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Identification of Unknown Turfgrass Pathogens: Koch's Postulates

by Eric B. Nelson

History

In 1876, a country doctor in Germany by the name of Robert Koch developed the first conclusive empirical evidence that a particular microbe causes a particular disease. Although he was working on anthrax, a deadly disease of warm-blooded animals (caused by the bacterium *Bacillus anthracis*), the procedures he laid out for determining the pathogenicity of a microorganism (in other words, its ability to cause disease) are still in use today. These procedures are commonly referred to as "Koch's postulates." Although the theoretical criteria for establishing pathogenicity in microbes had been laid down as early as 1840, Koch was the first to successfully apply these criteria experimentally. He went on to isolate the tuberculosis bacillus (for which he was eventually awarded a Nobel Prize) and the bacillus causing cholera.

What Koch's postulates say

Basically, Koch's postulates identify the steps necessary to establish the causal relationship between a particular microorganism and a specific disease. These steps are:

1) The microorganism must be present in every case of the disease.
2) The microorganism must be isolated from the diseased host and grown in pure culture.
3) The specific disease must be reproduced when the pure culture containing this microorganism is injected into a healthy, susceptible host.
4) The microorganism must again be recovered from the experimentally infected host and grown in pure culture.

The postulates in action

These principles are routinely applied in the diagnosis of previously undescribed turfgrass diseases. Over the past several years, a number of previously unknown diseases or previously unknown pathogens on particular hosts have been described, based primarily on the successful completion of Koch's postulates. And all the diseases that we now recognize on turfgrasses were once examined in accordance with Koch's postulates in order to demonstrate that causal relationship.

Problems in implementing the postulates

Turfgrasses present a number of unique problems in fulfilling Koch's postulates, however. This is due primarily to the constant presence of pathogens on turfgrass plants.

First, because both turfgrasses and their pathogens are perennial, almost any pathogen can be associated with symptomatic turf. In other words, the first step of Koch's postulates is almost always satisfied, even without a direct causal relationship between a given pathogen and a given disease symptom, precisely because of the pervasiveness of pathogens in a persistent turfgrass ecosystem.

Second, Koch's postulates state that "the specific disease must be reproduced when the pure culture is injected into a healthy susceptible host." One of the problems of inoculating healthy susceptible turfgrass hosts is that this is typically performed using greenhouse-grown turfgrass plants. Symptoms on immature greenhouse-grown turf rarely, if ever, match the symptoms observed on mature stands of turfgrasses in the field. This makes it difficult to satisfy completely the third step of Koch's postulates.

Finally, if one were to inoculate mature turfgrasses in the field in an attempt to reproduce accurately and completely the symptoms initially observed with the unknown disease, it would be impossible to eliminate other potential pathogens, making the successful completion of Koch's postulates problematic.

In diagnosing unknown turfgrass diseases, there is always doubt whether the right pathogen has been found. This is particularly true in the diagnosis of diseases of root systems, where many different pathogens may reside (see the accompanying article in this issue of *TurfGrass TRENDS* on the diagnosis of root and crown diseases).

One of the basic assumptions of Koch's postulates is that a single organism, isolated from a diseased turfgrass plant and inoculated into a healthy turfgrass plant, will reproduce the symptoms observed in the field. We now know, however, that many diseases in turfgrasses do not act alone. Often, the infection of a plant by one pathogen will facilitate its infection by yet another pathogen. This is particularly true of root diseases, where some pathogens create wounds that allow the penetration by other, lesser pathogens. Disease complexes like this are more commonly the rule than the exception.

We also now know that plant stresses influence significantly the nature and degree of expression of symptoms. Numerous potential pathogens of turfgrass become problems only when the plants are under stress. This, too, is particularly common with root-infecting pathogens.

No substitutes for these procedures

The foregoing discussion has been critical of the procedures used to establish the pathogenicity of an unknown microorganism to turfgrasses. That process, however, is currently the most effective and widely accepted technique available to us for establishing those relationships. We still don't understand fully how pathogenic organisms induce disease symptoms in individual turfgrass plants; nor do we understand fully how such symptoms are expressed in mature stands of turfgrass in the field. Until we have such understanding, will have to rely on Koch's postulates for establishing the disease-causing potential of unknown turfgrass microbes—even knowing what we now know about the tenuous applicability of these procedures to perennial plants like turfgrasses.