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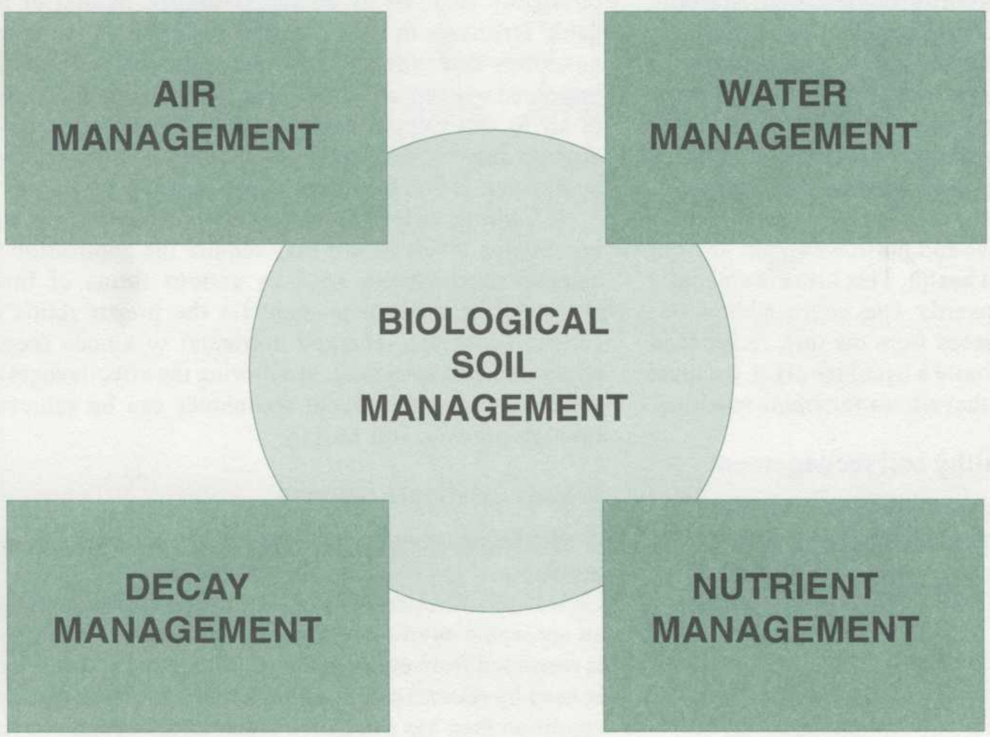
A re-evaluation

Biological soil management

by Joel Simmons

Many turfgrass managers today are re-evaluating their understanding of basic soil science. Many of us were exposed to the subject of soil science when we studied agronomy in college. But we often found it to be dry and boring. From this experience we often came away from our formal exposure to the subject with a limited knowledge of the dynamics of soils.

Unlike the instruction we received in col-



Components of the biological soil management concept

Figure provided by Dr. Richard Hull, Rhode Island University

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lege, soils are very dynamic. Once we glimpse the complexities of soils, a whole new world opens up and an excitement develops about the exploration of this vital area of turfgrass management.

Today, the more skillful turfgrass managers are those who practice sound soil management first and plant management second. These turfgrass managers gain tremendous benefits from practicing biological soil management.

Rediscovering the basics

Biological soil management is based on solid agronomic principles that date back decades. As an example, Dr. William Albrecht, the former head of agronomy at the University of Missouri, wrote in the late 50s and early 60s of the importance of maintaining a healthy soil. Unfortunately, through the shortsightedness of the times, Dr. Albrecht's reward for this advanced thinking was to be 'let go', as his ideas differed from the conventional wisdom of the chemical revolution that began to take hold in agriculture.

Today, agriculture is making major changes in its attitude toward managing soil health. Today's agriculture is going back to basics. Agriculture and the other plant management sciences are hearkening back to the principles that were espoused by people like Dr. Albrecht.

As many in agriculture are realizing, the benefits of these management principles and the advantages of biological soil management are becoming equally apparent to the turfgrass industry. An effective soil management program depends on an understanding of the agronomic principles behind biological soil science.

For years now, those of us in turfgrass management have focused on the above soil portion of plant growth, and have ignored the soil health. This historic emphasis on foliar health is backwards. Our concern for foliar health is based on our needs from the turf, rather than the turfgrass' needs. To build a healthier plant, we must first build a healthy soil that allows for ample nutrition.

The principles of healthy soil management

There are four basic agronomic principles that have to be considered when building a healthy soil.

Those are, in descending order of importance:

- air management
- water management
- decay management
- and nutrient management.

The interrelationship between these four principles is very important. Without good air management, the other three cannot produce healthy soil. If water management is not up to par, proper air, decay and nutrient management is difficult. Historically, most turfgrass managers have over-emphasized nutrient management (i.e. fertilization) without considering the interdependence that exists between air, water, decay and nutrient management.

A management program that keeps all four of these principles in mind assures good results, lessens plant stress and reduces the need for pesticides. This may sound simplistic, but it works. Unfortunately, our industry is focused on products designed to manage nutrients, often at the expense of air, water and decay management.

The breathing soil

Proper air management insures that ample plant-available oxygen exists in the soil. Soil microbes, the heart of a healthy soil, need ample supplies of oxygen in order to survive and proliferate. Soil compaction and poor soil structure dramatically impede air movement within soil, allowing available oxygen to become depleted and to have a deleterious effect on microbe populations.

A well-balanced turfgrass management program must first address the negative effects of soil compaction and poor soil structure in order to manage properly the soil oxygen levels. Too often, compaction is managed by the short-term treatments of aeration or top-dressing, ignoring the fundamental causes of the problem.

Soils that are prone to compact usually need to be physically changed by adding composts, natural or organic fertilizers or other organic materials in sufficient quantities that will help open the soil and provide for improved oxygen mobility. Over time, this improvement in air to soil oxygen exchange takes place when these organic amendments are worked into the soil and their application is combined with core aeration practices.

In addition to improving soil organic content, managing oxygen levels in soil may require the application of calcium amendments, such as various forms of lime, limestone or gypsum to maintain the proper ratios of cations (positively-charged nutrients) to anions (negatively-charged nutrients). Monitoring the effectiveness of these oxygen management techniques can be achieved through periodic soil testing.

Water: a delicate balance

Water management of healthy soil addresses the dual problems of too much or too little water.

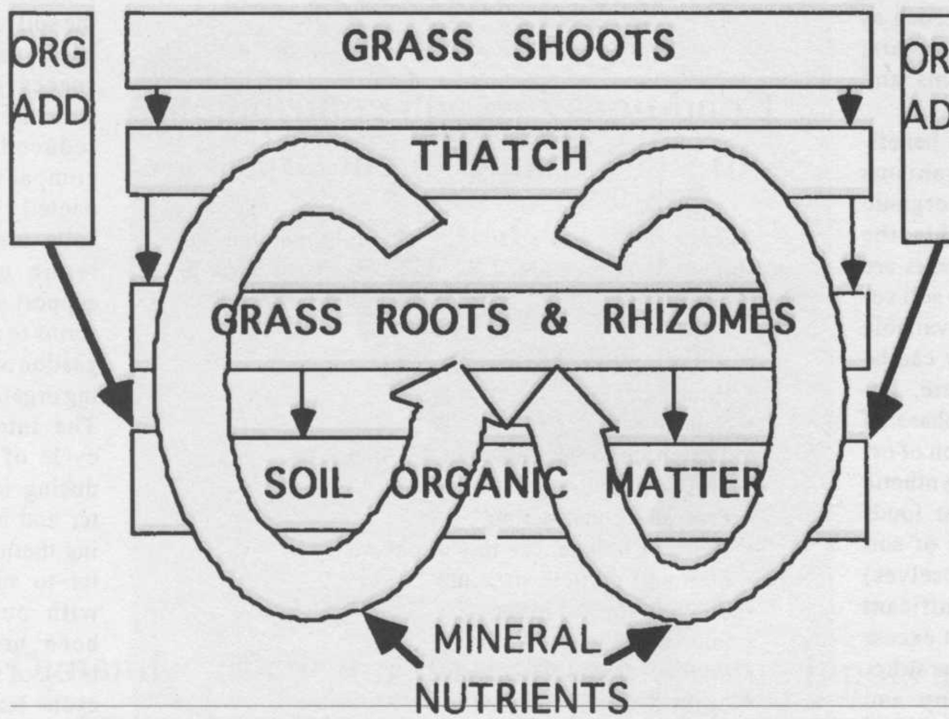
Too much water leads to saturated soil which creates an anaerobic environment. Under this condition, oxygen is restricted from entering the soil to replenish that which is used by normal plant and microbe respiration and this condition then has a negative effect on microbial activity and nutrient release. Excess water in the soil promotes root pathogen activity, blocks normal soil respiration thereby reducing beneficial microbial activity, and allows normal plant and microbial respiratory toxins to build up in the root zone and damage roots. It also leaches the soluble plant nutrients, such as nitrates, potassium, as well as small amounts of ammonium and calcium from the plant root zone. Many of these soluble nutrients are alkaline and their leaching often leaves the root zone soil acidic, further restricting the availability of other essential plant nutrients.

Too little water can produce similar results.

loss of the ability of plants to absorb soluble plant nutrients.

As with good oxygen mobility, the good structure of healthy soil will have a significant effect on water mobility. A richly organic soil will provide both the pore spaces to allow water to drain through and the sponging

Flow of organic matter and nutrients in the turf-soil system



This model integrates the decay and nutrient management aspects of biological soil management

Figure provided by Dr. Richard Hull, Rhode Island University

In addition to the obvious detrimental effects on shoot health that is caused by loss of shoot turgidity, extended periods of low soil moisture levels can reduce long-term beneficial microbial viability. Low soil moisture has a direct limiting effect on plant nutrient uptake through the loss of viable roots and root hairs and the

properties of organic matter, that will hold water for later plant or microbial use.

Soils low in organic components are low in humic acid, an important ingredient in the healthy process of soil granulation, and often do not have the stable soil structure that allows for good moisture mobility.

From decay comes life

Decay management of soils is a concept that has yet to be fully appreciated. As there is more research on the dynamics of decay it is becoming evident that here biological soil management will have its greatest impact.

Soil micro-organisms need the same kind of environmental conditions that many other organisms need to survive: air, water, and nourishment. Good air and water mobility within the soil must be maintained to sustain beneficial microbial activity. Nourishment for soil microbes is supplied from organic matter in the form of plant residues which contain compounds such as carbohydrates, sugars, proteins, vitamins and minerals.

As the soil's beneficial micro-organisms feed on these organic compounds within the soil, many nutrients are released into the soil solution in plant-available form where they can be used. Furthermore, humus (the final phase of the decomposition of organic matter, synthetic and natural plant foods and the remains of soil organisms themselves) provides a significant buffering against excess moisture, temperature, acidity, alkalinity and salts. This buffering reduces stress and increases the ability of plants to tolerate insect feeding, disease infestations and weed invasions.

Plant foods vary

Without proper microbial activity, the nutrients of some synthetic fertilizers cannot be made plant available and thus are not assimilated by plants. As an example of microbial involvement in plant food availability, the urea molecule of turf fertilizers is transformed into ammonia, one of the forms of nitrogen that plants can use, due to the activity of urease enzymes that are produced by these organisms. To make these enzymes, energy in the form of the soil available carbohydrates found in organic matter including humus must be present for microbes to use.

The over-use of synthetic fertilizers eventually destroys soil aggregates found in a healthy soil structure due to excessive salt accumulation. The high salt content of many synthetic fertilizers is a result of the manufacturing processes used to capture plant nutrients and allow for shelf life of the product. The application of these high salt fertilizers with large amounts of rapidly available nitrogen may overwhelm the natural balance of organic decomposition taking place in the soils.

The complex carbohydrates and nitrogen compounds found in humus are oxidized or broken down, and are used as an energy source to accommodate overloads of non-protein nitrogen. This depletion of microbe food sources slowly causes the soil to die. As this happens, the pore spaces or granular structure of the soil is reduced, creating compaction. Compacted, low-oxygen soils can no longer retain moisture or support adequate life forms to stimulate digestion of the remaining organic materials. The interdependent cycle of plants producing organic matter and microbes using that organic matter to supply plants with nutrients has been broken. This break of the nutrition cycle leads to plant stress which encourages insect and disease pressure and the subsequent "rescue chemistry," in the form of pesticides, is needed. The soil and the plants become "dependent", like plants in a hydroponic medium, on the use of these synthetic chemicals and a new artificial cycle develops.

Formula for success

Biologically friendly turf care programs improve the soil structure by adding organic matter from compost, natural organic fertilizers or even grass clippings and can help managers maintain the natural nutrient cycles.

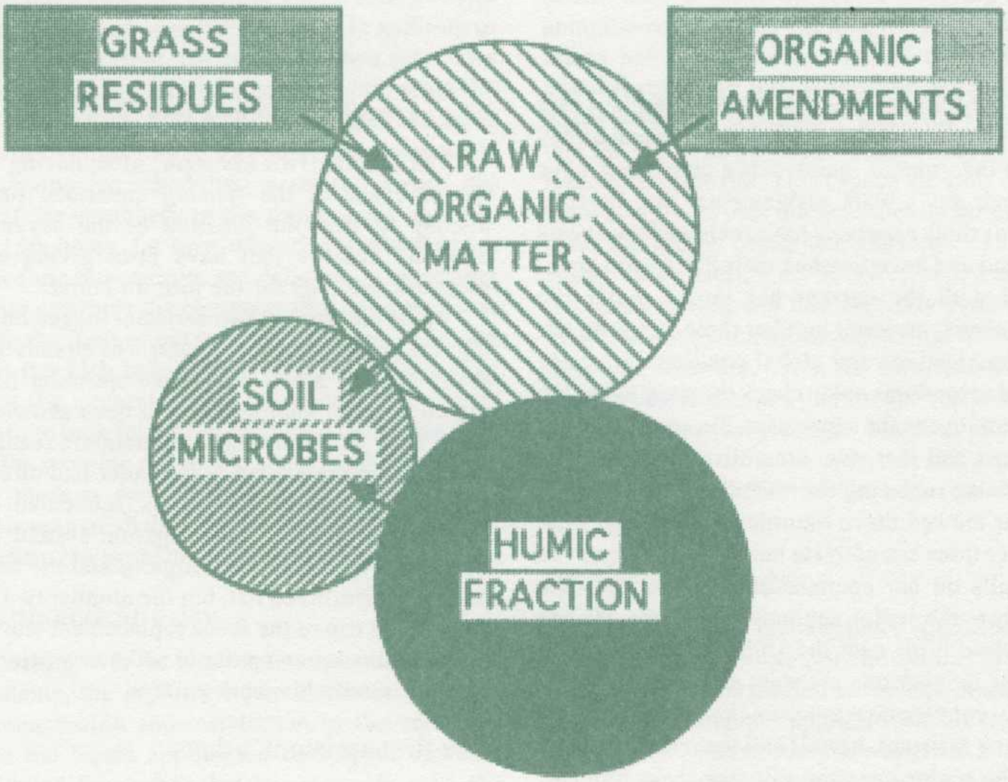
If turfgrass managers use synthetic products, then proper integrated pest management practices should be

Conditions that can contribute to short-term drought stress

The following is a partial list of conditions that—in combination with reduced rainfall, excessive heat or both—can contribute to short-term drought stress.

- Root damaging diseases
- Root damaging insects
- Soil layering
- Thatch depth greater than 1/2 inch
- Soil compaction
- Poor soil construction
- Nutrient imbalances in soil chemistry
- Poor soil particle structure
- Shallow topsoil mass
- Poor water percolation
- Poor species or variety choices
- Light frequent irrigation

All these conditions have a detrimental effect on a turf stand's root biomass.



Dynamics of carbon flow among organic inputs and organic matter pools of a turf-soil ecosystem

Figure provided by Dr. Richard Hull, Rhode Island University

instituted and followed to help negate the detrimental effects of the synthetics. Choosing the synthetic fertilizers that have the least harmful effect on the soil will also help.

Fertilizers should be chosen that have lower salt indexes and that are low in chlorine, as this element in high concentrations is detrimental to microbial life. One should consider the use of natural organic fertilizers as the increase in the amount of organic matter allows for a reduction in total nitrogen that must be applied for the year. One should also use fertilizers with less reactive sources of phosphorus such as colloidal or rock phosphates.

With the four basic agronomic principles of a healthy soil in mind:

- air management
- water management
- decay management
- and nutrient management

turfgrasses will get the most out of the soil. There will be more available nutrients, less plant stress and less dependence on the use of pesticides and synthetic fertilizers. ■