

# Plant disease epidemiology

**Plant disease epidemiology** is the study of disease in plant populations. Much like diseases of humans and other animals, plant diseases occur due to pathogens such as bacteria, viruses, fungi, oomycetes, nematodes, phytoplasmas, protozoa, and parasitic plants.<sup>[1]</sup> Plant disease epidemiologists strive for an understanding of the cause and effects of disease and develop strategies to intervene in situations where crop losses may occur. Typically successful intervention will lead to a low enough level of disease to be acceptable, depending upon the value of the crop.

Plant disease epidemiology is often looked at from a multi-disciplinary approach, requiring biological, statistical, agronomic and ecological perspectives. Biology is necessary for understanding the pathogen and its life cycle. It is also necessary for understanding the physiology of the crop and how the pathogen is adversely affecting it. Agronomic practices often influence disease incidence for better or for worse. Ecological influences are numerous. Native species of plants may serve as reservoirs for pathogens that cause disease in crops. Statistical models are often applied in order to summarize and describe the complexity of plant disease epidemiology, so that disease processes can be more readily understood.<sup>[2][3]</sup> For example, comparisons between patterns of disease progress for different diseases, cultivars, management strategies, or environmental settings can help in determining how plant diseases may best be managed. Policy can be influential in the occurrence of diseases, through actions such as restrictions on imports from sources where a disease occurs.

In 1963 J. E. van der Plank published “Plant Diseases: Epidemics and Control”, a seminal work that created a theoretical framework for the study of the epidemiology of plant diseases.<sup>[4]</sup> This book provides a theoretical framework based on experiments in many different host pathogen systems and moved the study of plant disease epidemiology forward rapidly, especially for fungal foliar pathogens. Using this framework we can now model and determine thresholds for epidemics that take place in a homogeneous environment such as a mono-cultural crop field.<sup>[4]</sup>

## 1 Elements of an epidemic

Disease epidemics in plants can cause huge losses in yield of crops as well threatening to wipe out an entire species such as was the case with Dutch Elm Disease and could

occur with Sudden Oak Death. An epidemic of potato late blight, caused by *Phytophthora infestans*, led to the Great Irish Famine and the loss of many lives.<sup>[5]</sup>

Commonly the elements of an epidemic are referred to as the “disease triangle”: a susceptible host, pathogen, and conducive environment.<sup>[1]</sup> For disease to occur all three of these must be present. Below is an illustration of this point. Where all three items meet there is disease. The fourth element missing from this illustration for an epidemic to occur, is time. As long as all three of these elements are present disease can initiate, an epidemic will only ensue if all three continue to be present. Any one of the three might be removed from the equation though. The host might out-grow susceptibility as with high-temperature adult-plant resistance,<sup>[6]</sup> the environment changes and is not conducive for the pathogen to cause disease, or the pathogen is controlled through a fungicide application for instance.

Sometimes a fourth factor of time is added as the time at which a particular infection occurs, and the length of time conditions remain viable for that infection, can also play an important role in epidemics.<sup>[1]</sup> The age of the plant species can also play a role, as certain species change in their levels of disease resistance as they mature; a process known as ontogenic resistance.<sup>[1]</sup>

If all of the criteria are not met, such as a susceptible host and pathogen are present but the environment is not conducive to the pathogen infecting and causing disease, disease cannot occur. For example, corn is planted into a field with corn residue that has the fungus *Cercospora zea-maydis*, the causal agent of Grey leaf spot of corn, but if the weather is too dry and there is no leaf wetness the spores of the fungus in the residue cannot germinate and initiate infection.

Likewise, it stands to reason if the host is susceptible and the environment favours the development of disease but the pathogen is not present there is no disease. Taking the example above, the corn is planted into a ploughed field where there is no corn residue with the fungus *Cercospora zea-maydis*, the causal agent of Grey leaf spot of corn, present but the weather means long periods of leaf wetness, there is no infection initiated.

When a pathogen requires a vector to be spread then for an epidemic to occur the vector must be plentiful and active.

- Plant disease triangle illustration

## 1.1 Types of epidemics

Monocyclic epidemics are caused by pathogens with a low **birth rate** and **death rate**, meaning they only have one infection cycle per season. They are typical of soil-borne diseases such as **Fusarium wilt** of **flax**. Polycyclic epidemics are caused by pathogens capable of several infection cycles a season. They are most often caused by air-borne diseases such as **powdery mildew**. Bimodal polycyclic epidemics can also occur. For example, in **brown rot** of **stone fruits** the **blossoms** and the **fruits** are infected at different times.

For some diseases it is important to consider the disease occurrence over several growing seasons, especially if growing the crops in **monoculture** year after year or growing **perennial plants**. Such conditions can mean that the **inoculum** produced in one season can be carried over to the next leading to a build of an inoculum over the years. In the **tropics** there are no clear-cut breaks between growing seasons as there are in **temperate** regions and this can lead to accumulation of inoculum.

Epidemics that occur under these conditions are referred to as *polyetic* epidemics and can be caused by both monocyclic and polycyclic pathogens. Apple powdery mildew is an example of a polyetic epidemic caused by a polycyclic pathogen and Dutch Elm disease a polyetic epidemic caused by a monocyclic pathogen.

## 2 Employment

Plant disease epidemiologists are typically employed as researchers by universities, or governmental institutions such as the **USDA**. However, private companies in agricultural fields also employ epidemiologists.

## 3 See also

- **Distance Diagnostics Through Digital Imaging (DDDI)**
- **Landscape epidemiology**
- **Plant disease forecasting**
- **Robert Hartig**
- **Forest pathology**
- **Phytopathology with historical landmarks in plant pathology**

## 4 References

- [1] Agrios, George (2005). *Plant Pathology*. Academic Press. ISBN 978-0-12-044565-3.

- [2] Arneson, PA (2001). "Plant disease epidemiology: temporal aspects". *Plant Health Instructor* (American Phytopathological Society). doi:10.1094/PHI-A-2001-0524-01.
- [3] Madden, Laurence; Gareth Hughes; Frank Van Den Bosch (2007). *Study of Plant Disease Epidemics*. American Phytopathological Society. ISBN 978-0-89054-354-2.
- [4] Drenth, A (2004). "Fungal epidemics – does spatial structure matter?". *New Phytologist* (Blackwells) **163** (1): 4–7. doi:10.1111/j.1469-8137.2004.01116.x.
- [5] Cormac Ó Gráda, Ireland's Great Famine, University College Dublin, 2006, ISBN 978-1-9045-5858-3, p. 7
- [6] Shultz, T.R; Line, R.F (1992). "High-Temperature, Adult-Plant Resistance to Wheat Stripe Rust and Effects on Yield Components". *Agronomy Journal* (American Society of Agronomy) **84** (2): 170–175. doi:10.2134/agronj1992.00021962008400020009x.

## 5 External links

- **Ecology and epidemiology in the R programming environment** - Open access modules published in The Plant Health Instructor

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