PLP 6404
Epidemiology of Plant Diseases
Spring 2015

Ariena van Bruggen, modified from Katherine Stevenson

Lecture 1: Introduction to epidemiology: history and terminology

What is an epidemic?

J.C. Zadoks: Epidemiology = the science of epidemics

- Επιδημιος = epidemios = what is among the people (Hippocrates, 460-380 B.C.)
- Epidemiology: epi + demio + logy (= on + people or populations + study)
- Is epiphytology more correct? Not used; botanical epidemiology is used

J. Kranz: Epidemic = a change in disease intensity in a host population over time and/or in space

Note: Does not necessarily imply massive occurrence of disease in a limited time period.

Branches:

- Medical epidemiology
- Veterinary epidemiology
- Botanical epidemiology

What is plant disease epidemiology?

J.E. Vanderplank (1963): "Epidemiology is the science of disease in populations"

Campbell and Madden (1990): "Plant disease epidemiology is the study of the temporal and spatial changes that occur during epidemics of plant diseases that are caused by populations of pathogens in populations of plants."

J. Kranz (1974): "Epidemiology is the science of populations of pathogens in populations of plants, and the diseases resulting there from under the influence of the environment and human interferences."

Epidemiology has both qualitative (descriptive) and quantitative components

- qualitative: when and where
- quantitative: how many propagules, lesions etc.

Epidemiology also has theoretical and practical components:

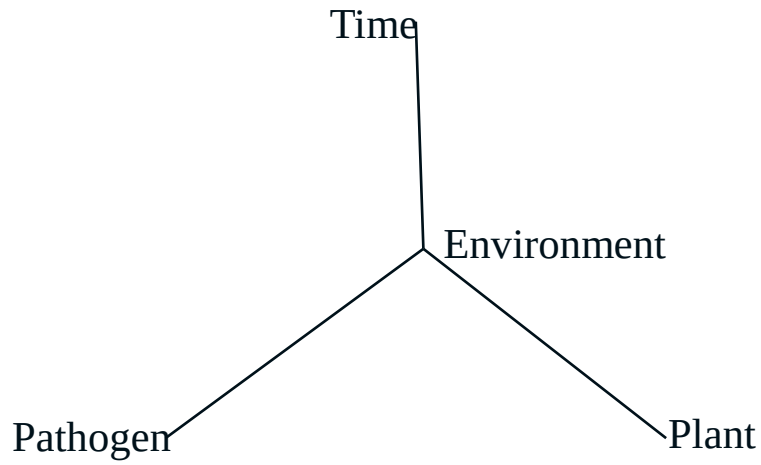
- acquisition of fundamental knowledge on relationships (basic)
- application of this knowledge in the field, for example for prediction (applied)

Leonard and Fry (1986): "From it's beginning, the science of plant pathology has been based on a commitment to agriculture. It grew from the premise that the causes of destructive diseases of

agricultural crops can be discovered, and that once they have been discovered and sufficiently understood, they can be controlled. With rare exceptions, plant pathologists are not concerned with providing therapy for individual plants. Instead, they justify their research on the conviction that the knowledge gained will be useful in finding ways to reduce the size of pathogen populations, reduce their rates of population growth, or to otherwise inhibit the spread of pathogens through populations of plants."
Understanding of the many biological and environmental factors that contributed to epidemics should provide us with information and opportunities that will allow us to avert future disasters. Principles and practices derived from this understanding should help us to manage plant diseases better. This understanding is what plant disease epidemiology is all about!

The disease triangle or tetrahedron:

Disease results from an interaction of



Where do epidemics occur? Any populations of organisms

Types of ecosystems:

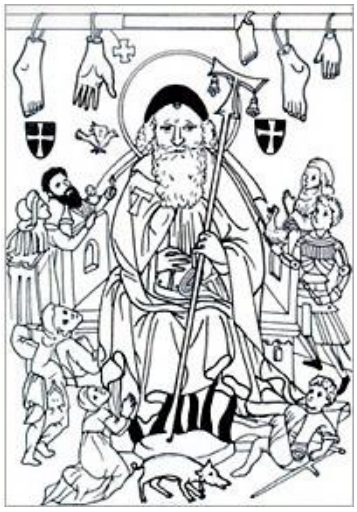
- Ecosystems
  - Terrestrial (Natural and Managed)
  - Aquatic (Natural and Managed)
- In managed ecosystems disease development is generally more intense

With the development of agriculture, man's influence added a new dimension to the occurrence and consequence of epidemics. Think of effects of monocultures and fertilization.

Examples of important historical plant disease epidemics

1. Ergot of rye and ergotism (*Claviceps purpurea*)

The fungus invades the grain and produces a large sclerotium containing alkaloids including LSD that act as blood vessel constrictors.



Small amounts of these alkaloids cause:

- abortions in humans and cattle
- tingling sensation
- numbness in extremities

Larger doses can result in:

- high fever
- gangrene
- mental derangement (dementia)
- death

857: First recorded epidemic of ergotism in the Rhine Valley resulted in 1,000s of deaths.
1951: In France, infected rye was ground and added to what was supposed to have been pure wheat bread, resulting in 200 cases of severe illness, 32 cases of insanity and 4 deaths.
1978: Starving Ethiopians were forced to eat wild ergot-infected grains.

2. Late blight of potato (*Phytophthora infestans*)

A family in Ireland could grow enough potatoes to feed themselves on 50% of the land required to produce the same amount of calories in grains. By 1800, the potato was the mainstay of the diet of Irish farmers, who consumed as much as 8 lbs of potatoes per day!

Factors contributing to occurrence of epidemics in 1845 and 1846:

- cool, wet Fall resulted in tuber infection
- infected tubers rotted in storage
- few tubers for 1946 were already infected
- planting of infected tubers in 1946.

Demographic changes between 1846 and 1851 due to late blight epidemics:

- deaths + starvation
- emigration

.

P. infestans was particularly devastating in Ireland for 4 reasons:

- sole food source
- unfavorable political structure (landlord tenant system)
- tremendous population growth in 1900-1945
- potatoes are genetically uniform

3. Coffee rust (*Hemileia vastatrix*)

Devastated the coffee crop in Sri Lanka (Ceylon) between 1870 and 1889 and is still a major disease of coffee today.

1835: Only 200 ha of coffee grown in Sri Lanka (Ceylon).
1869: The fungus was described by M. J. Berkeley, and was associated with symptoms of premature defoliation, but was not considered to be a threat.
1870: Nearly 200,000 ha of coffee were in production on the island and at that time, the most popular hot beverage in Britain was coffee.

1874: The disease had spread to every plantation on the island.
1878: Coffee yields were down by 55%.
1880: H. M. Ward made an effort to determine the life history of the fungus, the nature of the disease it caused, and demonstrated that it could be controlled with lime-sulfur.
1890: The coffee industry of the entire Asian continent was essentially destroyed, which led to the increase in the popularity of tea in Britain.

H. vastatrix most likely had been present on wild coffee plants in the jungles of Sri Lanka for centuries but was not a major problem. Why?

Coffee production has since shifted to South America, which was free from coffee rust until the 1970s; coffee rust is now also the most important disease there.

4. Important epidemics in the U.S.:

Chestnut blight (early 1900s): *Cryphonectria parasitica*
Southern corn leaf blight (1970s): *Bipolaris maydis*
Citrus canker (1990s): *Xanthomonas axonopolis*
Asian soybean rust (2000s): *Phacospora pachyrhizi*
Sudden oak death (2000s): *Phytophthora ramorum*
Laurel wilt (2008 in Florida): *Raffaelia lauricola*
Citrus blackspot (2010 in Florida): *Guignardia citricarpa*
Most of these are newly introduced pathogens, except *Bipolaris maydis*, which spread fast due to genetic uniformity of the host (Texas male sterile cytoplasm)

5. History of Epidemiology

Trends, events, people, and publications in plant epidemiology
The early years:
1728: First work published in epidemiology by Duhamel de Monceau, on a disease of saffron crocus, called 'Death' (*Rhizoctonia violacea*). For the first time, the biological nature was recognized.
1858: Julius Kuhn published a textbook on plant diseases, which included the concept of an epidemic as in the Irish late blight epidemics of 1845-46.
1901: H.M. Ward took a more ecological approach toward the study of plant diseases in his book on ***Disease in Plants***.
1946: Gäumann wrote the first book on plant disease epidemiology.

The "birth" of plant disease epidemiology:
1960: publication of a chapter entitled, "Analysis of Epidemics" by J. E. Vanderplank in Plant Pathology, vol. 3, edited by Horsfall and Dimond, was the birth of modern plant disease epidemiology.
1963: Vanderplank then expanded on and refined his ideas in his book, "Plant Diseases: Epidemics and Control".

This landmark book provided the first comprehensive treatment of the description and the quantification of plant disease epidemics, and provided a theoretical framework for epidemic analysis.

More recent publications in plant disease epidemiology:
1974: J. Kranz (editor): Epidemics of Plant Diseases: Mathematical Analysis and Modeling. (Revised in1990 as 2nd edition).
1979: J.C. Zadoks and R.D. Schein: Epidemiology and Plant Disease Management.
1980: J. Palti & J. Kranz (editors): Comparative Epidemiology: a Tool for Better Disease Management. Proceedings of the session on comparative epidemiology, 3rd International Congress of Plant Pathology, Munich, 1978.
1986: K. J. Leonard and W. E. Fry (editors) Plant Disease Epidemiology. Population Dynamics and Management. Vol 1.
1989: K. J. Leonard and W. E. Fry (editors) Plant Disease Epidemiology. Genetics, Resistance, and Management. Vol. 2.
1989: M.J. Jeger (editor): Spatial Components of Plant Disease Epidemics.
1990: C. L. Campbell and L. V. Madden: Introduction to Plant Disease Epidemiology*
2003: J. Kranz: Comparative Epidemiology of Plant Diseases
2006: B. M. Cooke, D. Gareth Jones, and B. Kaye: The Epidemiology of Plant Diseases
2007: Madden, L.V., Hughes, G., and van den Bosch, F.: The Study of Plant Disease Epidemics*

* recommended texts for this class (just to get an overview, not to study in detail)