Plant disease epidemiology -- an introduction

Ohio State University -- PP 7002

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Tuesday and Thursday, 11:10 am to 12:30 pm -- Internet connection
(Video links)

- What is epidemiology?
- How it relates to other sciences and disciplines.
- Types of research performed by epidemiologists.
- Questions addressed by epidemiologists.
- Usefulness of epidemiology for control/management.

"Chemical industry and plant breeders have forged fine tactical weapons, but only epidemiology sets the strategy."
Vanderplank (1963)

More specific objectives (see syllabus):

a. To gain an understanding of how plant disease epidemics occur in nature and how they can be monitored and analyzed.

b. To learn how plant diseases cause crop losses, how these losses are quantified, and how losses are predicted.

c. To learn how epidemiology is used to set the strategy of plant disease control.

d. To learn how to use some statistical procedures for quantifying and comparing and predicting epidemics.

1) **<u>Introduction</u>**
   Terminology,
   History
   Guide to course

https://u.osu.edu/thestudyofplantdiseaseepidemics/
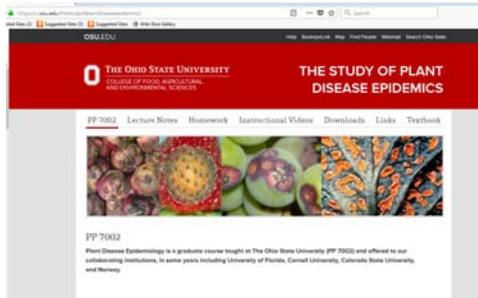
<u>Epidemic:</u>

"*Change in disease intensity in a
host population over time and space.*"

Change: often *increase* -- **a dynamic process**
Disease: dealing with **diseases,** not just the
   pathogen (or plant/crop)
Host: Organism infected (or potentially infected)
   by another organism; organism susceptible to a
   pathogen
Population: a **population phenomenon**
Time and space: two **physical dimensions**
   of interest.

Epidemiology
"Science of disease in populations"
Vanderplank (1963)

System
Community
Population
Individual
Organ
Tissue
Cellular
Molecular

Populations:
host and pathogen (and ….)

Note:
Epidemic does **not** mean widespread
and/or high level of disease!

We use ***pandemic*** for widespread, high disease
level ("*major epidemic*")

Why this definition?
Answer with an example.

Consider an epidemic of potato late blight, caused by
Phytophthora infestans...

Scenario (potato late blight)

A large field with 4 million plants (4×10^6)

   1 lesion/plant: 0.1% severity (that is, $y = 0.001$ or 1/1000 of the leaf surface covered by lesions)

(Practical limit of detection)

Disease progress curve

y

example

O 30   60   90

$t\,(time)$

44
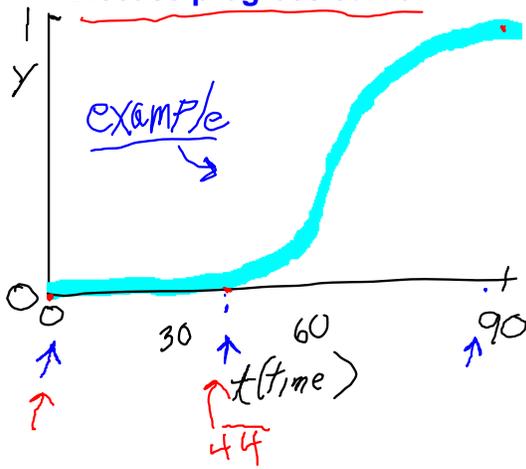
$t=44$ $y = 0.001$ (or 0.1%)
            (or 1 lesion/plant)

$t=83$ $y = 0.999$ (or ~100%)

1000 fold disease

$t=0$ 1 lesion/**field**   4 million
              (or $y = 0.001/[4 \times 10^6]$
              $= 2.5 \times 10^{-10}$)

fold increase

$t=44$ 1 lesion/**plant**
              (or 4×10^6 lesions/field,
              or $y = 0.001$)

t	y	Lesions
0	0.0000000025	1
10	0.000000080	32
20	0.0000026	1022
30	0.000012	32,695
40	0.00026	1,045,221
50	0.0083	33,154,000
60	0.21	
70	0.895	
80	0.996	

double ~2 days

rate parameter = 0.346/day
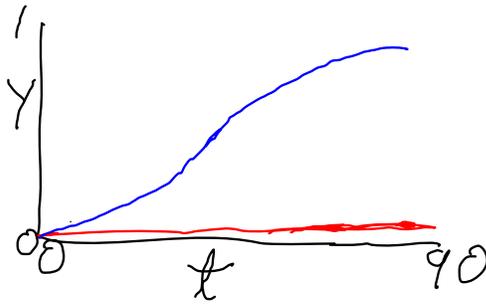
1) No obvious place to "draw the line between epidemic and no epidemic
2) Same biological processes occur over entire time (or disease) range

Thus, a change in disease intensity (in a population) is an epidemic

Other definitions:
1) *increase* instead of *change;*
2) drop *space* from definition (focus on **time**)

Other name for epidemic: *epiphytotic*   Unger (1833)
Whetzel (1920's)

Epidemic: *"what is among people"* (Greek origin)

However, equally valid meaning from Greek:
"what is in (or among) a population" ("*demio*")

"Epidemic" used for plants for a long time…..
1728: Duhamel   1691,1842: book titles
1858: Kuhn   1901: Ward

**Thus, no valid reason to use "epiphytotic"**

Epidemiology:

- *Study of epidemics.*
- *Science of disease in populations.*
- *Ecology of disease.*
- *Study of the spread of diseases, in space and time, with the objective to trace factors that are responsible for, or contribute to, epidemic occurrence.*
- *The science of populations of pathogens in populations of host plants, and the diseases resulting therefrom under the influence of the environment and human interferences.*


Epidemiology:
Involves the disease triangle, but at the population level
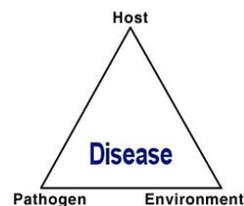
- Some efforts have been made to extend the disease triangle to encompass the dimensions of time and space (and other factors). This become awkward since we are limited to pseudo-3-dimensions.
- See *APSnet* **Education Center (**Teaching Articles) for interesting article by Francl on disease triangle.

http://www.apsnet.org/edcenter/instcomm/TeachingArticles/
Pages/DiseaseTriangle.aspx
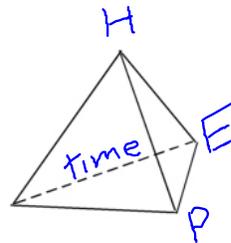
NOTE:

<u>If</u> one used **epiphytotic** (instead of epidemic), then one should use ***epiphytotiology*** instead of epidemiology**!**

-(<u>Epiphytology</u> is the study of epiphytes).

<u>History</u> (ancient to modern times):

Hippocrates (~400 BC)
   First use of "epidemic", widespread disease (human diseases)
Theophrastus (~340 BC)
   Plant diseases in fields
   Environmental influences
Pliny (~50 AD)
   Plant diseases; soil; climate
Duhamel de Monceau (1728 AD)
   Rhizoctonia sp. infecting saffron crocus
   Disease progress curves
   Comparison of plant and animal epidemics

Late 19th Century and forward…

Kuhn (1858) - 1st textbook of plant pathology

Ward (1901)
- book *"Diseases in Plants"* emphasized ecology (populations)
of disease

Jones (1913) - role of the environment

Gaumann (1946) - book *"Principles of Plant Infection"*
-Disease spread   ← *qualitative sense*
-Conditions leading to an epidemic
-'***Infection Chain***' (= disease cycle)
-compare with medicine (diseases of humans)
-theory (initial, in words)

Large (1952, and others)
-Disease progress curves →
-Crop losses
-Disease assessment (measurement)
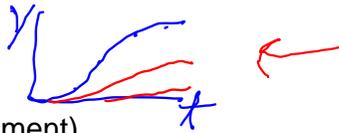
Horsfall & Dimond (1960)- book *"Plant Pathology, Volume 3"*
-Populations
-Inoculum density:disease relations
-Spore dispersal ←
-Analysis (mathematics) ←
-Forecasting, prediction
-*Traditional* definition ---> *Modern* definition

Inoculum
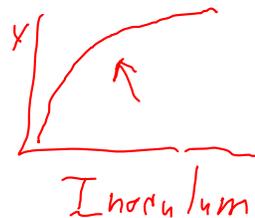
Gregory (1963, 1973)
"*The Microbiology of the Atmosphere*"
-spore dispersal, disease spread
   Aerobiology

*Don Aylor
2017 (16)*

Vanderplank (1963) (used to be "van der Plank")
- book "*Plant Diseases: Epidemics and Control*"
- Populations
- Rates (dynamic processes)
- Analysis, mathematics
- Models, theory ← *quantitative*
- Link epidemiology and control
- Established the science of plant disease epidemiology

host resistance
(Horizontal – partial
Vertical – R gene
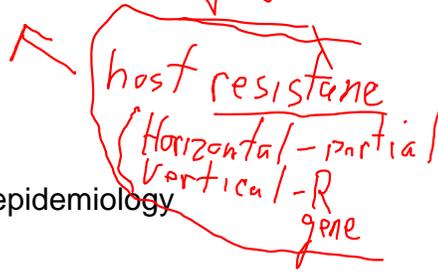
Other pioneers:
Zadoks (1960-1995), The Netherlands
Kranz (1968-1995), Germany
Waggoner (1960-mid --1980s), USA

Note: many developments in other fields…
Ecology, medical epidemiology,
Biomathematics, statistics, etc.

Guide to the course (condensed syllabus)…..

1) **Introduction**
Terminology,
History
Guide to course

2) **Monitoring epidemics**
Host measurement
Disease measurement
Severity-incidence

3) **Analysis of epidemiological data**
Models
Regression (introduction)
MINITAB/SAS/R

4) **Disease progress over time**
Disease progress curves
Models and analysis
Advanced topics
asymptotes
thresholds
components
controls

Guide (continued)...

5) **Disease spread in space**
   Dispersal gradients
   Models, analysis
   Spatio-temporal

6) **Spatial patterns (dispersion)**
   Concepts of aggregation
   Analysis
   Spatial scale
   Sampling

7) **Crop loss assessment**
   Concepts
   Models
   Prediction

Grading:

Two tests (65%) + Assignments (35%)

Readings from:

- Chapters from ***The Study of Plant Disease Epidemics***,
   o by L. V. Madden; G. Hughes, and F. van den Bosch (2007)
- Various book chapters and journal articles.
- Reading is for your benefit, to provide background. You will not be tested on any material in these readings unless I specially tell you so.

Students are expected to have access to a personal computer, and either Minitab,SAS, or R statistical software.
   (We can give advice on Minitab and SAS)

Reading assignment #1 (recommended):

- Chapter 1 Madden, Hughes, and van den Bosch (**MHV**)

- Chapter 2 **MHV** -- **for next two classes**

Original lecture notes will be sent out, or posted on the website. *Updated* lecture notes (with any handwritten additions, etc.) will be posted to the course website after each class, or after each lecture section is completed.

Classes are recorded, and should be available for viewing within a few hours of each class (maybe the next day).

Assignments, syllabus, and other items, available on the website.

https://u.osu.edu/thestudyofplantdiseaseepidemics/

Your source for information