A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

Volume 7, Issue 8 • August 1998

AGRONOMY

Soil Organisms
And Their Role In Healthy Turf

By Elaine R. Ingham, Ph.D.

What are the basic assumptions about growing plants by which we've been operating? We have assumed that plant nutrition is a relatively easy process and if we add chemicals at the right time, in the right place, and the right amounts, we can supply all the nutrients plants require and at the rates plants require. We thought we understood plant nutrition well enough to supply these needs. In fact, we now know that plants are much more complex than we thought.

Plant growth requirements have not been met by placing just enough nitrogen, phosphorus, and potassium for the whole of a plant's growth in the soil at one or a few times. We seem to have forgotten that plants require a host of nutrients, from boron to zinc, in small amounts that vary through the course of their active growth cycle, and for some perennial plants, even through dormant periods.

Plant roots colonized internally by beneficial symbiotic fungi called Vesicular-Arbuscular Mycorrhizae or "VAM" fungus. Parts of the VAM fungus reach out into the soil to collect phosphorus, other nutrients and water, which are transported back for use by the host plant. Where VAM is present the plant is protected from root rot disease and parasitic nematodes.

IN THIS ISSUE

www.landscapegroup.com

AN ADVANSTAR ★ PUBLICATION

TURFGRASS TRENDS

Editor
Terry McIver
440-891-2709; 440-891-2675 (fax)
turfgrasstrends@advanstar.com

Production Manager
Karen Lenzen
218-723-9129; 218-723-9576 (fax)
klenzen@advanstar.com

Circulation Manager
Frank Christopherson
218-723-9271

Layout & Production
Bruce F. Shank, BioCOM
805-274-0321

Group Editor
Vern Henry

Group Publisher
John D. Payne
440-891-2786; 440-891-2675 (fax)
jpayne@advanstar.com

Corporate Office
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

Editorial Office
7500 Old Oak Blvd.
Cleveland, OH 44130

Abstracts: 800-466-8443
Reprint: 440-891-2744
Permission: 440-891-2742
Single copy or back issues:
Subscription/Customer Service
218-723-9477; 218-723-9437 (fax)
Website address:
www.landscapegroup.com

ADVANSTAR
HOLDINGS, INC.

Chairman and Chief Executive Officer
Robert L. Krakoff

Vice Chairman
James M. Alic

Vice President, Business Development
Skip Farber

ADVANSTAR
COMMUNICATIONS

Executive Vice Presidents
William J. Cooke, Alexander S. DeBarr, Glenn A. Rogers

VP-Finance, CFO & Secretary
David J. Montgomery

Treasurer and Controller
Adele D. Hartwick

How do plants obtain nutrients without human intervention?

Over millions of years, plants have flowered, produced seeds and fruit, and generally gotten along just fine without man's "help". Over thousands of those years, humans have selected and bred plants to have unusually large fruits, more abundant grains, darker colored foliage, bigger and more abundant flowers, etc., to meet their own nutritional and aesthetic needs. However, as advanced as these selected plants have become, their basic physiology and how they obtain their required nutrition have not changed.

Plants obtain nearly all their nutrients through the help of a complex set of beneficial organisms working in the soil around the plant's roots, called the soilfood web. From the above-ground portion of their biomass, they obtain carbon dioxide and light energy - the only other resources that plants need.

The soil foodweb is made up of beneficial organisms located in soil surrounding plant roots. These organisms provide the following benefits for plants:

- they supply nutrients in plant-available forms,
- retain nutrients in the soil instead of allowing them to leach into ground water,
- compete with, inhibit and consume disease-causing and plant parasitic organisms,
- decompose plant residue, toxic materials and pollutants that kill plant roots,
- form soil aggregates that improve water infiltration, root penetration and the water-holding capacity of soil,
- improve plant quality and increase the nutritional and aesthetic value of plants by providing the above benefits.

What are these beneficial organisms and what do they do?

The soil foodweb is composed of plants, nutrient fixing organisms, and an additional group of organisms that prey on these nutrient fixing organisms. "Fixing" organisms convert excess plant material into their own biomass, metabolites, and respiratory by-products. They include certain bacteria, fungi, root-feeding nematodes, and arthropod herbivores.

Fixing bacteria and fungi immobilize nitrogen, potassium, sulphur, calcium,magnesium and other soil nutrients in their biomass. Once nutrients are immobilized in either bacteria or fungi, they must be transformed into plant-available forms in a process called mineralization, so that the nutrients are available to plants at the time and in the places they are needed.

Along with nutrient cycling, the soil foodweb keeps organisms that cause plant disease in check. This occurs as the diversity and number of functional groups of beneficial organisms in the soil increases. Beneficial organisms compete with disease causing organisms for food. This competition lessens the potential for plant injury caused by diseases.

The soil foodweb greatly influences soil structure. It facilitates greater root penetration and water infiltration through the production of soil aggregates, soil pores and soil channels. It also increases decomposition of a greater variety of plant materials and anthropogenic compounds.

Soil compaction and the food web

The soil foodweb plays an important role in soil compaction. Mechanical soil compaction is caused by major or repeated disturbance of soil aggregation. When heavy machinery or prolonged traffic moves across soil, the pores and channels within the soil collapse. As the spaces in the soil are reduced, the organisms living in those spaces are killed. Thus, the force applied and the strength of the aggregates in the soil determine the extent of damage.

Pesticides and the soil foodweb

The direct benefits that soil organisms provide to plants, and thereby to humans, are not obtained if the vital soil organisms that make up the majority of the soil foodweb have been killed. Pesticides, herbicides, and fertilizers (mostly through a salt effect), can have both direct and indirect negative impacts on all these beneficial organisms.

Clearly, the targeted plant diseases or pests are also negatively impacted. Unfortunately, these pests and diseases can develop resistance to the chemicals, whereas the beneficial organisms do not.

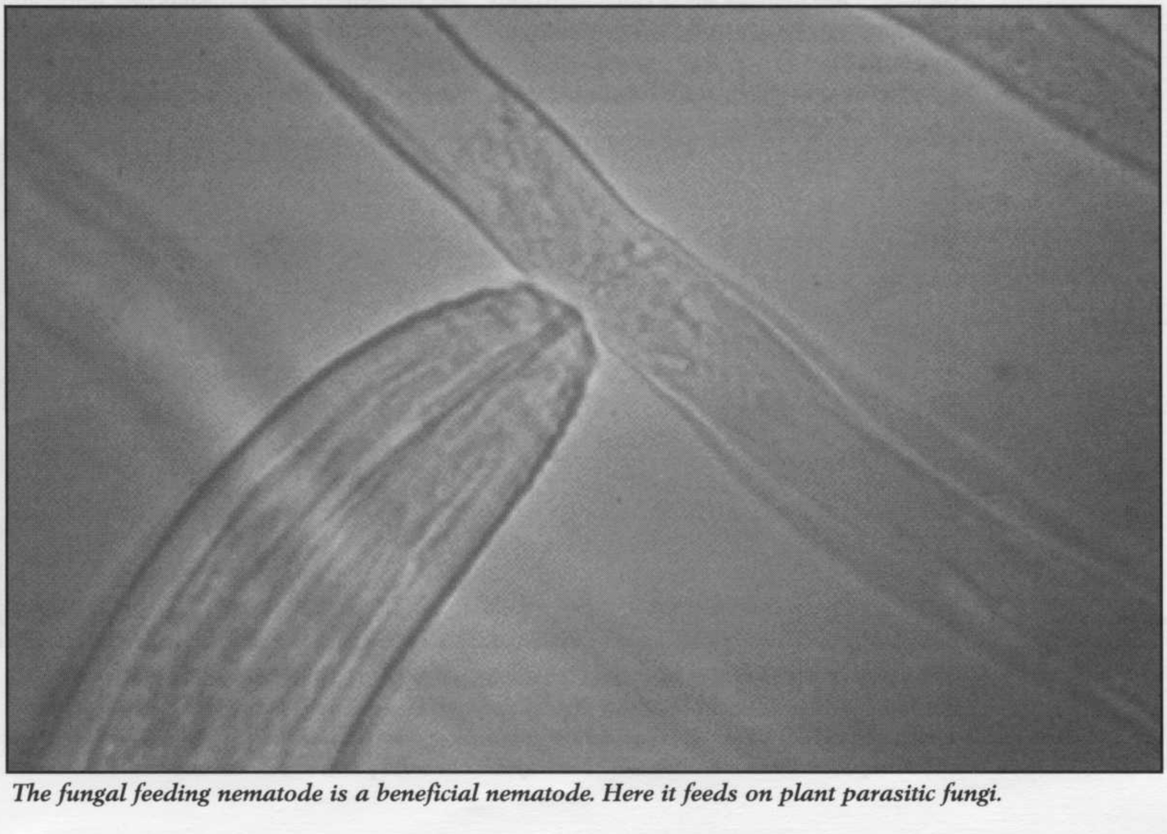
Why? Because plant pests and pathogens have naturally developed life styles that can respond rapidly to changing adverse environments. Pathogens have short life cycles (usually because they kill their hosts), produce many offspring (so at least one finds another host), and have reasonably wide genetic variability (so a response to a change in a plant's natural chemical defenses can be overcome).

Beneficial organisms don't operate the same way. They have long, complex life cycles, they don't produce huge numbers of offspring because their food resources are limited, and as time goes on, the habitats that they prefer become divided among other competing organisms. Thus, beneficials are very good at competing with other organisms, but they are not selected for the boom-and-bust conditions that typify the world of plant pests. Plants have been employing this long-term competitive approach for several hundreds of thousands of years.

Pesticides, herbicides, and fertilizers, when used in small amounts and used only once a year or less, are not all that detrimental. If the beneficials have months or years to recover, they will return and control the pathogens. It is rare in a healthy soil system to be able to document limits on plant distribution by disease, because the complex foodweb in the soil out-competes, inhibits, and consumes the disease-causing, parasitic and pest species.

Understanding the effect of cultivation on soil can be instructive for turf managers. Each time soil is disturbed during cultivation, some of the soil aggregates are broken open allowing soil organic matter to mix with the aggregates. Both processes allow bacteria to predominate, as compared to fungi. This tends to drive soil pH more alkaline (depending on the parent material, the pH may never become alkaline, but the soil will shift toward more alkaline). As bacteria dominate the soil, the major form of N will be nitrate because nitrifying bacteria are favored by soil conditions.

Meanwhile, nutrients are being taken



The fungal feeding nematode is a beneficial nematode. Here it feeds on plant parasitic fungi.

from the soil by the turf and not being replaced. This begins to reduce bacterial populations.

Reduced fungi and bacteria lower the N, P, S, or other micronutrients being cycled to the plants. These lost nutrients are traditionally replaced through the addition of manures, organic residues, and compost. But the microbial life in compost, manure, or organic matter isn't well-understood.

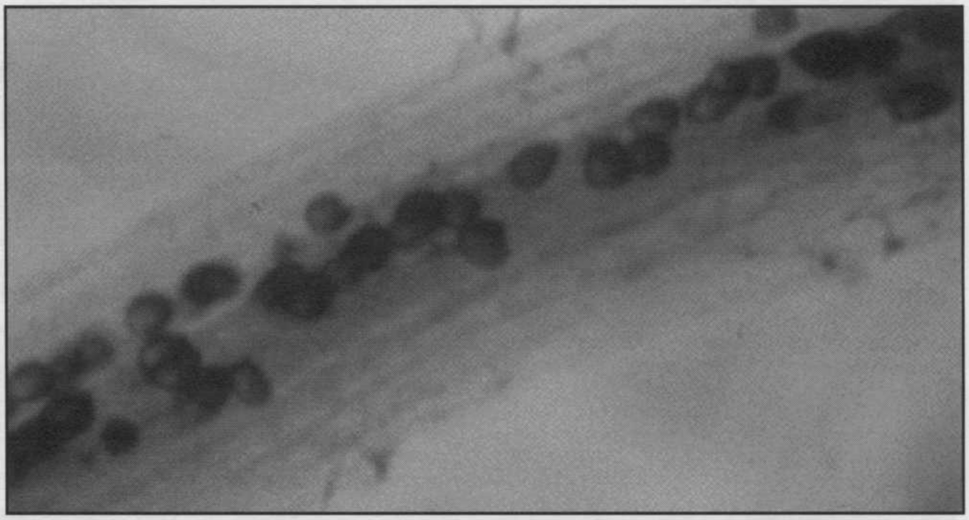
When synthetic fertilizers became available, they were easier to spreadand contained a much more concentrated form of N than compost, manures, or organic matter. The response was more reliable, since there was no question about disease-presence with fertilizer as there was with compost or organic matter. Plants grew taller, and left more residue in the fields. Thus, the micro-organisms in the soil benefitted, at least at first.

But, in many cases, too much fertilizer was applied - the classic, "if a little is good, more is better" syndrome. Fertilizer in high concentrations has about the same effect on soil organisms as dropping a human into a vat of salt - instant water removal and death. Thus, beneficials organisms within the foodweb began to be killed in increasing numbers. When the concentration of the fertilizer is lower, the effect is not nearly as dramatic. Synthetic fertilizers and the reduced use of natural fertilizers, started a downward spiral in soil health.

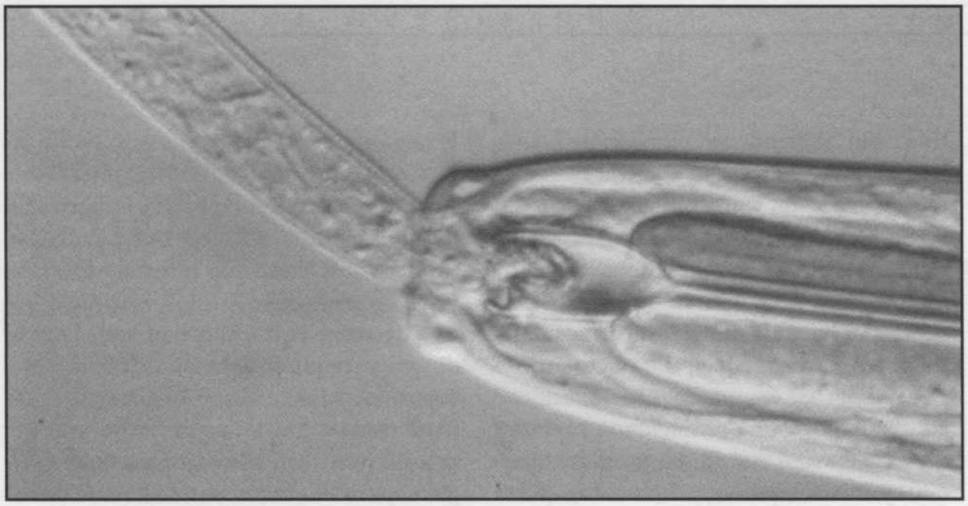
With the loss of organic matter and the negative fertilizer effect, populations of nutrient-cycling organisms (protozoa, nematodes, microarthropods) started to decline. Consequently, this increased the need for and dependency on synthetic fertilizers. As more fertilizer was used, more beneficial, pest-suppressive organisms died and damage to plants increased.

"Quick-fix" petroleum-based pesticides were observed to have noticeable detrimental effects on insect pests, fungal diseases, and weeds. Unfortunately, most pesticides were not tested for their long-term effect on non-target organisms - most of them still have not been tested even today. We still have little idea about the long-term effects of these materials.

Of those pesticides that have been tested, each has had negative effects on non-target organisms. Since these pesticides only reduce the targeted disease-causing organisms and cannot rid the soil of them completely, pesticide resistance has developed. As the beneficials were killed off, fewer and fewer competitors, inhibitors and predators of the disease-causing organisms remained in the soil. Natural biological control was



A section of plant feeder root heavily conlonized by a desirable fungus called Endomycorrhizae. Another name for endomycorrhizae is vesicular-arbuscular mycorrhize, or "VAM". Where VAM is colonizing a root, that portion will be protected from root rot and parasitic nematodes. VAM are symbiotic with plant roots.



<u>Clarkus</u> is the genus name of a beneficial species of nematode that hunts and eats other nematodes in the soil. Predatory nematodes help balance the populations of all other kinds of nematodes. Body waste products recycle nitrogen and other nutrients back into the soil. Predatory nematodes should be present in a balanced soil foodweb. They are very large nematodes and easily killed by physical disturbance of soils.

lost, through pesticide application, fertilizer application, and decreased use of organic sources of nutrients.

In the mid-50's, the problems of disease pressure became increasingly severe in areas where cultivation was intensive and the use of organic soil amendments declined. So, the University of California tested methyl bromide, and found it knocked down the fungal-disease causing organisms quite well.

At first, several years between applications were possible. But today, as continued application of methyl bromide has killed all but the resistant fungal diseases, nematodes, and insects, even application of methyl bromide before every crop - which can be every four months - does not prevent severe disease problems.

Pulling ourselves back from the "chemical" addiction

The chemical approach seemed to work and it would have continued to work if a healthy, complex soil foodweb had been maintained. But it wasn't and we need to move away from intensive chemical usage, and let the organisms do the work for us. The chemicals should be used *only if* there is extreme need. Defining exactly what extreme need is requires a great deal more thought.

The question is, how do we pull ourselves back from this degradation of the soil? Remember that beneficial bacteria and fungi retain the majority of nutrients in the soil, either as their own biomass or as metabolic by-products (organic matter). If you kill them off, there will be no new "absorber" for the excess nutrients that are applied to the turf each year in the form of fertilizer. With fewer nutrient absorbers, the excess fertilizer cannot be retained?. Without absorption and retention by soil, excess N added this year has a greater chance of percolating through the soil to groundwater aquifers. There is no way a soil with too few microbes can hold onto the N the plants require. If they did, the plant wouldn't require fertilizer.

Get soil foodweb in working order

Can we get the soil foodweb back in working order to grow quality turf without the addition of inorganic fertilizer N? Yes. It's being done all over the country!

Can you grow turf without any pesticides applications? Yes, it is theoretically possible, but you must define the time period you are asking about. Forever? Maybe not forever, but certainly for long periods. Given additional understanding of the soil, it might not only be possible, it may even come to pass. However a complete reduction will depend on climate, soil, site hydrology, grass species, and the tolerance of the players on your course.

So, how do we get started back along the right track? Easy, just get a complex, healthy soil foodweb back into the soil. Get all the species of bacteria, fungi, protozoa, nematodes, mycorrhizal fungi, and micro-arthropods back that compete with, inhibit, and consume the disease-problems on your turf. If you make sure that all the necessary nutrient-cyclers are present, then fewer pesticides and fertilizers would be needed.

Where to find these organisms

Where do you find these organisms needed for your particular soil, plant, climate, hydrology, and player load? How do you get them back and keep them working for you?

This isn't always easy. In fact, we don't know the species identity of most of the bacteria and fungi. What is needed is maximum diversity of beneficial organisms.

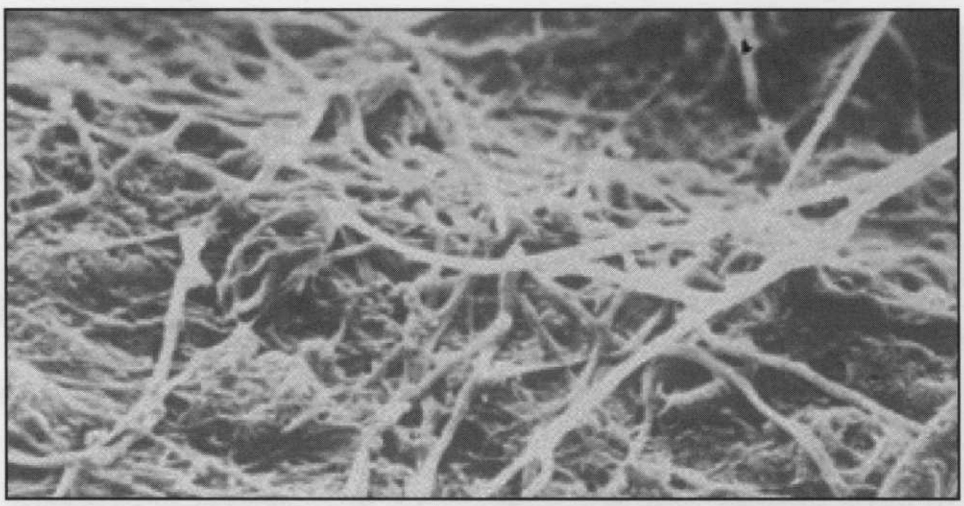
Consider these two examples. Think about a town with lots of restaurants, grocery stores -- fast-food, slow-food, every kind of food imaginable. Everyone would have the food they prefer. Lots of diversity of food resources leads to lots of diversity of beneficial organisms.

Consider if the only source of food in a town was one fast food vendor's sandwiches. The town would clear out rapidly. No diversity, just those that can make it on the vendor's sandwiches.

The story is the same in soil. Lots of diversity requires lots of different food resources. Monocultures of plant types are hard on soil health, so how do you get around it in turf? Grow mixtures of turfgrass species or, better yet, find some different food sources and apply them. Finely screened compost, compost tea, products with wide varieties of foods for beneficial organisms, or a mixture (depending on what organism needs to be encouraged) like molasses, algal extracts, and humic acids.

We need to pay more attention to beneficial organisms in the soil and reduce our dependence on synthetic, short-lived solutions to turf health. When the foodweb is in balance, plants can fully utilize nutrients available in the soil.

Elaine R. Ingham is an Associate Professor at Oregon State University, Corvallis and president of Soil Foodweb Inc.



Ectomycorrhizae on tree roots. This is a highly desirable colonization of roots, usually trees and shrubs, that causes the shape of the root branching pattern to change. Roots in this condition are very efficient at absorbing phosphorus, other nutrients and water. Also, where this symbiotic colonization is present, roots are protected from root rot and parasitic nematodes.