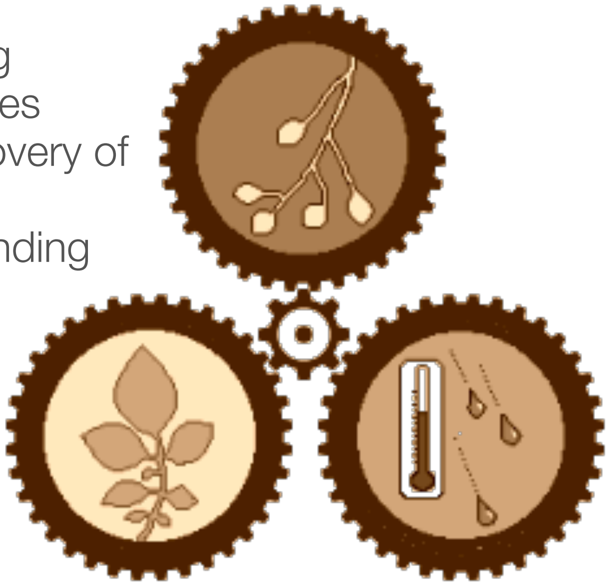
Plant Disease Management

☑ Plant Disease Management Strategies

Since the beginning of agriculture, generations of farmers have been evolving practices for combating the various plagues suffered by our crops. Following our discovery of the causes of plant diseases in the early nineteenth century, our growing understanding of the interactions of pathogen and host has enabled us to develop a wide array of measures for the control of specific plant diseases.



From this accumulated knowledge base, we can distill some general principles of plant disease control that can help us address the management of new problems on whatever crop in any environment. One such set of principles, first articulated by H. H. Whetzel in 1929 and modified somewhat by various authors over the years, has been widely adopted and taught to generations of plant pathology students around the world.

Traditional Principles of Plant Disease Control

1. **Avoidance**—prevent disease by selecting a time of the year or a site where there is no inoculum or where the environment is not favorable for infection.
2. **Exclusion**—prevent the introduction of inoculum.
3. **Eradication**—eliminate, destroy, or inactivate the inoculum.
4. **Protection**—prevent infection by means of a toxicant or some other barrier to infection.
5. **Resistance**—utilize cultivars that are resistant to or tolerant of infection.
6. **Therapy**—cure plants that are already infected.

Strategies versus Tactics

Ask a handful of pest management experts to name the major plant disease control strategies, and you are sure to find disagreement. The problem is generally one of semantics rather than of fundamental disagreement over the important means of disease control. The dictionary definitions for the two terms are similar, but generally speaking, an overall plan for reaching a particular objective is called a strategy, while the specific means for implementing a given strategy are called tactics. Like the goals and objectives that they are intended to achieve, strategies and tactics tend to occur in hierarchies. What is a "strategy" at one level of focus could be called a "tactic" at another level of focus.

The important point to remember is that countless human undertakings, be they military operations, political campaigns, football games, or any other kind of organized effort, have failed, despite flawless tactics, for lack of a sound strategy. Any endeavor that requires a series of connected tasks for its completion also requires some kind of overall plan. Each individual task, no matter how skillfully executed or how successful its outcome, will not advance progress toward the final objective unless it has a coherent relationship with all of the other necessary tasks.

The Epidemiological Basis of Disease Management

Plant disease epidemics can be classified into two basic types, monocyclic and polycyclic, depending on the number of infection cycles per crop cycle.The early stages of a monocyclic epidemic can be described quite well by a linear model, while the early stages of a polycyclic epidemic can be described with an exponential model. Since we are concerned with keeping disease levels well below 100%, there is no need to adjust the models for approaching the upper limit, and we can use the simple linear and exponential models to plan strategies:

Examining these models, we can see that in both there are three ways in which we can reduce x at any point in the epidemic:

Monocyclic Model

$$x = \overset{\overset{1}{\downarrow}}{Q}\overset{\overset{2}{\downarrow}}{R}\overset{\overset{3}{\downarrow}}{t}$$

Polycyclic Model

$$x = \overset{\overset{1}{\downarrow}}{x_0}\, e^{\overset{\overset{2}{\downarrow}}{r}\overset{\overset{3}{\downarrow}}{t}}$$

1) Reduce the initial inoculum

(Q in the monocyclic model and x_0 in the polycyclic model). (Actually x_0 is the initial incidence of disease, which is proportional to the initial inoculum.)

2) Reduce the rate of infection

(R in the monocyclic model and r in the polycyclic model)

3) Reduce the duration of the epidemic

(the time, t, at the end of the epidemic)

These, then, can be used as three major strategies for managing plant disease epidemics, and we can organize our plant disease control tactics under one or more of these overall strategies. Furthermore, by means of the model we can assess the quantitative impact of each strategy, not only by itself, but in its interaction with others.

The monocyclic model

It is clear from the above model of a monocyclic epidemic that Q, R, and t have equal weight in their effect on x. A reduction in the initial inoculum or the rate of infection will result in a reduction in the level of disease by the same proportion at any time, t, throughout the epidemic. If t can be reduced (for example, by shortening the season), disease will be reduced proportionately.

The polycyclic model

- If r is very high, the apparent effect of reducing x_0 is to delay the epidemic.
- If r is very high, x_0 must be reduced to very low levels to have a significant effect on the epidemic.
- Reducing r has a relatively greater effect on the epidemic than reducing x_0.
- Reducing x_0 makes good strategic sense only if r is low or if r is also being reduced.

It is easier to understand (and remember!) these concepts if we actually select different values for x_0 and r, plug them into the model, and graph the outcome. This can be done easily with a calculator that has an exponential function, or with the accompanying simulation. Clearly developing a sound disease management strategy requires enough knowledge of the biology of the pathogen and host to select the appropriate epidemiological model. It also requires at least "ball-park" estimates of the model parameters and the magnitude of the impact of each specific tactic on the initial inoculum or the apparent infection rate. Failure to adopt such a quantitative approach can lead to some embarrassing or even very costly errors.