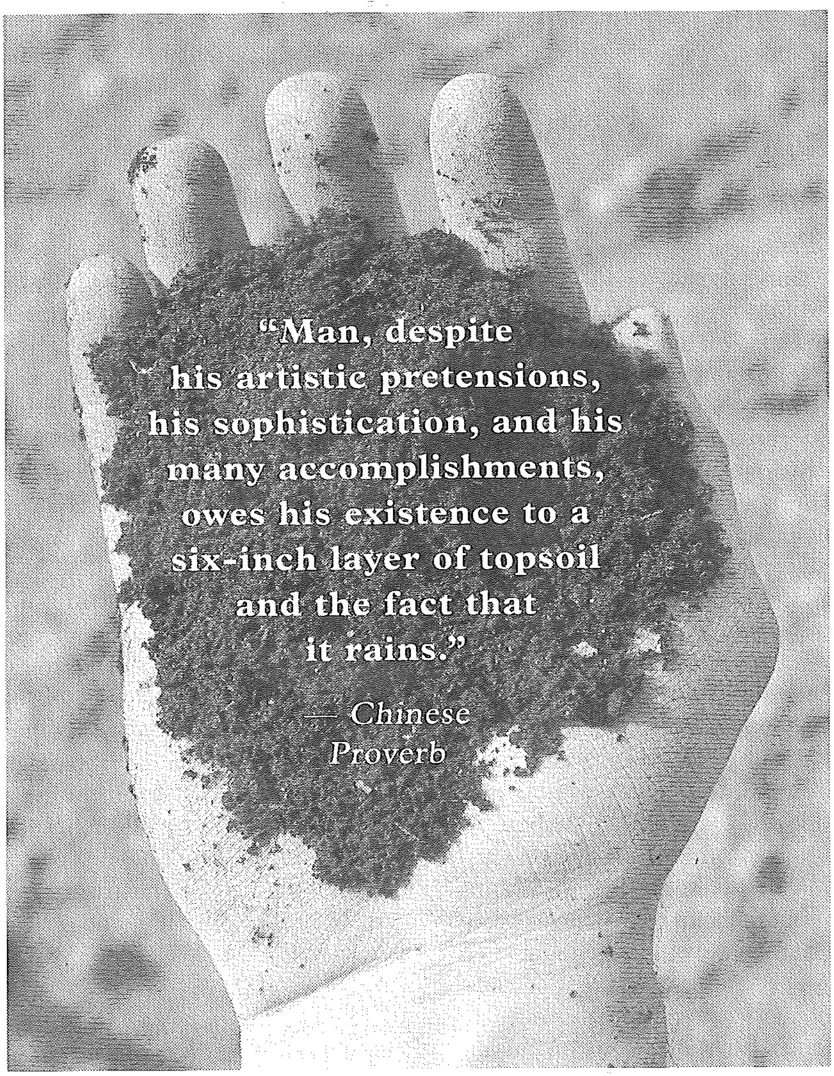
The Proper Care & Feeding of Soil & the Role of Microbes in Sustainable Agriculture



by Bruce & Athena Tainio

With its many facets, from the socioeconomic and political to the environmental, sustainable agriculture can mean many things to many people. Nevertheless, all issues eventually come back around to what lies beneath our feet — the soil, and how we treat it.

The dictionary defines *sustainable* as: "able to be maintained, or conserving an ecological balance by avoiding depletion of natural resources." Nature has provided billions of unseen communities of microscopic workers that make their home in our soils, each with its own specific job. All of these communities work together to maintain ecological balance and conserve the soil's natural resources, creating a rich and sustainable environment for plants. Some important roles microbes play in the soil include the breakdown of toxins and organic debris, the increase of mineral availability, the improvement of soil tilth, and the promotion of healthy, vigorous root growth.

Synthetic fertilizer manufacturers spend millions of dollars convincing the conventional farmer that plant roots require certain chemical "nutrients" in order to produce big yields, but how they are delivered or where they come from is not often considered.

In a balanced, sustainable soil-management program that emphasizes microbiology, however, fertilizers are regarded primarily as food for beneficial soil microorganisms, which in turn provide mineral availability and a wide range of other benefits for the plant, as mentioned above. For this reason, the type and source of fertilizer matters a great deal.

Highly soluble materials, for example, although readily taken up by plants, can actually inhibit the growth of or even kill microbes. Because they aren't easily incorporated into the soil food chain, soluble fertilizers are mostly lost to the environment by leaching, volatilization or immobilization (tying up in the soil structure, becoming unavailable to the plant). These factors promote overuse of synthetic fertilizers (otherwise known as the "more-on principle"), resulting in a significant amount of wasted dollars on input costs and an unhealthy environment for root growth, which leads to increased susceptibility to disease and insect infestations, and ultimately, serious damage to the environment.

An integral part of good sustainable soil management is testing (as opposed to guessing) in order to support both soil microbiology and plant health, which includes:

1. Correction of mineral imbalances, including adjustment of base saturation rates and cation exchange capacity (CEC).
2. Incorporation of and support for beneficial soil bacteria.

BASE SATURATION & CEC

Base saturation refers to the percentage of a soil's cation exchange capacity occupied by the base elements. The major cation nutrients are calcium, magnesium, potassium, sodium and hydrogen. To assure adequate plant nutrition they must be present in certain minimum amounts, which must be balanced. The excess of any one mineral may interfere with the availability of another, for example excess magnesium will create a potassium shortage, even though a laboratory analysis may show adequate potassium levels. Part of our mission at Tainio Technology is to teach growers to rely on the soil's base saturation rate as an essential tool in creating a balanced and healthy environment for both microbes and plants.

Cation exchange capacity is an important measure of potential for the soil's inherent fertility and moisture-holding capability. The CEC indicates the soil's ability to store cations, which include some of the major plant nutrients, as mentioned above.

The CEC depends mostly on the soil's colloidal content. Colloids in soil are gelatinous substances made of clay particles, raw organic matter and humus. They have a large surface area relative to their weight, and many negatively charged anion sites. The positively charged cations are held in place at these exchange sites (opposites attract), safe from leaching but available to the plant.

The higher the soil's CEC, the greater the deficit of nutrients needed to fill its reserves, but the longer those nutrients will be held available in the soil. CECs in western soils generally range between 10 and 30 milliequivalents (mEq), while a predominantly sandy soil will have a CEC of below 4 mEq. A soil with low CEC can be improved by adding more humus, which can have a CEC value of as much as 100 mEq per 100 grams.

Humus, usually black or dark brown in color due to the abundance of organic carbon, is made up of decomposed plant and animal material, and is colloidal in nature. Humus is necessary fodder for microorganisms, and its capacity to hold water and nutrients far exceeds that of clay, its inorganic counterpart. It takes only small amounts of humus to greatly enhance the soil's water and mineral holding capacities and plant growth.

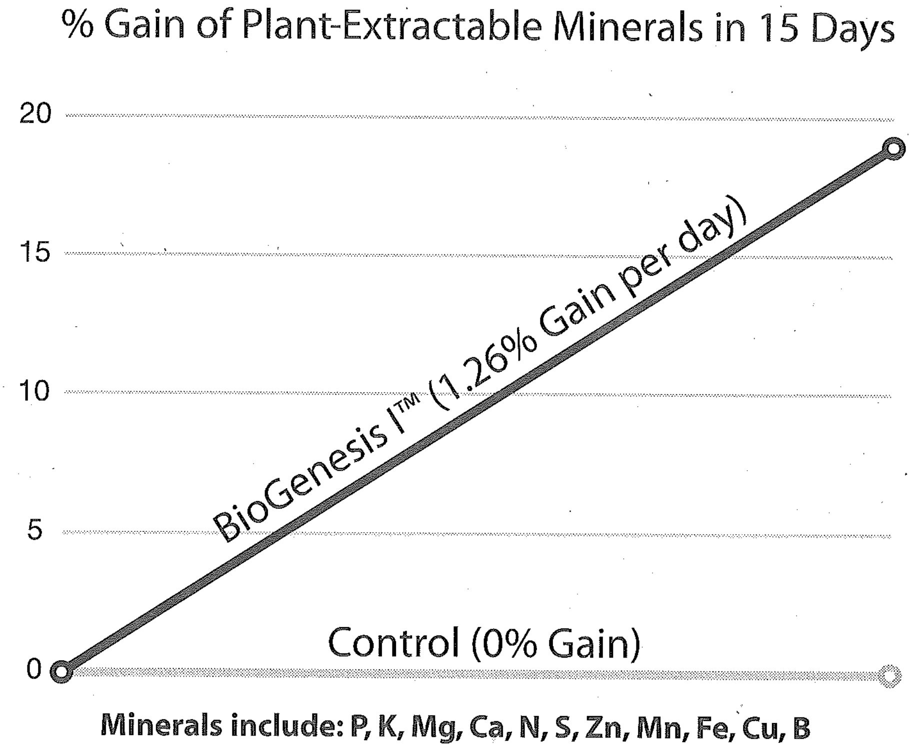


Figure 1.

1. *Two identical 10-pound samples of soil were collected and analyzed for nutrient levels.*
2. *One gram of a microbial formula (BFMS BioGenesis I) was added to one sample, the other designated as control.*
3. *Both samples were incubated at 68 F. for 15 days.*
4. *An analysis of each sample showed that a 19 percent overall gain in plant-extractable minerals was achieved in the inoculated soil, which had almost doubled in microbial activity within the 15-day test.*

MINERAL AVAILABILITY

The range of organic compounds from which microbes are able to extract nutrients and make them available to plants is seemingly endless. In fact, for every naturally occurring organic material there is a microbe capable of decomposing it. This is why microorganisms play such a vital role in the geochemical cycling of the elements, especially carbon and nitrogen. Figure 1 shows the efficiency with which microbes are able to free up minerals from the soil.

CARBON, NITROGEN & NEMATODES

Organic materials serve as sources of carbon, phosphorus, sulfur and nitrogen, which are made available through

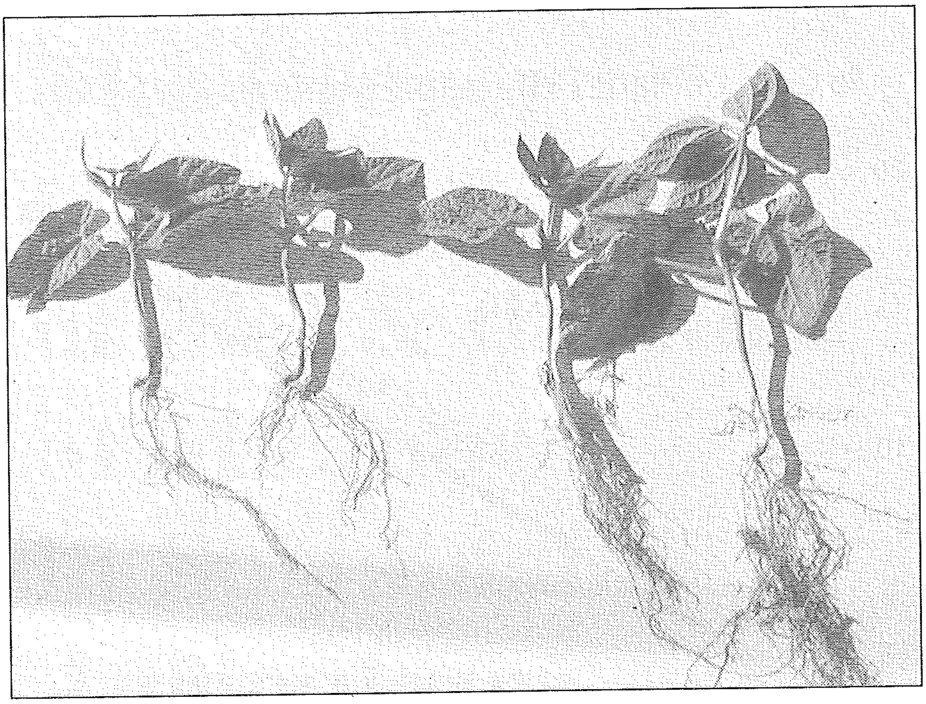


Figure 2. The untreated bean plants at left show considerably less vigor and development than the treated plants.

oxidation and reduction by microbes. Soil organic matter consists of two general groups: undecomposed plant and animal material, and humus.

Even though carbon, the building block for all life on earth, is the element required in largest amounts by organisms, it is often overlooked as a plant nutrient. The lack of organic carbon in the soil is a sure sign of low organic matter in the form of humus. Carbohydrates (sugars), which are made up of carbon, hydrogen and oxygen, are an energy source necessary for bacterial populations to thrive. Bacteria are most abundant in soils where the carbon to nitrogen ratio is 30 to 1.

When pathogenic nematodes get out of hand, there is almost always a carbon/nitrogen ratio imbalance. There are two basic types of nematodes: free living (beneficial) nematodes, and parasitic (pathogenic) nematodes, both of which have a natural function in the ecology of the soil. The parasitic nematodes only become problems when something has gone seriously wrong in the natural balance of things in the soil. When this happens, the soil becomes depleted of its armies of beneficial microbes that are responsible for keeping the pathogenic nematodes in check.

The list of things we do to soil that can destroy its natural balance is long, from fumigation and overuse of herbicides to overuse of nitrogen. Overuse of nitrogen can induce carbohydrate deficiency, which in turn inhibits bacterial populations. But the treatment is the same, no matter what the cause of imbalance or the species of nematode. With the following treatment plan, balance can be restored to the soil, thereby bringing the harmful nematode populations under control.

1. *Take a soil analysis, measuring the carbon to nitrogen ratio.* This serves as an indicator of how much carbon is needed to stimulate and support beneficial microbes. One can almost always expect the C/N ratio to be below 20:1 when pathogenic nematodes are present. If desired, a nematode count and a total plate count can also be taken at this time to determine baseline levels for later comparison.

2. *Apply a carbon source such as humic acid to restore the carbon/nitrogen ratio to at least 20:1.*

3. *Apply a microbial soil amendment containing a broad spectrum of beneficial microbes, plus a good enzyme product to help stimulate the microbes.*

Once these steps have been taken, the beneficial microbes will quickly multiply, increasing to population densities large enough to bring harmful nematodes under control in a natural, sustainable way.

HEALTHY ROOT GROWTH

Microbes provide a zone of protection around plant and tree roots, protecting them from pathogens and making minerals available. Figure 2 graphically demonstrates what a difference these microbes can make — note the vigorous root development on the treated plants versus the controls, which were planted side-by-side in a dense planting experiment.

The benefits from simply balancing and supporting the microbial life in our soils are huge, and go far beyond the scope of this article. Suffice it to say that with the help of the microbial community, we can take sustainability far beyond the standard definition.

Bruce and Athena (Teena) Tainio are president and vice-president of Tainio Technology & Technique, Inc., a manufacturer of biological products in Cheney, Washington. They can be reached at 509-747-5471. For more information, visit their website at *www.tainio.com*.