# The Mysterious Role and Composition of Humus

## IPM Corner

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Understanding the nature and value of humus is a worthy enterprise for turf grass managers because of the tremendous capacity of humus to increase the health of the turfgrass root system. In order to gain such an understanding, it is necessary to delve into the processes that turn organic matter such as compost into humus.

Humus is a substance with incredible properties. It can be the product of microbial decomposition of plant or animal tissue. Its exact composition can be very different depending on the nature of the starting material, the decomposing organisms, and the microclimate. We can compost animal manures or brewery sludge mixed with plant materials such as sawdust or leaves to yield partially decomposed material that is excellent for encouraging plant growth. Recommendations for the use of compost in fruit, vegetable, and ornamental gardens are nearly universal since organic matter is such an important soil amendment. Composts provide nutrients, increase the ability of the soil to retain nutrients rather than allowing them to leach away, and help to suppress disease-causing bacteria and fungi. These advantages are due to the living organisms of the compost as well as the partially degraded materials that provide the bulk. When compost is further degraded by microorganisms in the soil, it becomes humus, a gel-like mixture of soil minerals, remnants of the microbes, and organic matter.

### Steps in Decomposition of Plant Debris

When a plant cell dies, the membrane surrounding the cell breaks apart, and the liquid or gel-like cell contents or cytoplasm leaks out. The cell membrane and cytoplasm are the most nutritious components of the cell, containing sugars, proteins, and oils. High in nitrogen and available energy, these cell components are easily digested by animals or microorganisms.

The next step in decay is much slower — the breakdown of the bulky cell wall structure of plant leaves, stems, and roots. Plant cells are supported by a cellulose wall that is like a rigid basket. Fibrous plant tissues may in addition contain thick cell walls reinforced with gluelike substances, lignin, cutin, waxes, or oils, all of which are resistant to moisture. Woody roots and stems have such secondary walls resistant to degradation by most organisms. However, even tree roots and trunks can be degraded by certain fungi that secrete special digestive enzymes. These biological catalysts breakdown the secondary walls, releasing sugars and other nutrients to the decomposing organism, and turn the wood to a soft, dark peaty material.

The organic matter that naturally falls to the ground includes hardwood leaves, conifer needles, tree branches, and the flowers, fruits, seeds, stems, and leaves of grasses and other annual and perennial plants. The time required for decay at the soil surface depends on the type of plant material, the temperature, whether it is buried, moist, and in an oxygen-rich environment, and whether the appropriate decomposing microorganisms are present.

Grass tissue resists degradation because of sturdy cellulose cell walls, lignins and waxes which humans can't digest, but ruminants can. Humans are limited in their ability to digest plant material by the enzymes secreted into the stomach, the acid conditions tolerated, and by the activities of the beneficial bacterial population that resides there. Wheat bran is considered roughage in our diet because it is high in cellulose and passes through the human system only partially digested. Ruminants like cows, goats, and deer can digest hay because of a specialized four-part stomach, with a microbial fermentation cycle followed by repeated chewing. Specialized beneficial bacteria thrive on chewed hay in the moist, warm culture of the stomach. The physical breakdown from chewing the cud combines with activity of the microbial enzymes. In this way, chemical cleavage releases soluble nutrients, valuable food substances both to the microbes and to the animal whose stomach is the incubator. The solids that pass through the gut are still rich in nutrients and living microbes.

The decomposition of grass tissue can take place in soils when given the right conditions: air, moisture, high nitrogen-to-carbon ratio, and an active microbial population. This soil process is important to the degradation of thatch, the layer of dead grass stems and lower leaves that forms a barrier between the roots and the green portion of the grass plant. A small amount of thatch is healthy, acting to shade the roots and cushion physical impacts. A thick layer of thatch can make chemical treatments less effective, absorbing pesticides and blocking dispersal into the root zone.

### Contributions of Microbes and Earthworms

The decomposers in the soil contribute to the bulk of the organic matter. Earthworms take in soil mixed with dead and living organisms and pass it through their gut, depositing castings rich in digested substances and microbes. Their physical remains add to the soil organic matter. There are groups of fungi like the water molds that have cell walls made of cellulose or other unique variations of sugar chains bonded together. Bacteria and some fungi have cell walls made of chitin, a molecular structure similar in composition to the exoskeleton of insects and crayfish. Each type of cell wall can be broken down by certain decomposers that have the genetic ability to make the needed enzymes for release of the component molecules. This release provides nutrition for the decomposer or microbe, and left behind are undigested organic matter, secreted gluey substances, and dead microbial cells.

### What is so Special About Humus?

Humus is the endproduct of ordinary decomposition. It is a mucous-like mixture of the most resistant tissues of plants and animals, and the dead cells of soil bacteria and fungi. Humus is a remarkable material, with a cation exchange capacity (CEC) several times that of clay particles. This means that humus can hold positively charged molecules (called cations), then release them later as the components in the soil water solution change. A soil with high CEC will retain nutrients on clay or humus, then release the nutrients, making them available to roots as the plant roots or microbes release hydrogen ions into the soil water. In acid soil conditions there is a high concentration of hydrogen ions, and cations such as calcium, potassium, or magnesium are exchanged more rapidly into the soil water. Humus and partially degraded organic matter retain water in a surface film that is still available to plant root hairs after the free water has drained away from the root zone. Humus will continue to break down very slowly over time, as weather conditions, nutrient availability, and microbial populations change. Tropical soils contain very little humus and organic matter since they are rapidly degraded and disappear completely at high temperatures.

The microbes of the soil make nutrients available to roots by degrading complex substances into simpler molecules. But how can humus change the texture of soil? This occurs because a natural byproduct of microbial decomposition is a gluelike substance, a sticky material used by fungi and bacteria to remain fixed to the surface of the material on which they grow or divide. These glues called glycoproteins become part of the colloid mixture that is humus, causing aggregates or larger particles to form in the soil. This results in a coarser texture if the soil is composed of clay, silt, or loam, a better soil for plants that is more friable, looser, and drains more freely. The microscopic root hairs will grow into the humus and organic matter, taking advantage of the added nutrients, beneficial rhizosphere microorganisms, and water retained by the humus. These root hairs have much more surface area than larger roots, such as those that grow rapidly into wet sand. Greater surface area leads to significantly more absorption of water and nutrients. A larger root system can support healthier top growth. In addition, the humus will retain water to provide a safety net in dry conditions.

### Why Increase the Humus?

Why should a turfgrass manager try to increase the humus in the root zone? For three reasons: 1) humus increases nutrient availability for microbes and plants, 2) humus retains nutrients, reducing leaching, and, 3) humus improves soil texture through aggregation, increasing drainage.

The sources of organic matter in turfgrass soils are the original amendments at time of installation, grass clippings, thatch, and dead roots. In addition, soil insects, algae, earthworms, bacteria, fungi, and nematodes add substantially to the organic matter of the turfgrass root zone. Topdressing with compost is an excellent way to increase the organic matter, fertility, and microbial activity. Additionally, compost will reduce the problems of thatch layers, will help to suppress disease organisms, and over the long term will increase humus, reduce leaching, and improve the resilience of the turfgrass in times of stress.

When a nitrogen-rich compost is topdressed over turfgrass, the soil microbes will have a new source of nutrition. They will use the nitrogen from the breakdown of compost to increase the degradation of dead roots and thatch. The complex substances in the compost will favor a new balance of microbes with the specific ability to degrade the kind of organic matter present. There will be an increase in humus in the soil, leading to better nutrient-holding capacity (due to the increased cation exchange capacity and reduced leaching). Increased microbial activity will also speed up the degradation of pesticides in the soil. The high activity of microbes will tend to reduce the incidence and severity of turfgrass root rot diseases. After about three years of topdressing with compost, the improvement in the stand and resistance to drought and disease will be obvious. The health of the turfgrass and increased root surface area will reduce the necessity for pesticide applications. Understanding the microbial processes leading to decomposition of organic matter, including thatch and dead roots, will help move the turfgrass manager further along the integrated pest management continuum. Healthy turfgrass requires less maintenance and sets up the scenario for a more profitable season.

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