for free from ATTRA's Web site: www.attra.ncat.org Or call 1-800-346-9140 to order a free paper copy.



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| Alternative Soil Amendments | Nutrient Cycling in Pastures |
| Alternative Soil Testing Laboratories | Overview of Cover Crops and Green Manures |
| Arsenic in Poultry Litter: Organic Regulations | Potting Mixes for Certified Organic Production |
| Assessing the Pasture Soil Resource | Pursuing Conservation Tillage Systems for Organic Crop Production |
| Biodynamic Farming & Compost Preparation | Rye as a Cover Crop |
| A Brief Overview of Nutrient Cycling in Pastures | Soil Management: National Organic Program Regulations |
| Drought Resistant Soil | Soil Moisture Monitoring: Low-Cost Tools and Methods |
| Farm-Scale Composting Resource List | Sources of Organic Fertilizers and Amendments |
| Foliar Fertilization | Symphyllans: Soil Pest Management Options |
| El Manejo Sostenible de Suelos | Sustainable Soil Management |
| Manures for Organic Crop Production | Sustainable Management of Soil-Borne Plant Diseases |
| Notes on Compost Teas | Worms for Composting (Vermicomposting) |

Soil Health, Plant Health, Our Health

Rex Dufour, NCAT Technical Specialist

We are what we eat. This folk wisdom relates to plant health as well as to human health. Any organism that is provided a poor diet will be susceptible to a variety of ills and unable to grow well and be vigorous.

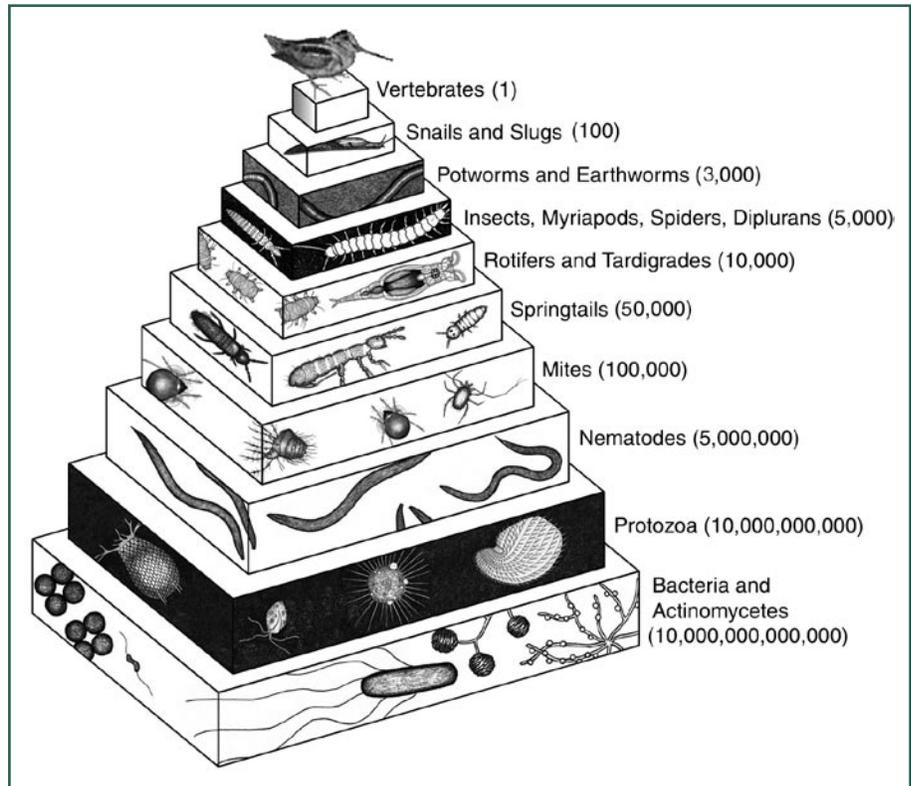
The soil is the primary source of nutrition for plants. When the soil is unhealthy, with low levels of organic matter, poor biological activity, and subsequent imbalances of nutrients, plants growing in that soil are likely to be more susceptible to attacks by various pests and diseases, and less able to respond and recover from these attacks. Plant pest problems may only be symptoms of an underlying problem – poor soil health.

The soil is the most complex ecosystem on earth, and we are only beginning to understand how this complexity relates to plant health. Consider that plants have evolved over hundreds of millions of years in non-agricultural systems. Over the millennia, plants have developed strategies and partnerships with soil organisms that enable plants to access the water and nutrients needed to successfully grow and reproduce.

Many soils around the country are in poor shape from excessive chemical and physical disturbance. Adding synthetic chemical fertilizers to these soils creates a situation in which a few nutrients suddenly become available in amounts that plants are evolutionarily unprepared to deal with. In some cases, such as the use of anhydrous ammonia, the act of fertilizing is directly destructive to the soil ecology. (See *Agronomy of Grassland Systems* by C.J. Pearson and R.L. Ison, 1987, Cambridge Univ. Press, p. 77.)

The effects of good soil management on plant health can be difficult to quantify because we are just beginning to understand enough to ask the right questions. However, the harmful effects of bad soil management are obvious, particularly when plants are under stress.

It's clear that good soil management has many positive impacts on plant health and likely on human health, too. The take-home message is that



The tremendous complexity of the soil food web is hard to comprehend. This drawing illustrates the estimated number of soil organisms that exist for every vertebrate animal, such as the bird at the top of the pyramid. Drawing by Dr. James B. Nardi, University of Illinois at Urbana-Champaign.

maintaining and increasing soil organic matter promotes soil health as well as the health of plants and humans.

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Some interesting tidbits from peer-reviewed articles about effects of pesticides and chemical fertilizers on soils and pests:

- This study showed a significantly higher occurrence of insect-harming fungal diseases in soils from fields of organically managed farms. "Effects of farming system, field margins and bait insect on the occurrence of insect pathogenic fungi in soils" by I. Klingen, J. Eilenberg, and R. Meadow in *Agriculture, Ecosystems and Environment*, 2002, 91(1/3): 191-198.
- Several fungal diseases, such as rust and powdery mildew, are enhanced by high levels of nitrogen, particularly in the form of nitrate. Many bacterial

diseases are promoted by high nitrogen levels as well. "Nitrogen form and plant disease" by D.M. Huber and R.D. Watson in *Annual Review of Phytopathology*, 1974, 12:139-165.

- Glyphosate (Roundup™) has been shown to enhance the development of root disease and inhibit the systemic acquired resistance response. "Glyphosate treatment of bean seedlings causes short-term increases in Pythium populations and damping off potential in soils" by R.C. Descalzo, Z.K. Punja, C.A. Levesque, J.E. Rahe in *Applied Soil Ecology* 1998, 8:25-33.
- Plants that are high in nitrogen also support large aphid or leafhopper populations and are often more susceptible to virus infection. "Cropping practices and virus spread" by J.M. Thresh in *Annual Review of Phytopathology*, 1982, 20:193-218.

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Thank you for helping us conserve resources!

Farm Aid's Farmer Resource Network: A New Sustainable Agriculture Tool for Beginning and Experienced Farmers

The nonprofit organization Farm Aid has launched an online Farmer Resource Network to help farmers answer the demand for high-quality, family-farmed foods.

The Farmer Resource Network connects family farmers to hundreds of organizations that are developing new approaches to production and marketing. These practical innovations provide the support farmers need to sustain their land, grow good food, and benefit from greater consistency and economic stability on their farms.

Farm Aid's national partners in launching the Farmer Resource Network include NCAT/ATTRA, the Organic Farming Research Foundation, and Rodale Institute. The online resource database of the Farmer Resource Network can be searched at www.farmaid.org/ideas.

Farm Aid's mission is to build a vibrant family farm-centered system of agriculture in America. For the past 23 years, Farm Aid board members and musicians Willie Nelson, Neil Young and John Mellencamp have hosted an annual concert to raise funds to support Farm Aid's work with family farmers and to inspire people to choose family-farmed food.



This tent banner at the September Farm Aid concert outside Boston announces the Farmer Resource Network partnership between Farm Aid, ATTRA/NCAT, the Rodale Institute, and the Organic Farming Research Foundation. Photo: Jeff Birkby, NCAT.

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New & Updated Publications from ATTRA

Organic Standards for Livestock Production: Highlights of the USDA's National Organic Program Regulations

Organic Standards for Crop Production: Highlights of the USDA's National Organic Program Regulations

Organic Standards for Handling (Processing): Highlights of the USDA's National Organic Program Regulations

Illustrated Guide to Sheep and Goat Production

Guía Ilustrada a la Producción de Ovinos y Caprinos

New Markets for Your Crops

ATTRAnews

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