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JOHN'S CORNER

ORGANIC FERTILIZERS AND NUTRIENTS 33: BIOFERTILIZERS

by John Ferguson

Over the last decade there has been a tremendous increase in our knowledge of how microbes act to acquire or provide nutrients to the soil and plants. We are now learning how to manage these microbes to provide many of the nutrients plants require.

First let's look at exactly what is in a plant, the major and minor nutrients (elements). The following are the average percentages of various elements in whole plants:

Oxygen	45 percent
Carbon	44 percent
Hydrogen	6 percent
Nitrogen	2 percent
Potassium	1.1 percent
Phosphorous	0.4 percent
Sulfur	0.5 percent
Calcium	0.6 percent
Magnesium	0.3 percent

Note the relatively low percentages of nitrogen, phosphorous, and potassium and the high percentages of oxygen, carbon, and hydrogen.

When buying fertilizer, remember how relatively unimportant nitrogen, phosphorous, and potassium really are in the total context. Think in terms of providing to the soil those ingredients that will help maintain the natural balance of nutrients in the soil. When we look at artificial fertilizers we often see very high numbers like 10-10-10 and we are led to believe that plants require these high amounts of nutrients. However, depending on the brand as much as 90% of the nutrients in the artificial fertilizer escapes to the atmosphere or is leached away polluting our rivers and streams. This is why a good organic fertilizer with a 6-2-4 rating will

actually deliver far more total nutrients to the soil (plants) than a synthetic fertilizer with a 10-10-10 rating as it does not leach.

We have to ask ourselves, "How did plants get these nutrients before fertilizers were invented"? The answer is that nature provided these nutrients through the Bio-fertilizers (special microbes) that are part of the beneficial microbe family.

Soil scientists have known for years that bacteria (Rhizobium sp.) colonizing certain plants (legumes) can fix nitrogen from the air into the soil system where plants can get it. In the picture below look at all the nodules where the nitrogen fixing bacteria occur. In a healthy soil (good soil biology), over seeding with a legume like clover can provide more than the nitrogen required by plants for the next growing season with the extra building the long term fertility of the soil.

Photo courtesy of Sustainable Growth Texas

Later we learned that many species of algae living on the soil surface can also fix nitrogen from the air ***IF*** the trace element molybdenum (Mo) is present which acts as a catalyst. Hence, the study of bio-fertilizers was begun. Today we know than many species of microbes can fix nitrogen if given the conditions they need.

A few years ago one of the first textbooks on the subject came out. It had almost 40 contributing authors supplying research from universities all over the world. The book states in the forward that the most important of the biofertilizers are the arbuscular mycorrhizal fungi.

Handbook of Microbial Biofertilizers , M.K. Rai Editor, Food Products Press, 2006, ISBN: 13: 978-1-56022-269-9

The subject is too long and complex for a lot of details here but a few examples how the microbes work.

A good compost contains many of these microbes. As one of my soil books stated, "Using compost as an organic soil amendment stimulates microorganisms to take nitrogen from the air and fix it in the soil where plants can use it. Up to **120 pounds of pure nitrogen can be fixed per acre** per year under ideal eco-conditions."

In previous articles we talked about the importance of trace elements and re-mineralizing our soils by using mineral dusts (green sand, basalt or granite sand, sea minerals, etc.). For other microbes to fix nitrogen (N) from the air they must have these trace minerals available.

If you noticed above that the two nutrients that a plant needs the most of are oxygen (O) and carbon (C), which compose 89% of all the nutrients required by the plant. Most of which are provided by microbes whether directly or indirectly. In order for the microbes in the soil to perform this service they must have energy. They are not in the presence of sunlight nor do they have chlorophyll like higher plants, so the microbes must get their energy from decaying plant or animal matter (carbon containing material) stored in the soil provided by good compost and mulches.

We have known for years that plant growth is often limited by the amount of CO_2available to the plant. C.H. Wadleigh, 1957 USDA Yearbook of Agriculture, "Soils", (p.41). Agronomists and farmers are increasing yields

by adding carbon dioxide (CO_2) to their bag of practices...Carbon dioxide is a basic requirement for plant growth (October 1968, World Farming, p.31).

We have evidence that CO_2 produced by the respiration of microorganisms in the soil is an important factor in the supply of the gas to photosynthesizing plants. A soil rich in decomposing organic matter provides a much higher level of CO_2 in the air just above the soil than a barren, infertile soil. Hence the soil and air will provide the carbon and oxygen required and the plant will grow quicker and stronger.

Arbuscular mycorrhizal fungi along with many other species of fungi grow on the roots of plants (or in the soil) increasing the plants' ability to pull nutrients and water from the soil. Root growth is greatly enhanced when plants and seed are exposed to the fungal spore products (inoculants) prior to planting. These living products can also be applied to growing plants but they have to get into the soil and have contact with the roots to work. Mycorrhizal fungi production works better in soils rich in organic matter with good structure and aeration.

The photo below is from one of my co-authors Mike Amaranthus, PhD whom is a microbiologist specializing in beneficial fungi.

Organic Management for the Professional,Howard Garrett, John Ferguson, and Mike Amaranthus, University of Texas Press, ISBN: 978-0-292-72921-6, 2012.*Note: This book is on how to manage all landscapes large or small without toxic chemicals. It is written in an easy to read and understand format that a professional or homeowner can use.*

In the photo the trees on the right were inoculated with mycorrhizal fungi spores at the time of planting. The research site was in California in soils with high levels of salt. Tremendous growth difference in just 3 years!

Many of the rest of the nutrients that plants require are locked up in soil minerals or rock grains and are not water soluble or available to plants. It is the fungi that produce acids that will dissolve these minerals and allow the nutrient to escape and be absorbed by plants.

Fungi can also absorb excess nutrients from the soil and store them till needed. This process naturally "balances" the minerals in the soil so that maximum availability occurs. For example if excess calcium (Ca) is causing other minerals to be locked up and unavailable, fungi will form calcium oxalate crystals (CaC_2O_4) on their hyphae removing the excess calcium from the soil solution bringing the soil back into balance.

Another example is from one of the silicate minerals found in granite and many clays that is called potassium feldspar ($KAlSi_3O_8$). The acids produced by fungi will dissolve the mineral allowing the potassium (K) to be released and used by plants.

A couple books that should be on every gardeners must read list are:

Teaming with Microbes. 2nd edition, A Gardener's Guide to the Soil Food Web, by Jeff Lowenfels & Wayne Lewis, Timber Press, 2013, *ISBN-13:*9781604691139, ***Highly Recommended***

Teaming With Nutrients, by Jeff Lowenfels, Timber Press, ISBN: 978-1-60469-314-0. This book is about how plants absorb nutrients and use them. It covers plant cell biology and how they work to move water and nutrients into the plant. It explains nutrition from a simple chemistry and microbial point of view.

SUMMARY:

For maximum beauty, productivity and health of our plants (from our turf grass or a rose bush to a fruit tree) we have to have organically rich soils full of microbes. This means we cannot kill them off using dangerous synthetic chemicals. If we follow modern organic methods based on soil biology then nature will provide much of the nutrition that a plant requires.

PROS:

- microbial and mycorrhizal inoculants are very cost effective
- make nutrients available to plants (major, minor and trace)
- does not affect soil acidity
- aerates heavy tight clay soils and helps light sandy soils hold moisture
- increases a plants resistance to insects and disease
- provides nutrients at NO cost!
- corrects many soil problems
- continue to provide benefits every year once established
- many nurseries selling organic products now carry inoculants
- several nurseries are selling compost tea rich in beneficial microbes
- helps prevent salt injury

CONS:

- sometimes hard to find
- limited availability
- killed by artificial fertilizers
- killed by herbicides, fungicides, pesticides and other dangerous chemicals
- killed by chemicals in municipal water supplies.