



LIFE UNDER YOUR FEET

I am a soil food-webbie. What does that mean? In a word, when it comes to growing a crop of healthy plants, I think soil microbes should be allowed to play the lead role, with growers playing a supporting role of ensuring that the right conditions exist for the microbes to do their thing. Plants provided with the right mix of soil organisms will thrive on their own—no poisons needed.

I've agreed to write a regular column for this magazine to examine the soil food web—the complex interactions of soil microbes and plants—and explain why I think a better understanding of the soil food web will help growers develop sustainable agricultural practices. I'm a believer in the principles of organic gardening and that growers who follow sustainable practices are better growers.

I've been writing about gardening for 31 years. I'm currently a gardening columnist for the Anchorage Daily News in Alaska, and I co-authored the book “Teaming With Microbes: A Gardener's Guide to The Soil Food Web.”

As a garden writer my job has been to try and reduce any gardening topic to simple terms using 500 words or less. The task of explaining new discoveries that impact gardening, and often hydroponics as well, is not always easy. Case in point: a recent announcement about a group of microorganisms called Crenarchaeota. Crenar... what was that?

Let me digress. Many gardeners recognize that the numbers and diversity of soil organisms are crucial to growing healthy plants. In particular, four types of microorganisms play key roles. The first of these organisms are bacteria and fungi. These are attracted to the root zone by plant exudates present on root tips. Many of the compounds contained in these bacteria and fungi, particularly those contain-

ing nitrogen, are released in plant-usable form in the waste stream produced by the second group of organisms, protozoa and nematodes that feed on the bacteria and fungi. It's a wonderful system. The bacteria and fungi are “fertilizer bags.” The protozoa and nematodes are “fertilizer spreaders.” Since the plant produces the exudates in the root zone, it is in control of obtaining its own nutrients.

We all know that nitrogen plays a key role in the life of plants. What many don't realize is that some plants, namely perennials, trees and shrubs, prefer their nitrogen in the form of ammonium (NH_4^+). Annuals, row crops and certain grasses prefer their nitrogen in nitrate form (NO_3^-). The nitrogen released by the digestion of bacteria and fungi is always in ammonium form. If there is lots of the right kind of bacteria in the soil, they will oxidize this ammonium, meaning oxygen is added to the nitrogen in the ammonium. This results in the formation of nitrites (NO_2^-), which are further oxidized to form nitrates. A Russian microbiologist discovered this biological process, known as nitrification, some 100 years ago. For many years after, biologists believed that bacteria were the only microbes involved in the nitrification process of oxidizing ammonium. Turns out, there's more to the story. These soil bacteria are classified as prokaryotes. Fungi, protozoa and nematodes are eukaryotes. The difference between the two is that prokaryotes do not store DNA in nuclei while eukaryotes do. Humans and plants are eukaryotes.

New Kid on the Block

Enter Archaea, organisms discovered in the 1970s. Now, most soil food-webbies and most other gardeners as well haven't the slightest notion of the existence of Archaea. As the story goes, some microbes once thought to be bacteria were discov-

ered to have very different biochemistry and DNA. Since they were so different from bacteria, scientists put them into a new “domain” called Archaea. These organisms are particularly well adapted to living in extreme environments such as hot springs and really cold soils.

It turns out that some of the Archaea, in particular a group called Crenarchaeota, also oxidize ammonium into nitrites. They are known to be one of the most abundant microbial groups in the ocean. In addition, we now know that soils contain up to 3,000 times more Crenarchaeota than bacteria. This is a lot, given that a teaspoon of soil contains a half-billion to a billion bacteria. What's more, Crenarchaeota operate at depths deeper than ammonium-oxidizing bacteria. As it turns out, Crenarchaeota are the most abundant ammonium oxidizers on earth, a startling discovery and one that's potentially important to sustainable growers.

It's still too early to tell how much of the ammonium in the soil is converted to nitrites by Crenarchaeota and, thus, how important these microbes are to the growth of plants. Who knows? We may find that Crenarchaeota contribute more to nitrification than bacteria.

What is clear, however, is that we are learning new things about the soil food web all the time, and that's a good reason to start this new column in Growing Edge. Stay tuned. 🌱

Jeff Lowenfels is an avid gardener with a special interest in soil biology and sustainable gardening. You can buy the book “Teaming With Microbes: A Gardener's Guide to The Soil Food Web” from the Growing Edge online bookstore (www.growingedge.com/store/books_multimedia.php).