



LAND  
STEWARDSHIP  
PROJECT

# Elaine Ingham & Soil Health: How to Weave a Web of Willing Workers

[www.landstewardshipproject.org/lspsoilbuilders](http://www.landstewardshipproject.org/lspsoilbuilders)

**NOTE:** Dr. Elaine Ingham is a world-renowned microbiologist who is exceptionally skillful when it comes to soil microorganism identification and soil chemistry. Among other things, Ingham has written “the book”—*Soil Biology Primer*—on soil microbiology for the USDA Natural Resources Conservation Service ([www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology](http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology)). In 1996, she started a consulting and education business called Soil Foodweb ([www.soilfoodweb.com](http://www.soilfoodweb.com)). Land Stewardship Project Bridge to Soil Health staffer Shona Snater developed this Q & A fact sheet based on Dr. Ingham’s webinars, online course work, and the resources she has developed around thermo aerobic turned composting systems.

## *What is the fastest way to build fungi in agricultural soils?*

The best practice would be to lay down a layer of fungal compost in the fall with a layer of organic matter on top to feed the growing fungus and protect the inoculum from the elements. Then in the spring time, do it again. Cover crops will also help keep and grow your fungi so you do not need to keep applying compost regularly.

If you do not have your own large compost source, buy a cheap, anaerobic, municipal compost that you can aerate and inoculate from a good, aerobic, small compost source. The good guys will take over the anaerobic organic matter and convert it. Use this to apply as your compost layer.

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***The quickest way to jump-start nutrient cycling in the soil is to make sure you have all your organisms in the soil web food chain present and in the correct ratios.***

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If you cannot apply a compost, other practices you can try include:

- Make a compost tea that you can soak your seed in.
- Lay down a compost extract in the seed furrow, under your seed (no seed treatments).
- Apply compost tea three times to the growing crop: once at true leaf stage, a month later, and then another month later. Check the soil under a microscope two weeks after each spray to see where your populations are at.

## *What is the quickest way to jump-start nutrient cycling in the soil? How do I know when I can cut back on fertilizer?*

The quickest way to jump-start nutrient cycling in the soil is to make sure you have all your organisms in the soil web food chain present and in the correct ratios. By using the techniques listed above, you can reintroduce the needed organisms back into the environment.

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## **Ideal Ratios & Counts for Row Crops (per gram of soil)**

Bacterial: Fungi  
(biomass/gram of soil)  
**= 350:300**

Protozoa (# organisms/gram of soil)  
• Flagellates = **10k+**  
• Amoeba = **10k+**  
• Ciliates = **20 to 100 or less**

Beneficial Nematodes  
(# organisms/gram of soil)  
**= 5-24**  
(bacterial, fungal, and predatory should add up to this number)

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Once the ratios are correct, you can start cutting back on fertilizer, but keep in mind that applying more than 100 pounds of salt\* per acre will start to diminish your microbial populations. You need to keep checking your soil to make sure you do not lose the microbes that you have replaced.

***How do you know when you have achieved the right microbe balance for the crop you are growing?***

You will know you have the correct microorganisms in your compost and soil when your microscope numbers are in the correct ratios. Then it is a matter of increasing all the population numbers together in their correct ratios. Another way to tell your compost is in balance is when weeds do not grow on your compost during the last turns of the pile because there is enough of a fungal presence.

*\* Technically, salts are composed of related numbers of cations (positively charged ions) and anions (negative ions), and readily dissolve in water. Many agricultural soil inputs are salt-based.*

***What is the best way to compost old hay?***

Thermal composting is the best way to compost old hay. When creating the compost with hay that is grown in **conventional** operations, you will need to source protozoa populations to inoculate the pile. To find a protozoan source, collect living leaves and even a little bit of soil from a native plant area such as a prairie, forest, or meadow that has not been disturbed. Take this back home and check under the microscope for protozoa. If they are present, collect more material and brew a compost tea from this source to inoculate the compost pile containing hay.

It is important to find and use the organic matter from these remote sources, because the original, native microorganisms only exist in these small and disappearing areas. Research in Australia has shown that fire retardants, pesticides, and herbicides can affect microbial populations up to 500 miles away. It has become so difficult to find native microbial populations in Idaho that they are on the brink of being eliminated completely, and in some cases may already be extinct.

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### LSP's Soil Builders' Network

The Land Stewardship Project invites crop and livestock farmers to join the Soil Builders' Network to get regular updates on workshops, field days, and on-farm demonstrations, as well as soil health and cover crop research. To sign-up, see [www.landstewardshipproject.org/lspsoilbuilders](http://www.landstewardshipproject.org/lspsoilbuilders). On that page, you will also find links to fact sheets, blogs, podcasts, and videos. More information is also available by contacting these LSP staffers:

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### ***How far do AMF spores travel? Do we still need to be inoculating?***

If you have healthy soil, fungal spores can be dispersed by movement through wind, rain, insects, larger animals, and even people. The fungal populations that exist in your soil grow at the bottom of the O horizon (see image below on the left) and are brought to the surface by the micro and macro organisms. Critters such as worms, beetles, and squirrels digging and moving through the organic horizon help disperse fungal spores.

There are two groups of beneficial fungi to focus on: the **decomposers** and the **mutualists**. The **decomposers** convert dead organic material into fungal biomass and can be seen growing on the surface of dead leaves and wood. Like bacteria, fungi are important for retaining nutrients in the soil. In addition, many fungi produce organic acids as a byproduct and help to increase the accumulation of humic-acid rich organic matter (humus) that is resistant to degradation and may stay in the soil for

hundreds of years. The **mutualists**, also known as mycorrhizal fungi, colonize plant roots. In exchange for carbon from the plant host, mycorrhizal fungi help solubilize phosphorus and bring soil nutrients to the plant. There are two groups within the mutualists: the **endomycorrhizae** and the **ectomycorrhizae**. In agricultural systems focused on growing grasses, row crops, and vegetables, endomycorrhizae is extremely important because it grows into the root cell to exchange nutrients and receive sugars from the plant. Vesicular-arbuscular mycorrhizal fungi (AMF) are a type of endomycorrhizal fungi that specifically forms vesicles (sacs) within the plant root and have been shown to greatly increase nutrient uptake in the plant host. The tree-like image below on the right is a type of AMF fungus growing inside of a plant root where the exchange of nutrients and sugars are taking place between the fungus and the plant.

If you have lost the biology in the top two inches of soil from chemical use, erosion, or tillage, you will need to inoculate to bring back these fungal populations.

