PLP 6404 Epidemiology of Plant Diseases
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Lecture 2: Measurement of disease

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Why quantification of disease?

- crop loss assessment
- pathogen population dynamics
- timing management
- evaluating host resistant/pathogen virulence
- evaluating control strategies

Quantitative epidemiology: the basic unit

Problems: pleomorphism, recognition, counting

- Smallest unit pathogen:
  - Spore (1 cell): n, n+n, 2n
  - Spore (>1 cell)
  - Clump of spores
  - Vector unit

- Smallest unit host:
  - Lesion
  - Diseased plant part
  - Diseased plant

Levels of disease

- Determining disease intensity is not easy!
- Level of disease:
  - Incidence (proportion of plants diseased)
  - Severity (proportion of area or length diseased)
  - Prevalence (binary yes/no)
  - Intensity (amount of disease, combination of incidence and severity)
- Which measures are easiest to obtain?
- Which more accurate?
- Which more appropriate at which time?

Levels of disease

- Types of data for intensity measurement:
  - nominal – qualitative, not ordered
  - ordinal – qualitative, ordered
  - interval – quantitative, ordered
  - ratio – quantitative, ordered, a "fixed origin" exists, usually expressed as a proportion or percentage

Time scales

- calendar time (more frequent, more accurate)
- physiological time (degree-days)
- host growth stage (e.g. Feekes scale for cereals)
- pathogen growth stage
Visual assessment of disease severity

- Counting or measuring -> ratio data
- Estimating using disease diagrams (e.g. James’ assessment keys) -> interval data
- Disease scoring scales (0-100% in finite classes) -> interval data
  - Horsfall-Baratt scale (Weber-Fechner laws not verified)
    - Acuity is proportional to log intensity
    - Largest error in center of scale
- Rating scales -> ordinal data
  - Example
    - 0 = symptomless
    - 1 = small root or stem lesions
    - 2 = large root or stem lesions
    - 3 = dead

Electronic and indirect measurements

- Electronic assessment – image analysis
- Remote sensing - Multispectral radiometry
  - Visual to near infrared (600-800 nm); http://www.cropscan.com/msr.html

Quality of measurement

- Reliability:
  - Reliability (precision): proximity of points to a regression line, measured by $R^2$ for the regression model
  - intra-rater reliability - the lack of variability in measurements when the same disease specimen is evaluated by the same evaluator
  - inter-rater reliability - the lack of variability in measurements when the same disease specimen is evaluated by two different evaluators

Horsfall-Baratt scale

<table>
<thead>
<tr>
<th>H-B Class</th>
<th>% Disease</th>
<th>Midpoint</th>
<th>Elanco Formula</th>
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Shortcomings:

- Assumptions not true
- Classes overlap
- Back transformations are needed before statistical analysis
- Elanco formula = geometric mean = square root of product of two numbers

Electronic and indirect measurements

- Indirect measurement of severity
  - Physiological effects like wilting
  - From relationship between incidence and severity

Duveiller, 1994

Lee et al., 2006

Campbell and Madden, 1990

Elanco, 1994

Duveiller, 1994
Quality of measurement

- **Accuracy**: the closeness of a measurement to the true value, closeness of the slope of the regression line to 1 and the closeness of the y-intercept to 0.
- Slope significantly different from 1 -> bias (scale shift)
- Slope > 1, then over-estimation
- Slope < 1, then under-estimation
- Intercept significantly different from 0 -> also bias (location shift).

Symbols, units, dimensions

- Use standard metric units

Dimensions

- Same units on left and right side of = sign

The epidemic as a process

- State and rate of a process
  - State = countable or measurable units when the process is frozen in place
  - Rate v = velocity of change from one state to the next
- Individual and population
  - Individual: x
  - Population x, var

Conclusion

- Proper measurement is extremely important
- Timing of measurements is also important
- There are many different methods: qualitative and quantitative
- Always calibrate your method and measure the bias and precision
- Only quantitative interval or ratio measurements can be subjected to ANOVA etc.
- Qualitative observations must be analyzed by non-parametric statistics
- Always use standard metric units and check the dimensions