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ATTRAnews

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Healthy Soils Can Help Manage Pests

Healthy soils are complex, dynamic ecosystems that interact with many other organisms—both above and below ground—through an incredible web of life. Researchers are just beginning to understand the interactions within these diverse underground communities. One thing is clear: it pays to nurture the soil by following nature's lead. Keep disturbance (both physical and chemical) to a minimum. Keep the soil covered. Add organic matter.

In this issue we look at some of the interactions and relationships between insects, fungi and other micro-organisms that work together to keep plants productive.

Top right:
A robber fly hangs by its front legs as it consumes a fly. (Photo: T. Beth Kinsey, www.fireflyforest.net)

Bottom right:
Onion maggot flies are active above ground and below ground at various stages of their life cycle. (Photo: B. Lyon, Purdue University Extension)

Healthy soils provide many invisible services that support the production of healthy crops and livestock. Orrsop's Fable presents a tiny slice of that picture which, even if multiplied by a million, would still underestimate the complexity of these systems.

Orrsop's Fable: Many Little Hammers

As retold by NCAT Specialist Rex Dufour with thanks to David Orr, entomologist at North Carolina State University

Once upon a time in Michigan, there was a fellow researching onion maggots. His laboratory insects died out due to pesticide residues in the onions, so a graduate student suggested they use organic onions. That solved the problem, but raised a question in the researcher's mind. He'd been told that you couldn't grow onions in Michigan without pesticides, but clearly someone was doing it. (This was in the days before national distribution of vegetables was common.)

So he and some students went to visit the organic onion farmer. They found a small farm next to a pasture. The farmer was able to grow onions profitably. When they looked closely at the farm, they found a wasp parasite that attacked the fly larvae living in the cow patties in the pasture next door. That wasp also parasitized the onion maggots.

Some weeds were growing between the beds of onions. The researchers found adult onion maggot flies on the tips of the weeds. The flies were dead, killed by a fungus that was now spreading spores from the dead flies, to the farmer's benefit.

The researchers also found a high population of robber flies preying on the onion maggot flies. Robber flies are generally larger flies that capture their prey "on the wing" and then pierce the soft membrane between the head and thorax of their prey and suck out the juices...but I digress. An interesting fact of robber fly life is that their larvae are parasites of earthworms. So in order to have a high population of robber flies, you need a high population of earthworms. Earthworms require healthy soil with a good amount of organic matter.

Moral of the Story

Silver bullets only exist in fairy tales, but healthy ecologies have "many little hammers"—lots of checks and balances that provide important services, even if we don't know about them.

Plant Roots Call in the Cavalry

Over the past 10 years, corn farmers in Europe have suffered crop losses from an invasive North American pest, the Western Corn Rootworm. Researchers studying the damaged fields found something remarkable. They noticed that when the adult rootworm beetles began to feed on corn leaves, the plant roots sent out a chemical signal that attracts beneficial nematodes. These nematodes prey on rootworms—the beetle larvae—and reduce crop damage.

The roots of teosinte—the Mexican wild corn that is the ancestor of today's varieties—also emit a nematode-attracting chemical when their leaves are attacked by this pest. However, most modern North American corn varieties do not produce the signal. Field experiments showed a five times greater nematode infection rate on rootworm larvae in a corn variety that produces the signal than on a variety that does not. Researchers speculate that this self-protective ability was lost during the commercial plant-breeding process. Now plant breeders may try to select corn varieties that attract beneficial nematodes, yet another tool in the pest management tool box.

(Reference: Recruitment of entomopathogenic nematodes by insect-damaged maize roots. Sergio Rasmann et al. Nature, 2005.)

Inside:

Ecological Pest Management Online Database

ATTRA's online search tool helps you find the least toxic ways to manage pest problems. It provides details on biorational pesticides and prevention techniques to manage hundreds of insect pests, weeds, plant diseases, and nematodes as well as snails, slugs and vertebrate pests.

One major downfall of conventional pesticides is that they can damage a wide spectrum of living creatures—not just the target pest.

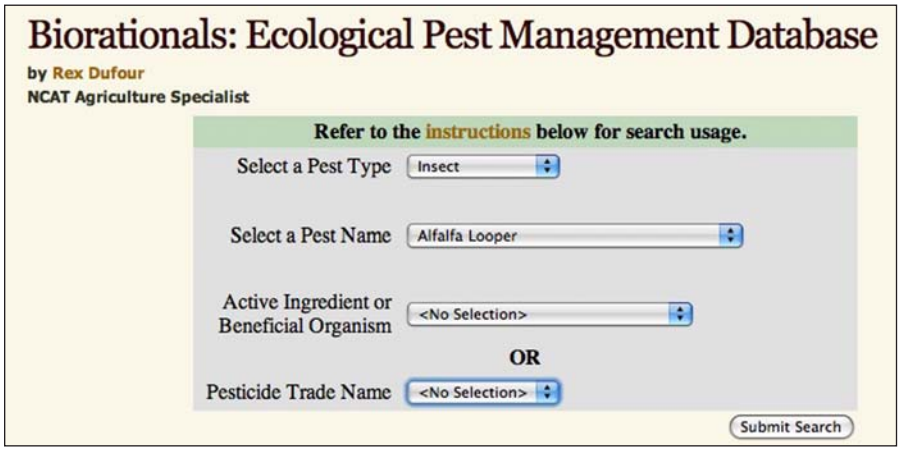
Ecological systems are highly complex, with many checks and balances. Elements of these systems can be unintentionally destroyed by over-reliance on "hard" chemical pesticides. If the natural controls are eliminated, then the pests take over. ATTRA's ecological pest management database provides softer pest management options that help avoid harm to non-target organisms.

What are Biorational Pesticides?

Although there is no universally accepted definition, ATTRA's database uses "biorational" to refer to a class of "softer" pesticides in one of the following categories:

- Microbial pesticides: formulations of viruses, bacteria, fungi, or nematodes that have low non-target impacts
- Pesticides derived from plants that have low non-target impacts and degrade into non-toxic components
- Various new types of pesticides, such as particle film barriers, pheromones, and compounds like Spinosad that have low non-target impacts and degrade into non-toxic components

You can use the database to search for materials and ways to control a specific pest. Or you can use it to find information about pesticide trade names and labels, active ingredients, beneficial organisms, and the manufacturers of all these materials. See the database on ATTRA's home page and at *www.attra.org/attra-pub/biorationals*



Resources on Soils and Ecological Pest Management

Sustainable Management of Soil-borne Plant Diseases is an ATTRA publication that explains the correlation between plant diseases and reduced biodiversity of soil organisms. Download from the ATTRA website for free.

Building Soils for Better Crops by Fred Magdoff and Harold Van Es. USDA-SARE, 3rd edition 2009. The complex interactions within the soil are explained here in practical, easy-to-understand terms. This 3rd edition has been refined, revised and expanded. Download free: *www.sare.org/publications/soils.htm*

Rhizosphere and Symbiosis is an online collection of illustrations and explanations about life in the root zone. This is just one section of Morning Earth, a website linking ecology and art. *www.morning-earth.org/graphic-E/Biosphere/Bios-C-PlantsNew.html#rhizosphere*

Sustainable Soils: The Place of Organic Matter in Sustaining Soils and Their Productivity by Benjamin Wolf and George H. Snyder. Haworth Press, 2003. This book explains the vital importance of soil organic matter, and how and why to protect and increase it in farm soils.

The following publications about soils and pest management can be downloaded for free from the ATTRA website, *www.attra.ncat.org.* Or call 800-346-9140 for a free print copy.

- A Brief Overview of Nutrient Cycling in Pastures
- Alternative Soil Testing Laboratories
- Assessing the Pasture Soil Resource
- Biodynamic Farming & Compost Preparation
- Biointensive Integrated Pest Management
- Companion Planting: Basic Concepts & Resources
- Converting Cropland to Perennial Grassland
- Drought Resistant Soil
- Farm-Scale Composting Resource List
- Farmscaping to Enhance Biological Control
- Intercropping Principles and Production Practices
- Introduction to Permaculture: Concepts and Resources
- Manures for Organic Crop Production
- Notes on Compost Teas
- Organic Chronicles No. 1: Mysteries of Organic Farming Revealed (Also available in Spanish: Las Crónicas Orgánicas)
- Organic IPM Field Guide (online or CD only)
- Overview of Cover Crops and Green Manures
- Pastures: Sustainable Management
- Phenology Web Links: Sequence of Bloom, Floral Calendars, What's in Bloom
- Rye as a Cover Crop
- Sustainable Management of Soil-borne Plant Diseases
- Sustainable Soil Management (Also available in Spanish: El Manejo Sustentable de Suelos)
- Symphylans: Soil Pest Management Options
- Worms for Composting (Vermicomposting)

See ATTRA's pest management publications for information about various specific pest problems. Most ATTRA publications about specific crops have sections on pest management.

Vital Partnerships in the Root Zone

Plants depend on their roots to bring them nutrients for vigorous growth. But in healthy soils, the roots don't operate on their own. They attract other organisms to help them perform their work.

The soil surrounding a plant root can be dense with bacteria and fungi. This is not surprising, since roots exude carbon compounds that the fungi and bacteria need. Using these sugars and acids as fuel, these organisms can give the plant access to the minerals in the soil.

In undisturbed soils, mycorrhizal fungi can form a dense layer on the root surface that may protect it from attack by pests. Some species of mycorrhizal fungi also enter the plant root, providing water and nutrients in exchange for the carbon compounds.

Mycorrhizal networks can "mine" a much larger volume of soil than plant roots could reach by themselves. It seems to be a fair trade. The plant gets access to an extensive supply of water and minerals, and the fungi and bacteria get carbon compounds to help them grow.

In another beneficial interaction, mycorrhizae trigger systemic acquired resistance (SAR) in plants, inducing the plant to produce special compounds that protect it against pest organisms in the soil. There is evidence that the SAR response "primes the pump" for plant defenses against above-ground insect attacks, too.

(Reference: Induced pathogen and insect resistance in Arabidopsis. Vivian R. Van Oosten. Wageningen University, Netherlands. 2007.)

But that's the situation in healthy soils... What happens in unhealthy soils?

In frequently tilled soils, many of the beneficial organisms no longer exist because the organic matter is depleted. Frequent applications of fertilizers and pesticides also reduce populations of earthworms and micro-organisms in the soil. Without these partners, the crops continue to exude carbon compounds—perhaps even greater amounts—in an effort to mobilize minerals or to attract mycorrhizal fungi. However, in less biologically active soil, there is much less competition for the carbon compounds. So it is more likely that harmful species of bacteria, fungi and nematodes will grow and develop in the root zone.

The struggle to produce extra large amounts of carbon compounds may stress the plant, making it more attractive to insect pests. The effort may also reduce the carbon the plant can use for crop production, reducing yields.

(Soil-Root Interface: Biological and Biochemical Processes by H. Marchner. Soil Chemistry & Ecosystem Health, Soil Science Society of America, 1998.)

Above: The interaction between a root tip and mycorrhizal fungi. These fungal strands form a foraging network in the soil around the plant roots, vastly increasing the plant's access to nutrients and water. Photo: Mycorrhizal Applications, www.mycorrhiza.com

Silver Bullets: Ecosystem Disrupters

Recent research shows the complex interactions taking place in the soil and the unintended side effects of over-reliance on "silver bullet" pest management strategies. If combined with poor soil management, some of the issues discussed here could seriously impact farm profitability and sustainability.

The researchers found that glyphosate (a broad-spectrum herbicide that kills weeds) can significantly increase the severity of various plant diseases, impair plant defenses against pathogens, and immobilize soil and plant nutrients, making them unavailable for plant use. Their research found that glyphosate reduces manganese in plants. This element is essential to many defense reactions that protect plants from disease and environmental stress.

In addition to manganese, glyphosate can immobilize other plant nutrients such as copper, potassium, iron, magnesium, calcium, and zinc so they are no longer nutritionally functional. Keep in mind that glyphosate is systemic. So when it is sprayed on a plant, it is absorbed and transported throughout the plant. It accumulates in the roots and is exuded into the root zone.

Many studies have shown that glyphosate is not entirely and immediately immobilized by soil colloids because a portion is available for metabolism by soil and root zone micro-organisms. However, glyphosate is also toxic to some bacteria and fungi, so the net effect is a disruption of soil ecology—some soil and root zone microbes are stimulated, while others are suppressed.

Some other findings of recent research on glyphosate include the following:

- Sprayed weeds in orchard alleys release glyphosate through their dying roots. The chemical can then be taken up through the living roots of orchard trees and may affect their nutrient uptake.
- Glyphosate is able to tie up many cation nutrients, including potassium, calcium, magnesium, iron, copper, zinc, and manganese. This binding ability of glyphosate is a critically important factor in nutrient deficiencies of crops observed in production systems that rely heavily on glyphosate for weed management.
- Previous glyphosate applications (ranging from 18 to 36 months before planting) was the most important agronomic factor in the development of diseases, primarily Fusarium head blight, in wheat and barley crops. Higher Fusarium infection rates of wheat and barley roots were also associated with glyphosate burn-down applications prior to planting.
- Glyphosate use can result in greater numbers of potential fungal pathogens on crops, increases in manganese-oxidizing micro-organisms, and decreases in beneficial bacterial populations (fluorescent pseudomonads, rhizobia) in the root zones of cropping systems that rely on glyphosate-resistant crops.

(Reference: Glyphosate interactions with physiology, nutrition, and diseases of plants: Threat to agricultural sustainability? D. Huber & G.S. Johal. European Journal of Agronomy, 2009. *http://stopogm.net/webfm_send/131)*

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Organic Practices Reduce Phylloxera Damage in Vineyards

Vineyards infested with phylloxera, a serious root pest, do better with organic management than in a conventional system. Researchers at UC Davis found equal numbers of phylloxera in the roots of conventional and organic vines. But the conventional vines suffered significantly more damage from secondary fungal infections as a result of the phylloxera feeding on them.

Root samples of conventionally managed vines showed 31 percent losses, while organically managed vines lost only 9 percent of their roots. The soil types of the two systems were quite similar, except for increased soil organic matter in the organic vineyards. The roots of the organic vines also had higher numbers of the beneficial fungus Trichoderma and lower levels of the disease-causing *Fusarium oxysporum* and Cylindrocarpon species.

(Reference: Grape phylloxera-related root damage in organically and conventionally managed vineyards. Don Lotter, et al. HortScience, 1999.)

New and Updated Publications from ATTRA

- Alternative Pollinators: Native Bees
- Aquaponics: Integration of Hydroponics with Aquaculture
- Assessing the Pasture Soil Resource
- Biochar and Sustainable Agriculture
- Beyond Basic Compensation: Using Bonuses, Profit Sharing and Employee Ownership to Motivate and Retain Workers on Your Farm
- Freeze Protection for Livestock Watering Systems
- Meat Chicken Breeds for Pastured Production
- Pastured Poultry Budgets: Slow Growing Broiler and Organic Comparisons
- Producción de Bovinos: Consideraciones para Productores de Carne y de Leche Basada en Pastoreo (Spanish translation of Cattle Production: Considerations for Pasture-Based Beef and Dairy Producers)
- Sustainable Cotton Production in the Humid South

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