



PRACTICAL USE OF MICROBES IN HYDROPONICS

I have already written about what organisms exist in soil, what they do, why they are important, that the wrong set of organisms can enhance weeds, and that the soil habitat determines what plants can grow, depending on the seeds that are present. These articles appear in previous issues of the Growing Edge, in the Soil Biology Primer (USDA), and in books available from the Sustainable Studies Institute. Check the list of reading materials on www.soilfoodweb.com

We can scientifically determine whether the proper balance of microbes is being achieved. We can determine if the right food web is being established, what is lacking, and whether it is being put to rights. This series of articles will be about a practical approach on how to do what we know has to be done to be sustainable.

Step One: What do you want to grow?

Each plant works to alter the area around its roots to produce a condition that is best for it to grow and flourish. Seeds carry a set of organisms that start the process of altering the soil environment, which help the seed obtain the nutrients it needs to germinate and grow. With the right biological conditions around the seed, germination time is generally half of what is observed when seeds have been sterilized.

As roots grow they produce exudates, which feed certain specific sets of bacteria and fungi. These in turn alter soil pH and forms of available nutrients. This improves the ability of water and air to move to the root zone, as these organisms begin to form aggregates and build soil structure. If the plant can become mycorrhizal, the plant releases specific exudates to encourage those spores to germinate.

The selective factor for distinct plant communities is the soil. The particular factors that work together in the soil to make these conditions right for one to several species

being predominant are organism balances, climate and the characteristics of the parent material.

Extensive soil testing – where biomass of active bacteria, active fungi, total bacteria and total fungi, numbers of flagellates, amoebae, ciliates, and nematodes have been examined – show clear direction to the balances of these organisms in the soil. Early in succession, photosynthetic bacteria are the sole set of microbes, but quickly will be joined by other decomposer bacteria, and then protozoa, which start the process of cycling nutrients into mineral forms.

Bacteria and bacterial predators predominate in low productivity, early successional plant communities. Fungi, fungal-feeding nematodes and fungal-feeding microarthropods will eventually out compete the bacterial-communities, because: (1) dead plant material contains more fungal-foods (cellulose, lignin, complex, not-easy-for-bacteria-to-use foods), (2) bacteria build micro-aggregates and (3) nutrient cycling by predator-prey interactions maintain bacterial populations at stable levels. As larger aggregates are built, more deeply-rooted, more productive, mid-successional plant species can out-compete the earlier, compacted soil requiring plant species (i.e., weeds).

Soil can develop slowly or rapidly, depending on the organisms in the soil and the management the soil receives. Remember that nature can send devastating floods, drought, fires and other disturbances that kill some of this biology in the soil and put the system back into an earlier stage of succession. Of course, humans can also reverse the direction of soil-building through tillage, intense field-burning, and use of chemicals that kill organisms. If a fungicide for example is used, that chemical kills fungi – not just the one or two species of fungi for which the pesticide is being used, but hundreds if not thousands of

individuals of many, many species. What we need to know is how far backwards in succession does any pesticide move soil biology, in order to really understand the impacts of these chemicals on the soil system and therefore on up-coming plant production.

As these mid-successional plant species produce more fungal foods than bacterial, fungi become even more predominant, and shift plant communities to later, more productive successional stages. When trees appear and flourish, the soil will contain much more fungal biomass than bacterial. There are still many millions of bacteria in that soil, just extremely more fungi.

The table (next page) is based on repeated observations of the organisms in the soil around the root systems of these plant species. The plants chosen were in habitats that no pesticides or inorganic fertilizers were used, so that factor is not biasing these results. The plants are listed according to their relative position in succession, with weedy species first, through vegetable to pasture to shrub to forest. Find the plant species that is closest to your desired plant on the list and that will give you a clue to what your plant requires.

In some of these plants, we find there is a range of ratios, depending on the soil parent material (what concentration of different minerals are actually potentially obtainable), the food web present (which does the conversion of the parent material minerals into plant available nutrients for the plant), the previous sets of plants actually present and climate.

(See Table on pg. 22 for examples)

For those who have followed my work, you will note that the ranges have expanded for some plants. As people have backed away from fertilizer inputs but have controlled plant species present, we have noted higher productivity and nutritional value in plants

Fungal-to-Bacterial biomass balance for different plant species

Plant Species	Ratio of fungi to bacteria	Selective conditions
<i>Bacterial-dominated</i>		
Chickweed	0.1 to 0.3	high nitrate, compaction
Thistle	0.1 to 0.5	high nitrate, compaction
Dandelion	0.1 to 0.5	low Ca, high nitrate, compaction
Crab grass	0.3 to 0.6	compaction
Johnson grass	0.3 to 0.8	high nitrate, low Ca, compaction
Bermuda grass	0.4 to 1.0	compaction, nutritional value directly related to the biology in the soil
Watermelon	0.5 to 0.8	
Carrots	0.5 to 1.0	
Tomato	0.75 to 1.0	
Corn	0.8 to 1.5	
Wheat	0.75 to 1.5	
<i>Fungal-dominated</i>		
Rose	2:1 to 5:1	
Rhododendron	2:1 to 10:1	
Blueberry	3:1 to 10:1	
Alder	5:1 to 50:1	likes to have wet feet, ercoid seed can germinate in bacteria which is why this is an early successional tree species and found in wetland areas
Oak	2:1 to 100:1	
Beech	10:1 to 100:1	different species span the range
Maple	3:1 to 500:1	
Pine	10:1 to 1000:1	certain species can start in bacterial and convert soil to fungal very rapidly if the seed carries the mycorrhizal fungi needed, or if an existing mycorrhizal network already exists, i.e., "safe-site"
Cedar	50:1 to 1000:1	
Fir	10:1 to 1000:1	
Hemlock	100:1 to 1000:1	

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that normally disappear with competition from later successional plant species. In other words, as other plants that usually begin to compete with vegetable or row crop plants as fungi become more prevalent are prevented from taking over, then the vegetable or row crop produces better and with greater nutritional value.

Once we reach a fungal to bacterial balance greater than 0.5, it appears that fungal biomass has to be a minimum of 300 micrograms per gram to achieve high production. This is an observation based on thousands of soil samples from all over the world. The idea really gelled in my mind when working with Betsy Ross (Sustainable Growth of Texas) and Merline Olson (Director, Soil Foodweb Australia).

Consider that in a soil where corn is grow-

ing, to achieve a condition of health, where no "plant-life-support-system" is required, i.e., no pesticides or inorganic fertilizer needed, a minimum of 300 micrograms of fungal biomass, with a fungal diameter of over 3 micrometers (no disease fungi prevalent, please) minimum, is required. That means bacteria should be a minimum of 300 micrograms per gram, but no more than that. If bacterial biomass is 1000 micrograms, then fungi need to be 1000 micrograms.

If bacteria are 1,000 micrograms and fungi 300 micrograms, the stage is still set for weeds to grow. 🌿

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