INTERVIEW: BEHIND THE DAIRY CRISIS

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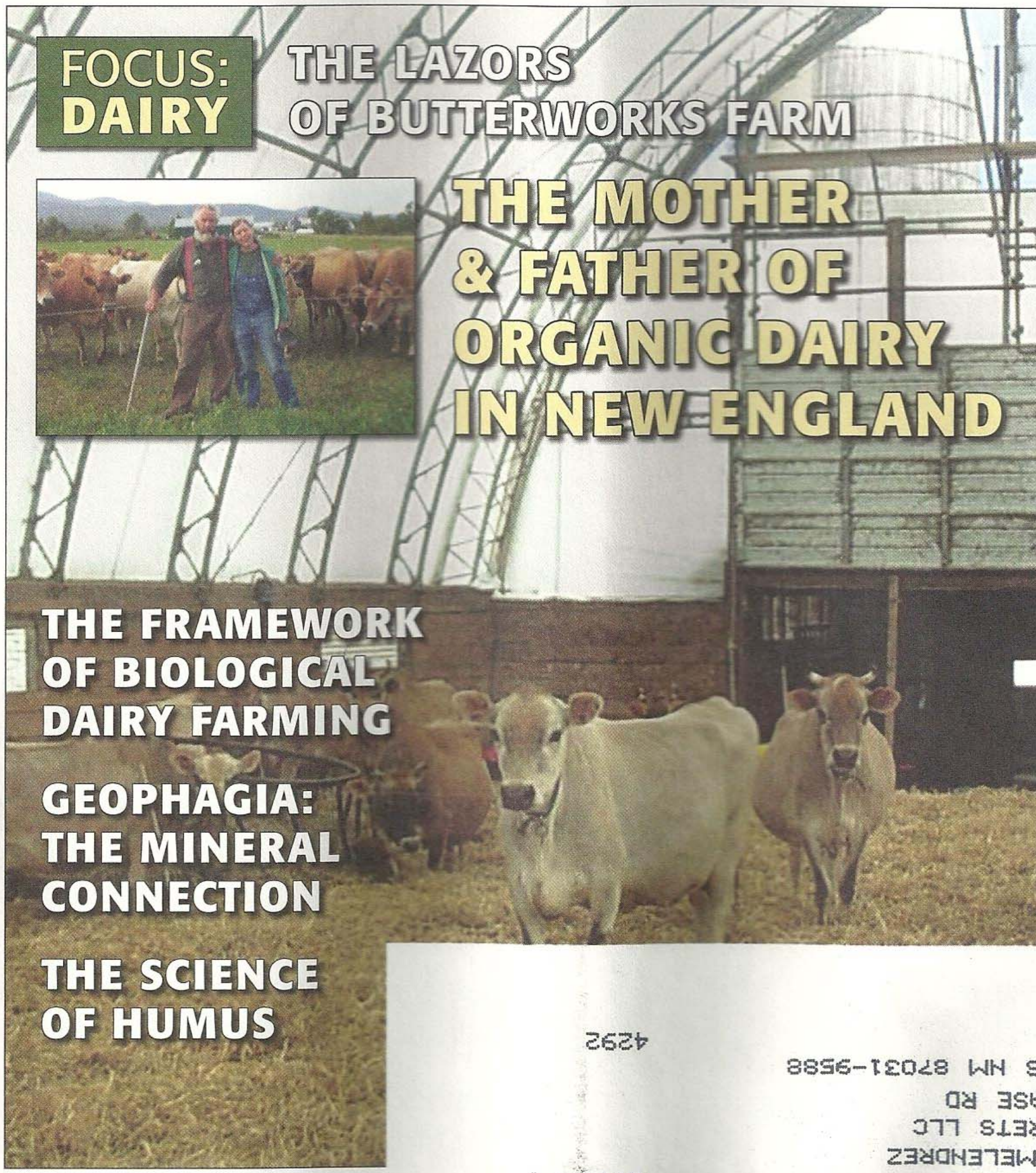

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The Science of Humus

How Humic Substances Benefit Soil & Landscapes

by Michael Martin Meléndrez

When dealing with the concepts of sustainable, organic or just traditional farming, the question should be asked, "What is the lowest hanging fruit as concerns creating the most sustainable and fertile soil situation possible?"

It is this author's opinion that the lack or deficiency of humus (the humic acids) are the weak link that hold us back from growing crops with optimum nutrition or from maintaining an urban landscape such as a park, golf course or even a private lawn and not be dependent upon high-analysis NPK fertilizers. It can be demonstrated that almost without exception soils of farms and urban sites across the globe lack a natural and ongoing formation of humus. This statement includes city parks, golf courses, traditional farms and even organic and sustainable farms.

When NPK salt index based fertilizers or high-nutrient-load organic fertilizers are used regularly we cause an inhibition of our soils natural ecology, called by some the soil food web, also causing an excessive need for water in arid climate agriculture and a soil environment that is not healthy for most plants. While there is no magic bullet or single product that can solve every problem, one common denominator seen in agricultural soils across the globe is a decline in humus production. For purposes of distinction, we must understand that a soil can contain "soil organic matter," and it can also contain humus. *Humus* is a generic (lay) term that labels the conglomeration of substances in a soil called *humic substances*, while *soil organic matter* is *material that is decomposing* (at various states of decomposition) in the soil. It's not done until it's gone!

To best understand the scientific nomenclature one must look at the origin of words, the linguistics and semantics of these terms, as that is how science is categorized and based. Both "humus" and "humic substances" are *hypernyms*, words or phrases whose semantic range includes narrower terms, their *hyponyms*. For example, scarlet, vermilion, carmine, and crimson are all *hyponyms* of *red* (their *hypernym*). Thus, the names of each acid of humus are the hyponyms, while the whole of humus is the hypernym. All the hyponyms together are called the "full hyponym."

For *humus* or *humic substances*, the full list of hyponyms is:

Fulvic acid, a yellow to yellow-brown humic substance that is soluble in water under all pH conditions and is of low molecular weight;

Humic acid, a dark-brown humic substance that is soluble in water only at higher pH values and is of greater molecular weight than fulvic acid — "the chemical half-life of humic acid is measured in centuries in an undisturbed soil";

Humin, a black humic substance that is not soluble in water at any pH and is of high molecular weight and is never found in base extracted liquid humic acid products.

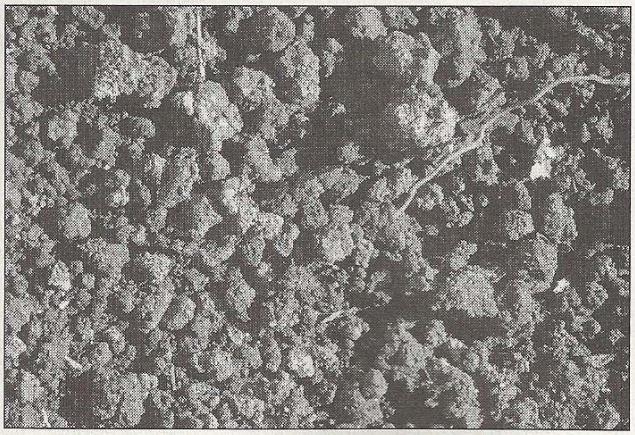
The word *substance* originates from the Latin *substantia*, which is the real physical matter of which a person or thing consists. For example, "Humic acid is the substance of humus."

The terms "humus" and "organic matter" are often confused and used interchangeably: Organic matter is certainly an excellent way to remineralize

The arboretum in 1986, before we started planting and rehabilitating the soil using our protocol.

The same land in 1998 (with my wife, Kari, and daughter, Amanda). Since then, the Redwoods have grown so large they now hide the lawn entirely!

Clay soils at the Arboretum Tomé before humic acids.



Aggregated clay at the Arboretum today, the result of humic acids.

a soil that has been leached or has no chemical reaction, such as the situation in some sands. In such cases, sand with a low cation exchange capacity (CEC) will have difficulty holding onto the cations of plant nutrition, as those ions will easily leach deep into the soil and be lost to plant nutrient uptake.

Equally difficult will be the ability to hold onto water in a sandy soil when arid conditions prevail and humus is lacking. When dealing with sand, a situation of "feast or famine" will be a constant problem, as the water and the nutrients will be available only for a short time after it's applied. Cation exchange capacity is all about the electronegativity potential of the soil, and, in the case of a sandy soil, it's the biomolecules of humus that will help retain water in soil along with the ionized plant nutrients coming from the natural cycling of organic biomass, compost or other sources of fertilizer.

The electronegativity factor of the humic acids is the key in developing and maintaining a healthy and sustainable soil. In the case of a sustainble agricultural program, organic certified farm or an urban landscape it can be decaying organic matter such as compost that's the source

of the minerals; in essence it's fertilizer in an organic form. This is why it's important to know what the nutrient analysis of the compost is, and what sources of ingredients were used to make the stuff. What's forgotten or just misunderstood is that it's humus that is the biomolecule and not the decomposing organic matter, such as compost. Humus is powerful stuff, and a tiny amount can give a huge measurable result. We've seen as little as 40 total pounds on an acre of farmland increase the yield of a crop dramatically.

THE PHYSICS OF HUMUS

Micronutrient exchange and water availability are improved with humus (humic acids) in the soil, and here's why. Humic acids are extremely important as a medium for transporting nutrients from the soil to the plant because the humic acids can hold onto the ionized nutrient, preventing them from leaching. The humic acids are then attracted to the depletion zone of the plant root carrying with it water and the cations of plant nutrients needed by the plant. The depletion zone is that area close to the root from which the root draws (depletes) the nutrients. This zone can become particularly depleted if there is a lack of either humic acids to help deliver ionized nutrients closer to the roots or mycorrhizal fungus to help transport water and nutrients to the host plant. When plants are mycorrhizal, the depletion zone is of less importance. Mycorrhizae have hyphae micro-tubes that can extend much further into the soil than the host plant can reach, and therefore can sequester mineral nutrition for the benefit of the host plant from outside of this depletion zone.

The dirty truth: Positive ions are more easily absorbed by a plant's root because the root has a negative charge. In other words, the positive (cation) is attracted to negative (the living root). Humic acids hold cations (positive ions) in a way they can be more easily absorbed by a plant's root, improving micronutrient transference to the plant's circulation system. This works because humic acids (ulmic, humic and fulvic) pick up positive ions and are attracted closer to the root depletion zone and to the hyphae micro-tubes of the mycorrhizae. Since the root's negative charge is greater than the biomolecules of humic acid's negative charge, scientists theorize that the micronutrients are taken up by a plant's root and absorbed by the plant's circulation system. Some of the micronutrients are released from the humic acid molecule as they enter the root membrane, but we are now realizing that the plant will also uptake some of the lighter molecular-weight humic acids as well. In essence, the humic substances are chelating the cations such as magnesium (Mg_{2+}), calcium (Ca_{2+}), and iron (Fe_{2+}).

By chelating the ions, they increase the availability of these cations to organisms, including plants. Remember, humus is even more critical for plant nutrient availability and uptake if you don't have healthy mycorrhizal relationships surrounding your plants.

It's important to understand that while compost and soil organic matter are calories and are therefore going to rapidly decompose, which will then leave the

minerals behind, these materials are what we call "rapidly cycling carbons." In short, the stuff does not stay in the soil for long as it will rapidly decompose, releasing its carbon into the atmosphere as CO_2.

This being the case, compost and other sources of decomposing organic matter are not an efficient way to build soil humus levels. Humic substances, the humic acids, are stable, long-lasting biomolecules that are not rapid cycling because they are not calories of decomposable organics like those of compost. The benefits will also be long lasting, as components of humus have a mean residence time (based on radiocarbon dating, using extracts from non-disturbed soils) of 1,140 years to 1,235 years, depending on the molecular weight of the humic acid.

It's for this reason that if you really want to fix or rehabilitate a soil, increase its CEC, improve its tilth and porosity, improve water availability for conservation, and therefore make a soil a healthier terrestrial biosphere for all plants, roots, microorganisms including the mycorrhizae, then you must depend on humus.

Humus is a product of soil chemistry dependent upon a source of the precursor chemicals, which are amino acids, the building blocks of protein. The best source of the amino acids in a natural ecotone is produced by the Glomus species of mycorrhizae associating with any grass in a natural, undisturbed site. The tallgrass prairies of the Midwest exemplify this soil-building process better than any ecotone on earth, because grasses use a Glomus-mycorrhizal relationship. That's the reason for all that humus-rich topsoil formerly found in the Tall Grass Prairies. Glomus makes a soil protein called glomalin, a substance that is rich in these amino acids, and combined with humus they provide us with a huge carbon sequestering and banking factor.

Given that we can measure the percentage of calories in compost that are coming from protein (the amino acids), carbohydrates and fats, we can also measure the lack of humus-making potential of compost. In other words, even in supreme-quality compost, the percent-

age of calories coming from amino acids (protein) will be less than 5 percent. Since it is difficult to rely on the perfect amino acid ratio in compost because of manufacturing quality control and ingredient consistency, we cannot predict a 100 percent efficient conversion of all these amino acids into the humic substances, therefore compost or other soil amendments of organic matter are not a dependable or a reliable way of increasing soil humic substances. To do so would require such a huge amount of compost, it could lead to overdosing the site with nutrients.

In fact, the better the quality of the compost, the more concentrated the nutrients will be, and the less you should use. For example, in the case of our TTP Supreme Compost we say to use it sparingly, never more than 60 pounds per 1,000 square feet or 2,600 pounds per acre, and that's assuming that no other fertilizer is being used at the same time. Although it's a great fertilizer, this amount is not enough bulk or protein to be a significant source of humus formation, therefore humus supplementation is necessary if you want humus.

You can also measure the quantity of humic acid in a compost product at a qualified lab, and if you did so, you will find that a good quality compost will measure around 5 to 8 percent humic acids, which is not much. The point is that you must know what the tool in your toolbox is for, otherwise if the only tool you have is a hammer, everything will look like a nail.

One obvious benefit of humus we have seen at our Arboretum in Los Lunas, New Mexico, has been the aggregation of clay, making the clay more porous, soft, aerobic, with better drainage, resulting in deeper root growth of all plants (see accompanying before and after images of the clay). The site was purchased in 1986 with clay soil 12 feet deep and a pH ranging from 8.3 to 9.2, so alkaline that in the winter the site would turn white. Today we have one of the largest oak species collections of the Quercus genus in the United States and the largest collection of native oaks of the Chihuahuan Desert Region in North America. Also on the site are several types of redwoods, maples, dogwoods and giant timber bamboo. None of these plants should be able to grow on soils with the conditions we started with, but with the power (or magic) of humic acids we have rehabilitated the soils to a productive and healthy level.

Finally, "Humic Acids: Marvelous Products of Soil Chemistry" (*The Journal of Chemical Education*, December 2001) states, "Humic acids are remarkable brown to black products of soil chemistry that are essential for healthy and productive soils. That they are functionalized molecules that can act as photosensitizers, retain water, bind to clays, act as plant growth stimulants, and scavenge toxic pollutants. No synthetic material can match humic acid's physical and chemical versatility."

In an upcoming article, we will go into more detail on the science and the many benefits of humus.

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