Modeling of Plant Disease

Julia Nelson

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History of Modeling Plant Disease

“A plant disease model is a simplification of the relationships (between a pathogen, a host plant, and the environment) that determine whether and how an epidemic develops over time and space.”

Major Plant Disease Epidemics pushed for need for better understanding of disease

Irish Potato Famine (1845-1849)

Models used for plant disease management to protect crop growth

https://doi.org/10.1007/978-90-481-9277-9_15

Types of Plant Diseases

- Fungi
- Fungus-like Organisms
- Bacteria
- Viruses, Viroids, Virus-like Organisms
- Nematodes
- Protozoa & Algae
- Parasitic Plants

* Does not include plant-eating pests, insects, or ectoparasites.

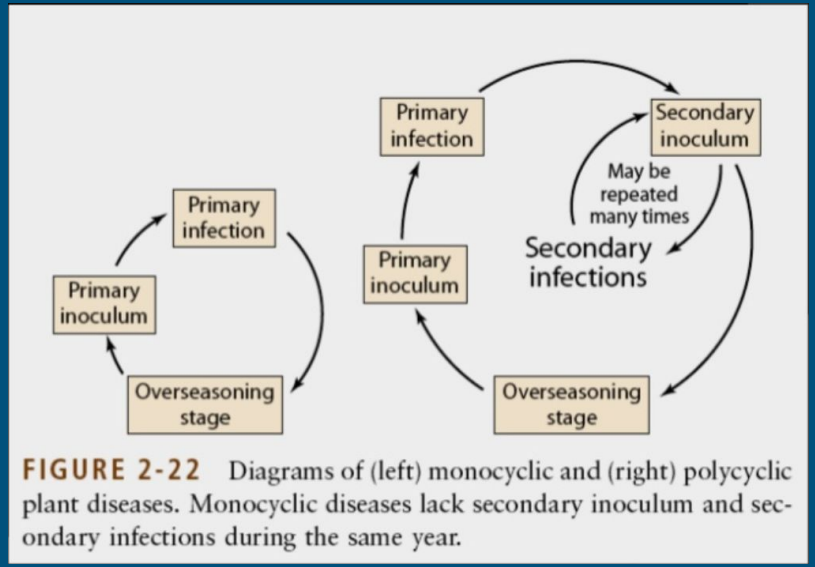


FIGURE 2-22 Diagrams of (left) monocyclic and (right) polycyclic plant diseases. Monocyclic diseases lack secondary inoculum and secondary infections during the same year.

Infection Cycles

- Monocyclic
- Polycyclic

Disease Forecasting Systems

Use multiple parameters to predict growth and change of plant diseases and can determine whether action must be taken to control a disease (pesticide treatment)

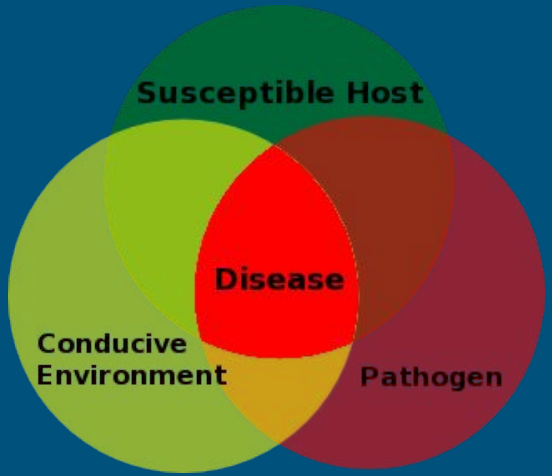
Stewart’s wilt first forecasting system - low winter temperature would kill disease range preventing epidemic

Assumption-based prediction on interactions (Disease Triangle) - prediction of when the pathogen, host plant, and environment interacting in a way that causes a disease

Modeling Factors: Plant Disease Triangle

Factors necessary for disease:

- Susceptible Host
- Pathogen
- Conducive Environment
- Can also include Humans & Time



* Need understanding on actual disease parameters for Forecasting System

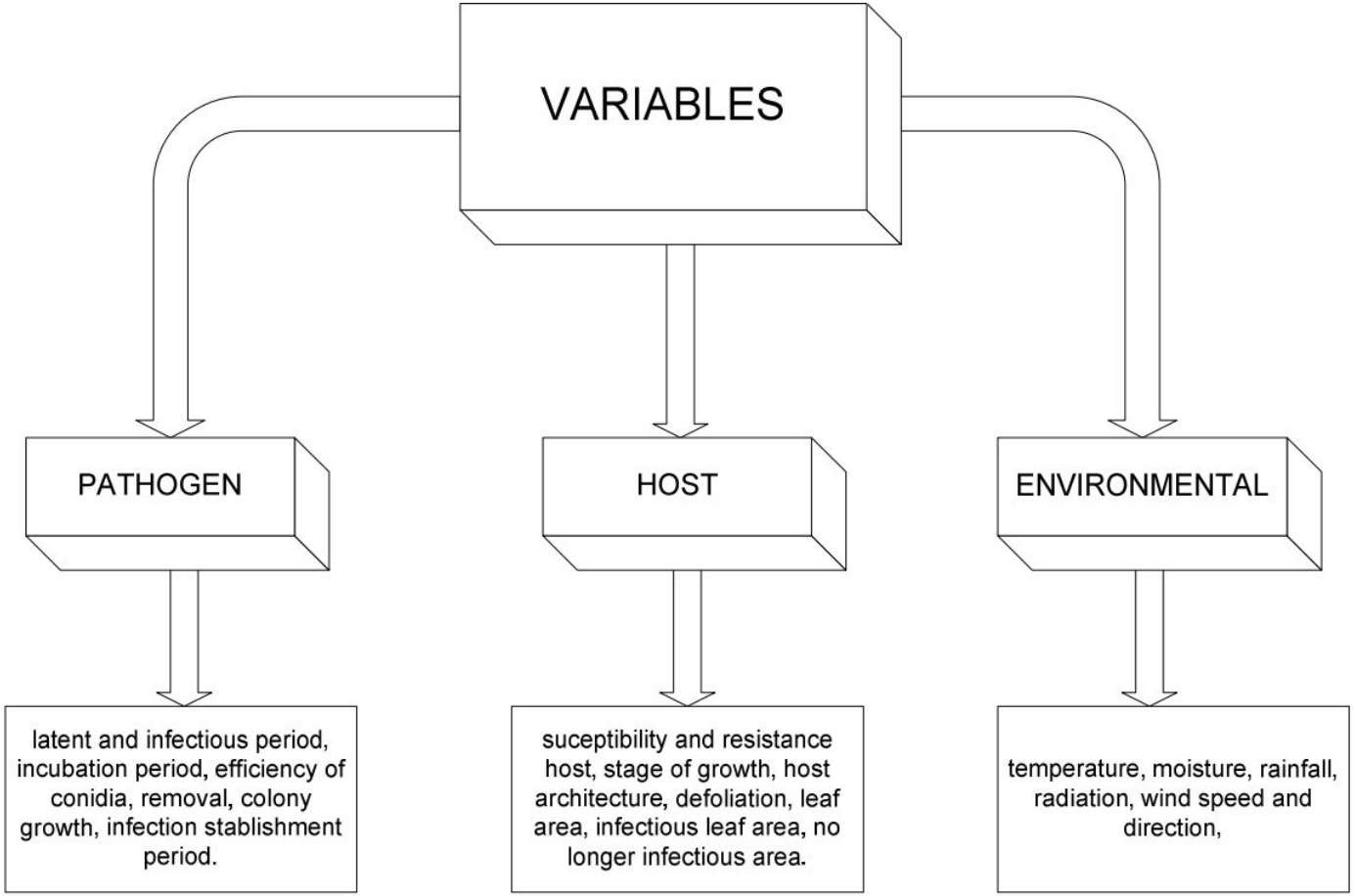


Figure 2. Classification of variables according to pathogen, host and environment.

Disease Progress Curves

- Monomolecular - used single cycle diseases
- Exponential - used when one infected plant infects another
- Logistics - common for epidemic description with secondary spreading

Compares effects of variables on disease development

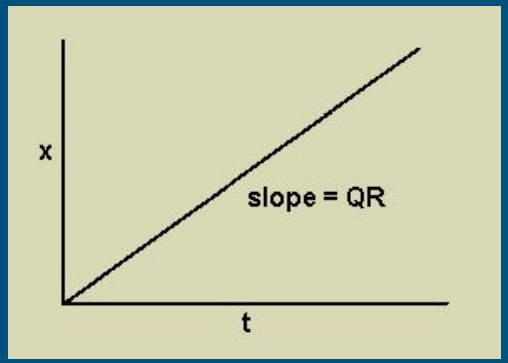
Predict future outcome and control

Area under the Disease Progress Curve used to make comparisons between cycles and treatments

Monocyclic

Differential Equation: $dx/dt = QR$

After integration: $x = QRt$

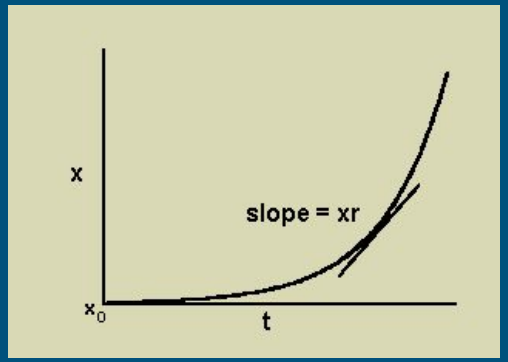


x - variable measured
t - time
Q - initial inoculum
R - rate of disease progression per unit of inoculum

Polycyclic

Differential Equation: $dx/dt = xr$

After integration: $x = x_0 e^{rt}$



x - variable measured
t - time
x0 - initial proportion of disease
r - rate of disease progression per unit of inoculum

Computer Simulations

Large number of computer simulations exist for plant modeling.

They differ depending on the host plants, pathogens and environment.

Model to demonstrate valid/controlled interactions to gather data, possible solutions to and control of the disease.

Based on extension of LDE modeling and follows general form:

$$\frac{\mathrm{d}P}{\mathrm{d}t} = B(P) - D(P),$$

Importance of Plant Disease Modeling

Disease is estimated to decrease plant yield 10%-20% each year, causing farmers to face major economic losses

Modeling of Plant Diseases can help provide valuable data, disease management solutions and reliability in crop growth.

Sources

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"I pledge my honor that I have abided by the Stevens Honor System."