Sources of Beneficial Biology

Written by Dr. Elaine Ingham, Ph.D. and Dr. Carole Ann Rollins, Ph.D.

Biology Available in the Marketplace

It is becoming increasingly more apparent that maintaining adequate levels of beneficial bacteria, fungi, protozoa, nematodes, microarthropods, and mycorrhizal fungi is critical for growing plants without weed problems or without pests or disease impacts, improving nutrient cycling and uptake in proper balance for the plant, reducing water use, and preventing erosion and soil loss.

Essentially, three types of biological materials are available in the marketplace: (1) actively aerated compost tea; (2) compost, worm compost, or castings (vermicast); and (3) various combinations of limited numbers of species that can be added to soil, compost tea, or compost.

Which material is the right one to buy? It depends on what you want to do; there is no one-size-fits-all solution. Discussing your needs with a microbial ecologist might be necessary to understand what exactly is needed to solve particular problems, but the following summary ought to be helpful to most people to reduce confusion.

First, we will discuss the main factors that limit soil organisms and their functions in soil and soilless media for organic growing systems. Then the major groups of organisms and what they do will be reviewed, followed by a discussion of the organisms that can reasonably be expected to be present in the different materials available in the marketplace.

Factors Limiting Activity of Organisms

Temperature, oxygen concentration, humidity and moisture, kinds of food, interactions between organisms, and chemicals present all help to determine which species of microorganisms are active and growing. While only a few species are actively performing their jobs at any particular combination of temperature, moisture, humidity, foods, nutrients, and so on, full diversity is needed. Then, there are always species present that will wake up, given that conditions constantly change. Therefore a huge diversity of different species in each group of organisms is needed in soil or soilless media.

Major Functional Groups

Some of the major groups of beneficial organisms that need to be present for a sustainable growing system are organisms that enhance disease protection, so pesticides are not needed; organisms that convert nutrients tied up in rocks, pebbles, stones, sand, silt, or clay into organic forms; and organisms that eat the organic forms and convert them into plant-available forms of nutrients. If both the nutrient immobilizers and the nutrient mineralizers are present, then there is no need for inorganic fertilizers.

Each Organism Group Performs Particular Functions

A major function of all bacteria and fungi is to hold nutrients in their bodies. They also sequester nutrients in the organic matter they release and the organic matter they help build. If nutrients are held, they do not leach and end up in lakes, rivers, and streams. All the groups of soil life help maintain soil or planting media structure and thereby keep soil or potting mixes aerated, with good drainage (but not too much), resulting in healthier, deeper-growing roots. When roots grow deeper and the soil holds more water, less water is needed to keep plants alive. Let's briefly review what each of the main organism groups does.

Bacteria

All bacteria immobilize nutrients in their biomass—every single nutrient required to keep a cell alive, in the proper balance for living organisms, is retained. Most soil bacteria glue particles of organic matter together to help build structure. When air passageways and hallways are built, water retention and air availability will be adequate and promote root growth. It might seem that bacteria are altruistic, to build structure like this, but of course, they are doing it for a reason. Bacteria need to hold themselves onto surfaces to keep them where their food is being made available, so they glue themselves to leaf and root surfaces. When they attach, then disease

organisms cannot attach in the same place. Thus a protective coating of beneficial organisms, both bacteria and fungi (see the following section), live on the outside of plants and are fed by the plant. Say good-bye to leaf-eating and sap-sucking insects, and disease-causing fungi and viruses!

Fungi

Fungi grow in long threads and bind to leaf, plant, and root surfaces and organic matter. Fungi retain nutrients in their biomass just like bacteria. Fungi also work to suppress disease-causing organisms by improving structure, thus alleviating anaerobic conditions and, in turn, reducing disease-causing organism activity. Fungi are major holders of calcium and major producers, as well as decomposers, of complex carbon compounds such as humic acid. Three types of fungi that most gardeners need to know about are mycorrhizal, saprophytic, and pathogenic (disease causing). Conditions in the soil help to select which of these groups will be active and growing. If there is no air flow, then disease-causing fungi will win the competition for food and space. If conditions are aerobic, with moisture-holding capacity built correctly, then aerobic, beneficial fungi will grow, including beneficial saprophytic (or decomposer) fungi as well as mycorrhizal fungi.

Protozoa

Protozoa primarily eat bacteria. Bacteria retain greater amounts of all types of nutrients, except carbon, relative to protozoa. Thus, when protozoa eat bacteria, they will release those excess nutrients in a form that just happens to be exactly what plants need. This is how plants manage to grow in natural organic systems, without human beings supplying inorganic fertilizer. Remember, every place on this planet was once sterile. Without any inorganic fertilizer provided by humans, soil was built and plants started growing. The most productive systems on this planet are found in natural areas, where people aren't adding anything "to help the plants grow." When human management destroys the life in the soil, then humans are forced to use inorganic fertilizers, with all of the ultimate harm to the environment that entails.

Nematodes

Beneficial nematodes also make nutrients available to plants. Again, just like protozoa, nutrient concentrations inside bacteria and fungi are much greater than what the predator, in this case, nematodes, requires. Some beneficial nematodes eat mainly bacteria, whereas others eat only fungi. Others can only eat other nematodes. Then there is also the bane of agriculture: root-feeding nematodes; they, of course, only eat roots. But beneficial nematodes help build larger spaces in soil structure and stimulate prey groups to grow faster, so there are multiple benefits to a plant-growing system when the good-guy nematodes are present in soil or soilless media.

Sources of Groups of Beneficial Organisms Found in the Marketplace

Aerobic Compost Tea

Compost tea contains active and nonactive sets of bacteria, fungi, protozoa, and nematodes, some of which will be in dormant (spore or cyst) stages. Whatever life was in the compost used to make the tea will be moved into the tea. Therefore the compost must be aerobic, with the right sets of organisms in it, to provide a diversity of different kinds of beneficial organisms. It really isn't important whether the compost was made through thermal processes or through worm action. It just has to be aerobically made and be chock full of good-guy bacteria, fungi, protozoa, and nematodes. If the beneficial species of these organisms are present, then nutrient cycling will also be occurring.

Compost tea is available as fresh tea, which must be used immediately, or as packaged tea, held in an active state in special, breathable containers. There may be very little difference between the quality of fresh tea and what is in a breathable bag, but of course, checking to see exactly what is present in any tea is recommended.

Compost, Worm Castings, and Vermicompost

Compost and worm castings contain both active organisms and dormant spores. Most of the species in compost cannot be grown in lab media, in lab conditions, and thus are unnamed. But in compost and worm castings, the full diversity of beneficial organisms will be present, based on the starting materials and conditions of composting or the process of making worm castings. In aerobic conditions, when adequate aerobic organisms are present, disease organisms cannot cause disease.

The worm casts are the tiny balls of encapsulated organic matter containing an outstanding community

of bacteria, fungi, and protozoa that come from being passed through an earthworm's digestive system. Some beneficial nematodes survive passage through the earthworm's digestive system, as well. Worm compost (vermicompost) includes some microorganisms that did not pass directly through the worm digestive system, but rather, came in contact with the surface of the worm. These microorganisms also suppress disease-causing organisms. High-quality worm compost, which includes the cast, also contains plant growth hormones and a number of enzymes that promote decomposition of plant material. Enzymes, while useful, do not last very long (mere hours to days) and are rapidly consumed by bacteria. Thus the real workhorses of the soil or soilless media are the microorganisms that require a microscope to be seen.

Limited Species Inocula

Cultures of various microorganisms can be packaged in a dry or liquid form. However, less than 0.01 percent of the known species of bacteria or fungi can be grown in lab conditions. While a product containing only a few species of bacteria could add some beneficial organisms, those species have limited conditions in which they will actually do any work in the organic plant-growing system. With only a few of the tens of thousands of species needed to protect plants in all the various weather conditions that are possible in the real world, limited-diversity cultures will not be useful, except on the rare occasions in which most of the life in the soil or soilless medium has been destroyed by chemical treatment.

Some fungal cultures are available to control specific species of disease-causing fungi and pest insects, for example, *Beauveria* or *Trichoderma*, but these should be used only when the pest or disease-causing organism has escaped the normal biological controls found in quality compost, compost tea, worm castings, or vermicompost. The typical mycorrhizal fungi for agricultural crops and commercial trees are available from a number of sources, though most of these mycorrhizal products are basically made by one company in the United States and are resold under various labels.

No commercial companies produce protozoa inocula. Only a few species of nematodes are presently commercially marketed (e.g., *Steinernema* and *Heterorhabditis*). The only place to obtain the full spectrum of beneficial protozoa or nematodes is from compost, worm castings, vermicompost, and compost teas.

Because each set of environmental-plant conditions requires a unique set of active bacterial and/or fungal species, many beneficial species that are needed are missing in dormant or packaged biological products.

Some bacterial or fungal species are known to be quite beneficial, although there are related species that actually cause disease. Care must be taken in isolating and identifying bacteria or fungi in packaged biological products. Some examples of beneficial species found in the marketplace are discussed in the following sections.

Bacillus subtilus

The group of *Bacillus* species of bacteria is known for insect repellency and suppression of specific fungal diseases through the species' production of inhibitory compounds. But there are also disease-causing species within the *Bacillus* group. Different subspecies perform different functions under different conditions. Only use a single species inoculum if you know what environmental conditions that particular species requires and if it can perform the function you want under those conditions.

Pseudomonaa fluorescens

Pseudomonads are a group of species of bacteria known for their pesticide-decomposition ability. But beware, because there are certain species of pseudomonads that are disease causing. Otherwise, the same cautions need to be considered as for *Bacillus* species, as discussed in the preceding section.

Trichoderma sp.

Trichoderma is the name for a group of fungi that parasitizes other fungi. When mildew is in outbreak mode, application of active, growing *Trichoderma* can help ward off that outbreak. Gray mold (botrytis) is another fungal problem easily controlled by parasitic fungi. But *Trichoderma*, regardless of which exact species is used, will also attack and consume beneficial fungi such as mycorrhizal species. If *Trichoderma* is used routinely as a preventative, nearly all fungi may be removed, which will harm plant protection, plant uptake of nutrients, and suppression of a number of different diseases. Do not add any more *Trichoderma* than needed, and once used, the diversity of beneficial fungi that was lost must be replaced.