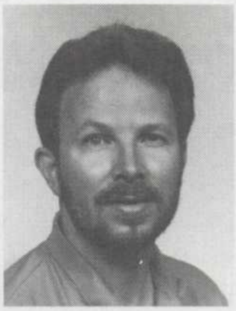
The disease triangle and the disease cycle

by Dr. Eric B. Nelson



For those of you who have had an introductory course in plant pathology, you might remember learning at least two important concepts: the concept of the disease triangle and the concept of a disease cycle. I would like to refresh your memories about these two important concepts and their applicability to managing turfgrass diseases. In fact, they are perhaps the two most important concepts to know in turfgrass disease management.

The disease triangle

First, let us define plant disease. A plant disease is any disturbance to the normal physiology of the plant brought about by an agent so that the affected plant changes in appearance and/or is less productive than a normal healthy plant of the same variety.

In nearly all turfgrass diseases, the primary disease-causing agent is a fungus. In fact, with the exception of nematode-incited diseases, all of the economically-important turfgrass diseases are caused by fungi.

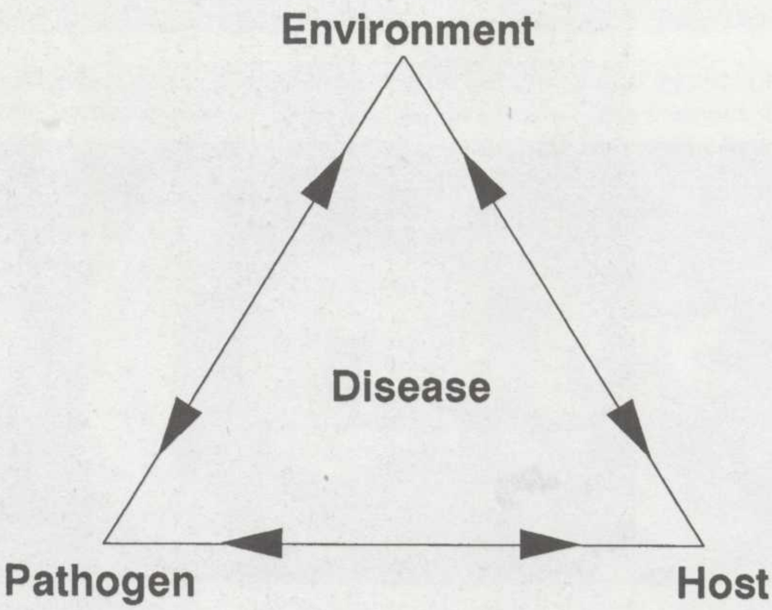
Over the years, pathologists have come to learn that disease development in a plant population is determined primarily by the interactions among three major factors. These are: the presence of a susceptible host plant, the presence of a virulent pathogen, and a favorable physical, chemical, and biological environment.

The interactions among these factors have been traditionally conceptualized in the form of a disease triangle (See figure right).

Conceptually, these interactions dictate that if either the host is less susceptible, the pathogen is less virulent, or the environment is less favorable, diseases will either occur at a reduced level, or they will not occur at all.

Now, how can this concept be applied to turfgrass diseases? There are a few facts about turfgrass diseases to consider. First, for the vast majority of turfgrass germ plasm, there is little or no resistance to turfgrass diseases (obviously there are plenty of specific examples contrary to this statement). Second, since both the turfgrass plants and the pathogens are perennial in nature, infections in turfgrass plants are also perennial. In other words, turfgrass plants are continuously infected with virulent fungal pathogens.

Therefore, the environmental conditions are the overriding factors in determining whether or not a turfgrass disease develops at all. As a result, many control strategies are aimed primarily at alleviating the more favorable environmental conditions favoring disease epidemics. For example, cultural management practices such as fertilization can be manipulated so that the increased or decreased fertility not only creates an environment less favorable for the pathogen, but it helps increase the plants natural abilities to withstand pathogen attack, thus reducing disease development. It should be understood, however, that if environmental conditions favoring disease development are not minimized, other control strategies will not be as effective.



The disease triangle

Figure provided by Dr. Eric B. Nelson, Cornell University

The disease cycle

Another important concept relative to turfgrass disease management is the concept of the disease cycle. A disease cycle is the chain of events involved in the development of a disease, including the stages of development of the pathogen and the effects of the disease on the host plants.

All infectious disease-causing agents go through a disease cycle. A generalized disease cycle is illustrated in the figure below.

If we use fungal pathogens as an example, the over-seasoning stage of most fungal turfgrass pathogens occurs in the winter months when the pathogen persists either in soil, thatch, or in root and crown tissues as a quiescent spore. Snow mold pathogens are the exception to this rule. They over-season during the summer months. When temperature and moisture conditions become favorable, these spores can be transported to adjacent healthy turfgrass plants either by wind, rain, irrigation water, equipment or other means.

Once at the surface of the healthy plant, the spore can then germinate and penetrate the plant tissues. In penetrating tissues, a nutritional relationship is eventually established between the pathogen and the plant. It is at this stage that the plant is considered to be infected. As the pathogen continues to grow between and within cells of the host plant, it can rapidly invade adjacent tissues and organs. It is during this invasive stage that plant symptoms become apparent. Eventually a new batch of spores are produced on and within infected plant tissues. These spores can be again transported to adjacent healthy plants where they initiate secondary disease cycles, or they can over-season in a quiescent state once again.

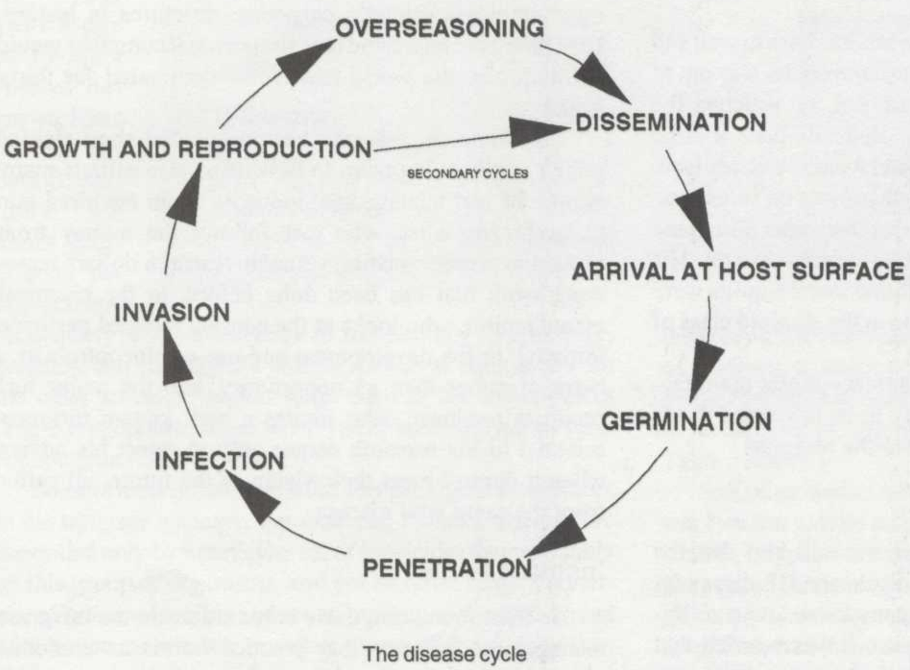
The importance of knowing the disease cycle of various turfgrass diseases is apparent when one considers that each stage in this cycle is required for the next stage. Therefore, if any part of the cycle is interrupted, the disease will not develop.

Turfgrass managers can use this knowledge to develop control strategies. For example, since most fungal pathogens are disseminated by water, simple management of water movement on turfgrass surfaces can minimize losses from certain diseases. Furthermore, water management may reduce the amount of spore germination. Since fungal spores generally require water films in which to germinate, practices that minimize leaf wetness periods will greatly reduce or prevent spores from germinating, thus interrupting the disease cycle. Similarly, most fungicide applications are aimed at preventing spore germination, penetration, and invasion of the fungal pathogen on and in turfgrass plants.

It is clear that, due to the nature of turfgrass ecosystems, environmental conditions are the principal factors driving disease development. Certainly the most effective long-term disease control strategies will be those aimed at minimizing environmental conditions favorable for pathogen germination, spread, penetration, and sporulation. Similarly, environmental conditions that enhance plants' natural abilities to tolerate chronic infections will ultimately be the best approach to disease control.

The concept of the disease triangle and disease cycles are important in understanding what makes diseases develop and how to tackle disease control.

Turfgrass managers will continually be faced with unique and difficult disease control situations. Applying the knowledge of the disease triangle and the disease cycle will enable managers like you to develop logical strategies for minimizing turf losses.■



The disease cycle

Figure provided by Dr. Eric B. Nelson, Cornell University

Making the most of our opportunities

by Christopher Sann

The other day, in one of the few quiet moments that I have, I was reading one of the many magazines that clog my mailbox. I came across a story about porcupines. More specifically, the story was about porcupine quills and an antibiotic present on the outside of these quills.

Why don't porcupines suffer from wounds of their own quills?

The quills of the porcupine are such an effective defense that they can even be a problem to their owners. Yet, the porcupines do not seem to be bothered by self-inflicted wounds.

The author had been wondering about how porcupines managed to deal with this inevitable problem when he got a lesson in wound management. While he was handling a porcupine, he got one of the quills deeply embedded in the flesh on the back of his hand. The quill was so deep and the tip so well barbed that he had two choices — have it removed surgically, with all its associated complications, or wait several days to see if the quill tip would work itself out.

Faced with two unpleasant choices, he chose to wait and see. While he was waiting for the tip to work its way out of the back of his hand (which it did do), he watched the wound for any sign of infection. Had this been a large splinter of wood or a thorn, the wound would certainly have become infected. To his surprise, there was no infection.

His curiosity was piqued. He examined other porcupine quills for the antibiotic that must have been present. His diligence was rewarded when he found that the quills were coated with a very potent antibiotic in the alkaloid class of toxins.

He took his discovery to a pharmaceuticals manufacturer, fully expecting the company to be interested in his discovery. He was not prepared for the response.

Not interested

The pharmaceuticals manufacturer told him that the company was not interested in his discovery. His discovery was not rejected because the company knew about antibiotics on porcupine quills, or because it was worried that alkaloids as a class of chemicals had proven to be too problematic to spend time and money on, or even that the company's research and development budget was stretched to the limits and it would be years before they could even begin to look at this substance as a potential new antibiotic.

The reason the company gave was that the compound was "not complex enough". Read that statement to mean "not patentable".

It did not matter that the author's discovery might have been the beginning of a new class of antibiotics that could help mankind. The pharmaceuticals manufacturer summarily decided that the tail would wag the dog and that maintaining market share was more important than making a new discovery.

The pharmaceuticals manufacturers are not the only group in this country who have mistakenly allowed sales departments to override important advances. Unfortunately, this narrow-minded, short-sighted policy is rampant in this country.

Build a better mouse trap?

The person who coined the phrase "build a better mouse trap and the world will beat a path to your door" wasn't living in this country in the late twentieth century. Corporate America's recent history is replete with the failures of chief executives to understand the foolishness of this policy.

Most recently, the failure of giant IBM to understand this policy has lead to the downfall of one of the largest and most employee-friendly corporate structures in history. IBM failed to understand how the personal computer would revolutionize the world that it had dominated for thirty years.

Unfortunately, this same narrow-minded, short-sighted policy of not being open to new ideas also afflicts many within the turf management industry. From the hired-gun turfgrass specialist, who just follows the money from project to project wasting valuable research dollars recreating work that has been done before, to the chemical manufacturer, who looks at the coming reduced pesticide initiative or the development and use of biocontrols as a betrayal rather than an opportunity, and the major turf products producer, who invites a well known turfgrass scientist to his research center only to reject his advice when it doesn't meet their vision of the future, all suffer from the same fatal disease.

Innovate or die

As IBM found out, those corporations in the turfgrass management industry that practice hubris as a modus operandi and fail to develop a long-term perspective with

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Is *Pythium* really a fungus?

by Dr. Eric B. Nelson

Species of *Pythium* have always been known as some what unusual organisms. Not only are they pathogens of plants, but they are major pathogens of fish and horses as well. Ecologically, they don't quite fit in with other well-known fungal pathogens, and morphologically, genetically, and physiologically, they are quite different from other fungi. As a result, there has been much debate over the years on the precise taxonomic placement of *Pythium* species.

Discovered in 1823

Certainly these organisms look like fungi and behave pretty much like fungi. After all, they have been studied by mycologists for over a century. Yet confusion over this organism has existed from the beginning. *Pythium* was first discovered in 1823 by Nees, but the official date for the establishment of *Pythium* as an official genus was not until 1858 by Pringsheim. As our knowledge of *Pythium* species has grown, it has become apparent that there are many significant peculiarities, particularly with differences in morphology, physiology, genetics, and ecology of *Pythium* species as compared with the other so-called higher fungi such as the ascomycetes (e.g. Pyrenophora "Leaf Spot") and basidiomycetes (e.g. Rhizoctonia " Brown Patch").

Table 1

Classification of pythium species

Present Scheme	**Classification**	Former Scheme
Eukaryotae	**Superkingdom**	Eukaryonta
Protoctista	**Kingdom**	Mycetae
Oomycota	**Phylum/Division**	Mastigomycotina
Peronosporomycetidae	**Class**	Oomycetes
Pythiales	**Order**	Peronosporales
Pythiaceae	**Family**	Pythiaceae
Pythium	**Genus**	*Pythium*
aphanidermatum	**Species**	*aphanidermatum*

Some of these differences with other pathogens are apparent to the turfgrass manager. For example, *Pythium* diseases are controlled only by a particular set of fungicides that work only on this group of organisms, and not on other fungi. Furthermore, *Pythium* species produce swimming spores and spread with water movement; no other group of fungi does this. *Pythium* species cause diseases largely under excessively-wet to water-logged conditions. Few other diseases are problems under these excessively-wet conditions.

Other differences, however, are not so apparent to the turfgrass manager, but are quite obvious to the mycologist or the plant pathologist. These include things such as the chemical composition of *Pythium* cells, the type of propulsion system on the swimming zoospores, and some specific aspects of their reproductive genetics. All of these are quite different from characters found in other fungi.

DNA studies are revealing

Current studies on the phylogeny (i.e. the evolutionary history or relatedness among organisms) of *Pythium* species have revealed some interesting relationships to organisms other than fungi. For example, by comparing the DNA of *Pythium* species with that of higher fungi and some of the green and yellow-green algae, it was discovered that *Pythium* species are more closely related to the algae than they are to the higher fungi. There is now a large body of evidence to support this relationship. As a result, the genus *Pythium* has been moved from the fungal kingdom, Mycetae, and placed into the kingdom Protoctista (See Table 1 above.).

Still other studies have compared the DNA from plants and *Pythium* species and have found striking similarities. In general, it appears that organisms containing certain types of chlorophyll, the main photosynthetic pigment in plants and green algae, are more closely related to *Pythium* than other fungi. This is an interesting fact, since plant pathologists have known for a long time that oospores of *Pythium* and other

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closely related genera of plant pathogens, require certain wavelengths of light for their spores to germinate optimally.

How does the naming change affect *Pythium* diseases of turfgrasses?

Conventional wisdom and recent experiences with other misidentified pathogens like *Magnaporthae* (Summer Patch) would say that all the *Pythium* species are not really all that different from other fungi or that the *Pythium* species are really just another as yet to be identified "new" branch of the fungal world, waiting to be discovered.

In fact, *Pythium* species are different from the other fungal pathogens. They are as different from these fungal pathogens as fungal pathogens are different from insects. This means that *Pythium* species should be placed into a separate pest category when considering overall control strategies. The control of *Pythium* diseases requires measures unique to this new category, with little or no overlapping strategies with the control of fungal diseases of turf. Interestingly, some of the fungicides that are used for algae control, in particular mancozeb, are also effective *Pythium* fungicides. Perhaps we can learn something about the control of *Pythium* diseases by learning something about the biology and management of algae, and vice versa.

How did *Pythium* evolve?

It is intriguing to note that a number of algal species are parasitic on plants, although none have yet been described on turfgrasses. The most interesting thing about these parasitic algae is that they infect plants by means of zoospores and prolonged culture of these organisms in the laboratory causes them to lose their chlorophyll pigments. Upon losing their pigment, they take on a fungal appearance which very closely resembles that of *Pythium*. Perhaps through evolution or environmentally, *Pythium* was an alga that became a fungus. Or was it a fungus that became an alga? Stay tuned. ■

Making the most continued from page 10

long-term plans will fall by the wayside in the coming 10 to 20 years.

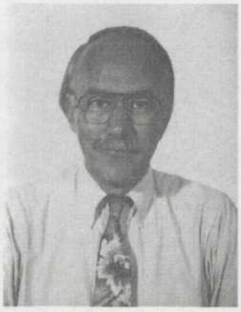
Turfgrass product manufacturers must spend the time and effort to make promising alternative products, strategies, and information available. Turfgrass product suppliers who cling to old product lines and distribution channels, and fail to offer their clients an expanding list of these new "tools", both goods and services, will fade.

As the regulatory pressures grow on turfgrass managers, those manufacturers and suppliers that understand the future and provide answers to future turfgrass management questions will thrive. Those that fail to meet those needs will not survive. ■

The dog days of August

Seeing grubs and Pythium in a new light

by Juergen Haber



As the dog days of August come upon us we have to worry about a totally different animal: the grub. But now there are more weapons in the arsenal with the completion of an historic first phase study led by Dr. Michael Villani, associate professor, soil insect ecology, New York State Agricultureal Experiment Station, Cornell University.

This second large contribution by Dr. Villani to Turf Grass Trends, (Effective management of Japanese beetles, July 1992), is the first large-scale survey of grub populations in lawns. To understand the scope of the survey one must be told that the researchers took more than 3,000, four-inch round samples.

Field Editor Christopher Sann follows up Dr. Villani's story by telling us how grubs might be less of a problem by increased use of integrated pest management.

Finally, we follow up Sann's story with news brief that bring more bad news for traditional turf managers: pesticides may be curtailed even more.

And speaking of follow-ups, Science Advisor Dr. Eric B. Nelson finishes last month's discussion of Pythium in this issue. The question of whether Pythium is a fungus bears directly on the way turf managers should treat diseases resulting from Pythium infections.

Finally, we have a correction to make: on page 5, lower right, of the July issue, we ran the wrong photograph. It should have been the following:

Photo provided by Dr. Eric B. Nelson, Cornell University

Symptoms of Pythium snow rot on a golf course fairway.