Humic Materials for Agriculture

By R.L. Mikkelsen

Humic materials...very large and complex molecules extracted from organic matter...have been used in many ways for plant production. There are numerous reports of plant response and also of no response to these materials. This article reviews their use in agriculture and points to consider before using humic materials.

Few agricultural products have been subject to more confusion and conflicting information than humic-type additives. The scientific literature is full of reports where humic additives have directly or indirectly stimulated plant growth. There are also many reports where no response was found following the use of humic substances.

Unlike fertilizer, which has a long history of documented research and university recommendations, humic acid is widely sold and used without as much detailed research. This brief review will cover the nature of humic substances and how they are currently being used in crop production.

Humic material can be extracted from soft brown coal-like deposits called leonardite, found with lignite coal.

What Are Humic Substances?

There is no one single chemical known as humic acid, since the chemical structure has never been completely defined. These materials are composed of complicated organic mixtures which are linked together in a random manner, resulting in extraordinarily complex materials (**Figure 1**). It has been suggested that no two molecules of humus are exactly the same. The special properties of humic materials result from this extreme heterogeneity and their high chemical reactivity.

Humic materials have an abundance of carboxyl groups and weakly acidic phenolic groups, which contribute to their complexation and ion-exchange properties. They exhibit both hydrophobic and hydrophilic characteristics and can bind to soil mineral surfaces.

Over the years, many methods have been used to extract humic acids from stable organic matter. Most commercially

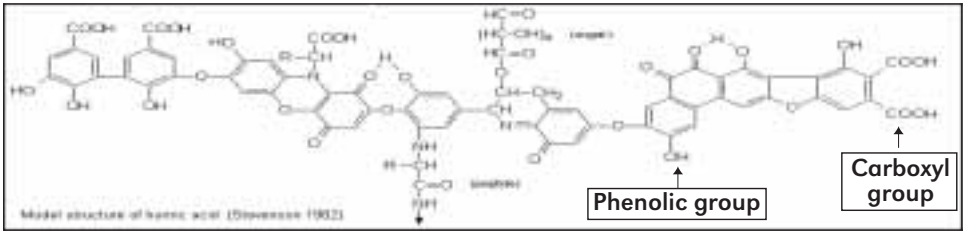

Figure 1. A simplified example of the structure of humic acid extracted from soil.

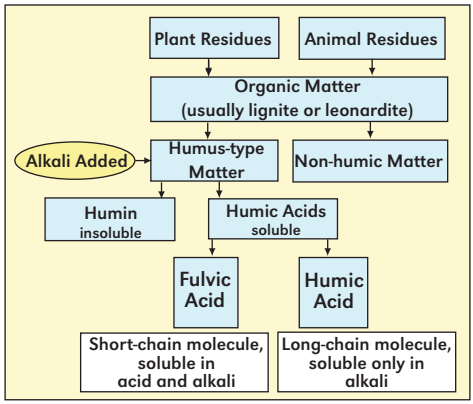

Figure 2. Common chemical extraction technique for extracting organic materials into various fractions commonly applied for crops.

available humic material is extracted from soft brown coal-like deposits with an alkali solution (**Figure 2**). Following extraction, it may be subjected to many secondary processes for stabilization and enhancement, including addition of nutrients. Given the wide range of extraction methods and processes used to produce commercial products, it is frequently difficult to compare specific materials.

With their high pH-dependent charge, when the cation exchange sites are filled primarily with hydrogen (H) ions, the material is considered an acid and is called humic acid. This material has no great effect on soil pH because this acid form is insoluble in water. When a cation other than H dominates the exchange sites, the material is technically called humate (a salt of humic acid). **Humic materials are not fertilizers, since they contain only small amounts of plant nutrients, but their potential usage has been classified as providing soil physical, chemical, and biological benefits.**

Use of Humic Substances

Physical benefits—The conditioning value of high rates of organic matter added to soil has long been known. Both fresh and stable organic matter provide benefits such as improved tilth, water retention, and a nutrient reservoir. However, consider that a soil containing just 1% organic matter has over 20,000 lb/A of organic matter.

Clearly, massive amounts of organic matter addition are required to make significant changes in this soil property, and usually this is a very long-term process. However, it may be feasible to make important changes in localized soil zones, such as the seedbed or in a fertilizer band.

Soil chemical benefits—Humic materials are able to complex various cations (pseudo-chelation) and serve as a sink for polyvalent cations in the soil. They have a negative surface charge at all pH values where crop growth occurs. Reports of improved cation availability following addition of humic materials are common. Detailed reviews of this phenomenon have been published elsewhere.

Essential micronutrient cations that might normally be expected to precipitate at pH ranges found in most soils are maintained in solution through complexation with many organic compounds. Enhanced plant growth following addition of humic materials has sometimes been related to increased micronutrient availability… especially iron (Fe) and zinc (Zn). There are also numerous reports of metal concentrations being reduced to non-toxic levels following addition of complexing organic matter.

Organic substances have been demonstrated to enhance the solubility of soil phosphorus (P) through complexation of Fe and aluminum (Al) in acid soils and calcium (Ca) in calcareous soils. For example, researchers at the University of Idaho showed positive yield and quality responses of potatoes to humic acid added to band-applied P in a calcareous soil. Other researchers have noted similar increases in nutrient availability for plants following the use of humic substances, although there is still much to learn about these reactions.

Biological benefits—-Numerous reasons have been proposed for the stimulatory plant responses sometimes seen following addition of humic materials.

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Figure 3. Cultivar differences in canopy appearance at 114 days after planting in 2004 at Jackson, Tennessee.

remobilization of carbohydrates in these cultivars, to improve their efficiency.

In short season environments like Tennessee, the likelihood of a satisfactory cotton crop is promoted by planting well-adapted, early maturing cultivars and managing them for earliness. **An important element in earliness management is a K fertility maintenance program based on annual soil test results and local extension recommendations.** BC

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However, there is currently not enough research to explain possible mechanisms and accurately predict when humic materials might prove beneficial. There are reports of growth and yield responses from various conditions...from soil and foliar application...banded, broadcast, and fertigated applications...and solid and liquid humic formulation. Thus, defining the positive effect is difficult.

A benefit sometimes mentioned regarding humic material is that it can provide a carbon (C) source for soil microorganisms. This mechanism does not appear to be likely, since a typical application of 5 to 20 gal/A of humic material will supply only 3 to 15 lb C/A. Compare this with more than 4,000 lb of C/A returned in the residue of a typical corn crop. The hormonal effect of humic materials on plant growth has also been carefully studied and largely negated. Humic acids have been shown to function as a urease inhibitor and a nitrification inhibitor in some circumstances. The search for a biological explanation for the plant responses to humic materials will continue and will not be simple.

The use of humic materials in production agriculture continues to grow. There are numerous reports of both successful and unsuccessful use of these materials. Due to the wide variation in their raw materials and processing methods, it is difficult to accurately compare the efficacy of specific commercial products without careful study. Due to the range of recommendations for use, it is not easy to define a mode of action that can be applied across many crops, soils, and growing conditions.

Users of humic materials should keep careful records and conduct on-farm field trials to determine product effectiveness. Research organizations should continue to study the value of this expanding agricultural input. Remember that no additive will compensate for poor management and inadequate crop nutrition. BC

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