NEMATODE PESTS OF TURF

By Dr. Ann E. MacGuidwin

Nematodes are the most numerous multicellular animals on earth, with densities ranging up to 29.8 million individuals per m^2. Most nematodes feed on bacteria, fungi, or invertebrates; relatively few species are specialized enough to parasitize man, plants or animals. Those that do, however, can cause serious economic loss.

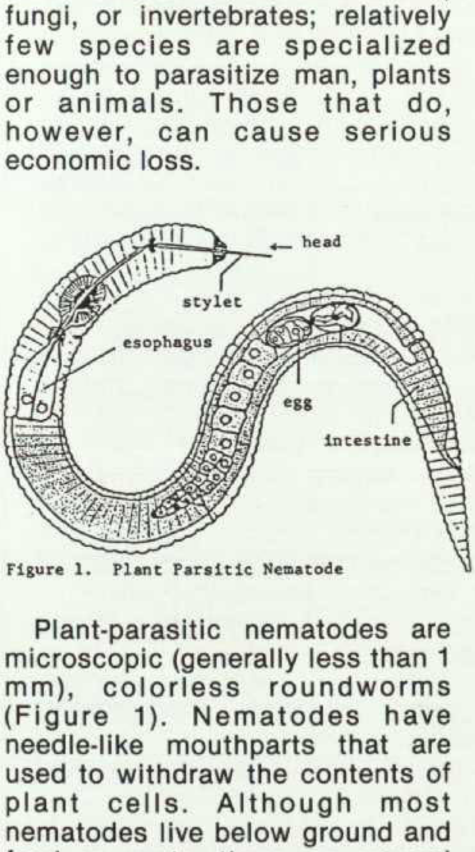


Figure 1. Plant Parsitic Nematode

Plant-parasitic nematodes are microscopic (generally less than 1 mm), colorless roundworms (Figure 1). Nematodes have needle-like mouthparts that are used to withdraw the contents of plant cells. Although most nematodes live below ground and feed on roots, there are several species which parasitize stems, leaves, and even trunks of trees. Soil-inhabiting nematodes are either ectoparasites or endoparasites. Ectoparasites reside in the soil and insert only their mouthparts into roots. Endoparasites enter and inhabit root tissue. Generally, endoparasites are more damaging to plants than are ectoparasites.

Most of the nematode species that attack turfgrasses are ectoparasites. The most common species associated with turf in Wisconsin are: **Tylenchorhynchus** (stunt), **Criconemella** (ring), **Helicotylenchus** (spiral), **Paratrichodorus** (studdy-root), **Xiphinema** (dagger), and **Hoplolaimus** (lance). Three endoparasites have been recovered recently in Wisconsin as well: **Meloidogyne microtyla** (root-knot), **Punctodera** (cyst), and **Pratylenchus** (root-lesion).

The life history of these genera is similar, although they do differ in their mode of reproduction (males are absent in some genera) and habits of egg deposition. The life cycle consists of an egg, four juvenile stages, and an adult stage. The time necessary to complete one generation depends, in part, on soil temperature and moisture conditions. Many nematode genera in Wisconsin only complete one generation each year.

Bentgrass, fescue, **Poa annua**, and Kentucky bluegrass are all excellent hosts for nematodes. Symptoms of nematode damage include: chlorotic foliage, patches of declining growth (especially in hot or dry weather), sparseness of roots, root discoloration, and stubby, galled, or swollen roots. Symptoms generally occur in circular patchy areas rather than uniformly, and may be evident only at certain times during the summer.

In addition to directly causing plant disease, nematodes often act as predisposition agents to increase the incidence and severity of fungal and bacterial diseases. Reports from Michigan indicate that stunt nematodes (**Tylenchorhynchus dubius**) play an important role in Fusarium Blight disease. Work in southern states, however, has not confirmed this nematode-fungus association. It is likely that the epidemiology of Fusarium Blight differs with soil type, climatic conditions, and nematode species, as is the case for other nematode-fungus interactions. Even in situations where a direct interaction is lacking, nematodes are probably important contributors to plant stress, thereby threatening plant health.

The extent of damage to turf from nematode parasitism is directly related to the number of nematodes present. Due to its profuse root system, turf generally supports high levels of many nematode genera with no significant damage. The relationship between nematode levels and turf health, however, is affected by many factors, including the age and nutritional state of the turf and the presence of other disease agents or inspect pests. Management strategies for nematodes should be implemented if population levels are above the damage threshold, and/or if symptoms are present.

Nematicides are relatively effective and the most practical means to reduce nematode populations levels. Granular nematicides registered for turf include Dasanit, Nemacur, Nemacur 3, and Mocap. These materials attack the nervous system of nematodes and cause paralysis, aberrant behavior, or death. Unfortunately, nematicides have much the same effects on humans, so should be used with great caution and regard for safety.

Anyone suspecting a nematode problem may submit soil and root samples to the:

Department of Plant Pathology
1630 Linden Dr.
University of Wisconsin-Madison
Madison, WI 53706
ATTN: Dr. A. MacGuidwin

Cost of the analysis is $20.00 per sample (both root and soil assays included). The samples can be collected anytime and should consist of multiple cores taken from the area showing symptoms (do not sample dead turf). The samples should be kept moist and cool. A description of the site and suspected problem should also be included.

Editor's Note: A native of suburban Detroit, Ann MacGuidwin is the nematologist in the UW Department of Plant Pathology. Dr. MacGuidwin earned her B.S. degree at Michigan State, travelled to Florida and received an M.S. in Nematology at the University of Florida in 1979, and returned to MSU and studied for her Ph.D. in Entomology-Nematology. She graduated in 1983, came to Madison to teach a short course in nematology for five weeks and shortly after that she accepted a position as an Assistant Professor in the Department.

DUTCH ELM DISEASE:

RESISTANT CULTIVARS

By Dr. Eugene B. Smalley and Dr. Raymond P. Guries

Since 1957, a program of elm germplasm collection and screening for disease resistance has been conducted at the University of Wisconsin. This collection is now one of the most extensive in the United States and provides a unique genetic base for disease resistance elm breeding. Our program has previously emphasized the Asian gene pool, especially Japanese and Siberian elms, but more recently emphasis has been given to improvement of the American elm.

General screening and seasonal susceptibility testing have identified many elm clones with good to excellent ornamental characteristics and having very high levels of resistance to Dutch elm disease. Many of these clones also possess resistance to other elm diseases such as black leaf spot, Taphrina leaf blister, and Verticillium wilt.

SAPPORO AUTUMN GOLD. In 1973, as a result of our early investigations, we (with D. T. Lester) released the cultivar SAPPORO AUTUMN GOLD which combined the high disease resistance of Siberian elm with the moderate resistance and desirable ornamental characteristics of the Japanese elm. SAPPORO AUTUMN GOLD has been widely planted, in North American and Europe, and because of the "Elms Across Europe Program" (Pitney Bowes Ltd) received considerable notoriety following ceremonial plantings at the Pitney Bowes Factory at Harlow, Essex by the American Ambassador Kingman Brewster (1979), by Prime Minister Margaret Thatcher (1982) and at Windsor Castle by Prince Phillip (1980). Presently SAPPORO AUTUMN GOLD is the only elm grown in Hyde Park in London, where the English elm was once the park's principal shade tree.

Reception of our resistant elm in the U.S. has been less enthusiastic. Our attempts to persuade President Reagan to accept SAPPORO AUTUMN GOLD for planting on the White House grounds failed. In fact the grounds keeper at Windsor Castle told us that Prince Phillip's ceremonially planted SAPPORO AUTUMN GOLD tree at Windsor Castle was very nearly decapitated by President Reagan's helicopter when it landed near the tree during his state visit there a few years ago. However, that National Capitol Parks has now planted a SAPPORO AUTUMN GOLD tree near the Capital Mall in Washington, D.C., and anticipates future plantings of new Wisconsin cultivars as they become available. Ceremonial plants of SAPPORO AUTUMN GOLD have also taken place in Wisconsin. One specimen which was planted in Arbor Day celebrations several years ago on the State Capitol grounds in Madison became notable recently when it provided shelter over several days for a large group of apartheid protesters. The tree survived the protest, but the lawn had to be re-sodded.

Following initial resistance testing, SAPPORO AUTUMN GOLD was selected for release over other candidates because of its American elm-like vase-shaped branching habit. We were mislead by this youthful characteristic since it is now clear that in age SAPPORO AUTUMN GOLD tends to develop a single strong central trunk. The amount of crown-spread is dependent upon the planting location and distance from other trees or buildings. In marked contrast to its maternal Siberian elm parent, SAPPORO AUTUMN GOLD tolerates close competition from other trees and competes in situations where adjacent trees are nearby. Because of it's strong vigor, however, it generally needs to be planted at least 30' feet from other trees or buildings. The tree requires careful management during its formative years. In open grown situations, excessively vigorous side shoots need to be removed early to prevent premature side-branch development. In certain years, SAPPORO AUTUMN GOLD trees produce large seed crops, and as the tree ages, successive seed crops may result in death of fruitful twigs. Occasional cosmetic pruning may be required. In spite of its rapid growth, however, "heartwood" boards sawn from the trunks of older SAPPORO AUTUMN GOLD trees have a beautiful grain and color and could be useful for producing high quality plywood verneer.

REGAL. In 1983 we released a new hardy elm cultivar called REGAL possessing a columnar form, high disease resistance and a vigorous growth habit. It was selected from seed obtained in 1960 from Holland as part of a cooperative exchange with the Dutch elm breeding program. The improved hardiness and disease resistance of this selection, as contrasted with its maternal parent (COMMELIN) may be attributed in part to its 25% Siberian elm ancestry as well as the northern (Denmark) origin of its grandparent (**U. carpinifolia Hoersholmiensis**).

Soon after planting, REGAL develops a strong central leader and young plantings require a minimum of care to maintain a vigorous, upright, columnar habit of growth. Under very good growing conditions, top-pruning may be necessary to reduce the rate of height growth while allowing increased diameter growth. If this is not done, the tree may sustain unnecessary wind or ice storm damage. REGAL develops well in situations near buildings and provides an attractive accent to otherwise harsh exterior building surfaces. Young trees develop rapidly and in general form resemble the maternal parent COMMELIN. It grows more slowly than SAPPORO AUTUMN GOLD, and in mature plantings is less densely foliated than American elm. Such plantings allow full lawn development while maintaining an attractive columnar habit. Its uniform, upright growth makes it an excellent choice for boulevard plantings or urban plantings associated with shopping malls, condominiums, and other modern housing developments. REGAL has been planted extensively on the University of Wisconsin, and some of the oldest specimens of this cultivar can be seen here. A large specimen of Regal was recently planted at the U.S. Forest Products Laboratory in Madison as a part of the program celebrating the Centennial Anniversary of the Laboratory.

AMERICAN LIBERTY. The AMERICAN LIBERTY elms are a group of recently released hardy American elms (eg **Ulmus americana**) from our breeding program possessing an upright vase shape, disease resistance and a vigorous growth habit. These elms constitute a genotypically diverse, multiclonal variety having similar phenotypes. The AMERICAN LIBERTY elms were derived from control-pollinations (with D.T. Lester) between selected DED resistant parents. The parents include superior survivors from the Wisconsin program, as well as resistant individuals from the New York and USDA programs. In total the parents constitute survivors of over 60,000 inoculated American elm seedlings from many locations over the natural range of the American elm. The most distinctive of the AMERICAN LIBERTY elms has been given the name INDEPENDENCE.

Growth of AMERICAN LIBERTY elms is vigorous and typical of cross-pollinated seedlings of American elm. General leaf size, shape and color, bark color and texture and other growth characteristics are not distinctive and are generally typical of the North American white elms (**U. americana**). AMERICAN LIBERTY elms exhibit unusual resistance to DED following screening with a mixture of North American strains of the pathogen. Their resistance, while clearly improved over nonselected American elms, is inferior to resistant cultivars such as SAPPORO AUTUMN GOLD or REGAL derived from Asian or European sources. However, their resistance represents the highest level thus far achieved by selection and breeding within American elm.

Reduced resistance in young, vigorously growing ramets from resistant parents suggests that in their early years AMERICAN LIBERTY elms can succumb to Dutch elm disease, although even under these conditions their period of susceptibility will be much less that comparable non-selected American elms. We postulate that vigorously growing ramets which are not infected during the first few years of growth will generally fail to become infected in later years after reaching maturity. The long-time survival and mature plant resistance of parents of the AMERICAN LIBERTY elms make their selected progeny worthy candidates for release and public trial. The multi-clone approach to release of American elms for urban planting may counter the problem inherent in wide-scale planting of identical genotypes with limited genes for resistance to DED. It is anticipated that as our testing continues additional and perhaps improved individuals will be added to the AMERICAN LIBERTY multiclone.

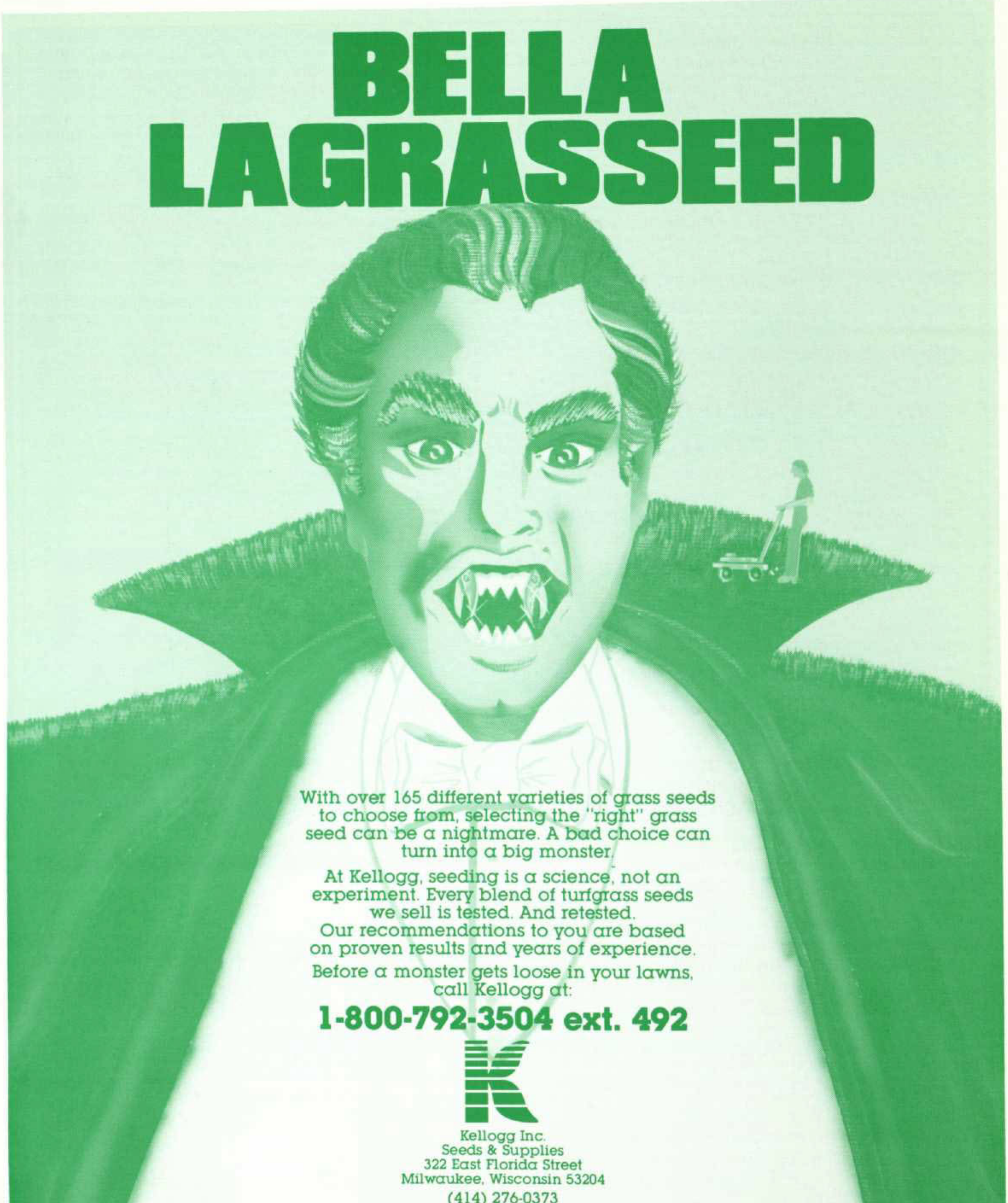
AVAILABILITY. SAPPORO AUTUMN GOLD and REGAL are available from commercial sources under license form the Wisconsin Alumni Research Foundation. Inquiries can be directed to the McKay Nursery Company, Waterloo, WI 53594; The Conservation Foundation, 11a West Halkin Street, London, SW1X8JL, and Elms Across Europe, Pitney Bowes, The Pinnacles, Elizabeth Way, Harlow, Essex, in England; or Conrad Appel, Forst-und Geholzsaaten Baumschulen, Bismarkstrasse 59, Postflach 110147, 6100 Darmstadt, West Germany. Commercial development of the AMERICAN LIBERTY elms in the United States has been assigned to the Elm Research Institute, Harrisville, NH 03450. Tel. 1-800-FOR-ELMS.

Editor's Note: Dr. Gene Smalley is nearing thirty years as a member of the UW—Madison Plant Pathology faculty. Educated in California, Professor Smalley received a B.S. degree from UCLA in 1949, a M.S. and a Ph.D. from Berkeley in 1953 and 1957, respectively. He has been at Wisconsin since 1957.

Dr. Smalley's research interest is in the control of Dutch Elm disease and mycotoxins in grain and hay. He addressed the 1974 GCSAA Conference in Anaheim on DED chemotherapy.

Dr. Ray Guries is a professor in the Department of Forestry at the UW—Madison.

Dr. Eugene B. Smalley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Disease Modeling: What is it all about?

By Dr. Douglas I. Rouse

Modern Scientific inquiry depends upon models; a model being a simplified approximation to reality. This is because the goal of science is to extract from the seemingly complex world around us the important relationships (laws) that explain the behavior of physical entities. These important relationships are often hidden by the complexity of the real world. For example, how does the scientist approach an understanding of this complex phenomenon we call Pythium blight or turf grass? By simplifying! There are many factors that can be imagined to influence the occurrence of Pythium blight on turf grass. Presence of the pathogen, of a susceptible host, and proper environmental conditions each play a role. Plant pathologists are interested in knowing what the relationships are among these factors and which ones are most important for development of disease.

Models are used as a way of stating a hypothesis. The model may begin as a conceptualization of how Pythium blight develops. The hypothesis may be that the fungus resides in soil or plant debris as mycelium and as spores, that wet conditions and warm temperatures result in growth and subsequent infection of the host. To formulate this conceptual model initial decisions based on observations must be made as to the most important factors influencing Pythium blight disease development. These are the factors that will be included in the conceptual model and studied first. At some point this conceptual model (hypothesis) must be tested. Experiments must be conducted. The approach usually taken is to choose one factor as a variable and study its effect on disease. For example, the effect of wet conditions on disease development may be studied. But how do we determine that wet conditions are necessary for development of the disease? First we must be precise about what we mean by 'wet conditions.' At this point a portion of our conceptual model must be refined to reflect the quantitative or mathematical relationship that hypothetically exists between some aspect of 'wet conditions,' such as duration of leaf wetness, and amount of disease. An experiment may be designed where treatments consist of turf grass kept wet for several different time intervals. The result may be represented by a mathematical equation. Of course all of the treatments with respect to other factors (i.e. same temperature and turf grass cultivar, etc.) remain constant, otherwise we would not know whether the different responses of the treatments were due to duration of leaf wetness or not.

Does that mean that the resulting mathematical model is only valid for one set of conditions (those of the experiment)? How do we incorporate the effect of temperature into our mathematical model? To do this it will be necessary to repeat the experiment under a number of different temperature conditions. The result will be a mathematical model with two variables. What about the effect of solar radiation, soil temperature, soil moisture, and other variables? We cannot hope to conduct our leaf wetness by temperature experiment a million and one times to include every possible variable. In addition the development of Pythium blight depends on much more than the presence of appropriate environmental conditions. Also important is the presence of the pathogen itself. Thus, we might embark on a study of the relationship between amount of inoculum and the chance of disease development. This might lead to a relationship between dose and response that would be potentially useful if we had a means of assaying for the presence of the pathogen prior to development of the disease. We already know that even if the pathogen is present, without adequate moisture the disease will not develop. Thus, a complete explanation for why disease develops when it does is dependent on a very large number of factors, interacting in complex ways, several of which we have just mentioned.

Empirical models derived directly from experimental data as described above represent a reductionist approach to scientific inquiry. As illustrated above this approach may lack the ability to explain the entire host-pathogen system because of the complexity of that system. In other words, in the scientist's endeavor to simplify the system in such a way that the important relationships between components of that system are distilled out there is the danger of missing important relationships. In this way scientific inquiry is an iterative process of searching out relationships. Nevertheless simple empirical models may have predictive value if they represent the important driving variables of the system. Alternatively a variable may be chosen that represents a composite of several variables at least one of which is important. For example, a decision could be made to relate rainfall to disease as the key factor in predicting disease development. Notice that rainfall influences leaf wetness and soil moisture as well as many other variables each of which may be the variable that actually explains disease development. It may not be necessary to know why rainfall is important to disease development for predictive purposes.

In contrast to the purely reductionist/empirical approach just described there has developed a systems science approach to the study of plant diseases. With this approach an attempt is made at the very outset of a scientific investigation to develop a complex mathematical model using logic and best guesses or opinions as well as existing empirical results to describe the entire plant disease system. This type of model may have hundreds of variables and require considerable computer resources to implement. This approach to modeling attempts to put the conceptual model of the entire disease system into a mathematical framework initially. The systems model represents a complex hypothesis or a complex of hypotheses that explain the entire system.

Testing of this hypothesis is referred to as model validation. Partial model validation is obtained simply by comparing results generated by the model with results of field observation of disease development. The systems approach has been attempted for a number of plant diseases. In most cases it has been possible to obtain a model that compared favorably with observed disease development. However this test alone is not sufficient to determine the validity of the model. Systems models have so many variables it is possible for such models to give the right answers for the wrong reasons. Adequate validation requires actually conducting many of the same experiments the reductionist would perform to confirm that the systems model has incorporated the correct opinions. The systems scientist would argue however that the systems approach is more likely to guide the researcher to the 'critical' experiments.

It is clear that both simple empirical models and complex systems models are imperfect as tools useful to the disease manager. The disease manager is in need of a model that is more than a hypothesis but actually has substantial proof via experimentation of its validity. In most cases the manager wants a model that can provide an unequivocal statement to treat or not to treat with a chemical for control of a disease. Both empirical and systems models may be useful in this regard despite their imperfections. For example, in the case of Pythium blight there is a model that has been developed to aid the timing of fungicide applications based on moisture. With this disease wetness is such an overriding factor that such a model is quite useful. Notice that it cannot be expected to be perfect however. Systems models on the other hand are often thought of as research tools as opposed to management tools. However, with continued research and the development of powerful but affordable desktop computers these models will find increasing usefulness for management.

In summary, models are an essential part of scientific inquiry. They are statements of the hypotheses that we wish to test and they relate directly to the questions that we want answers to. The various types of models which are employed represent the diversity of thought as to how scientific inquiries should be conducted. Both simple empirical models and complex systems models have potential as useful tools for the disease manager who must make decisions on the basis of available knowledge.

Editor's note: Dr. Doug Rouse is an Associate Professor in Wisconsin's Plant Pathology Department. He came to Wisconsin in 1979 after training at Ottawa, Kansas (B.S., 1974), Colorado State (M.S., 1976), and Penn State (Ph.D., 1979). His research work focuses on the mathematical characterization of pathogen variation and plant epidemics.

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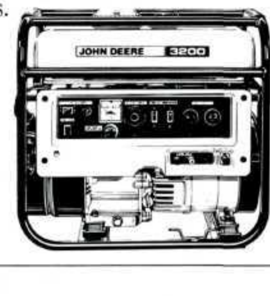

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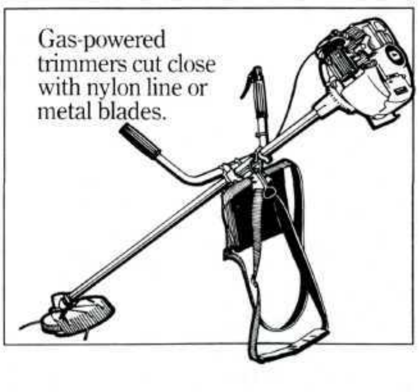

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