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

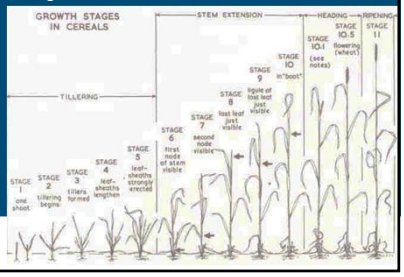
- Determining disease intensity is not easy!
- Level of disease:
  - Incidence (proportion of plants diseased)
  - Severity (proportion of area or length diseased
  - Prevalence (binary yes/no)
  - Intensity (amount of disease, combination of incidence and severity)
- Which measures are easiest to obtain?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

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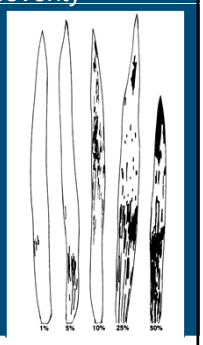
Visual assessment of disease severity

- Assessment keys
- Example: bacterial leaf streak of cereals
- Copied on tracing paper, infected areas cut and passed through Delta T leaf area meter



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Duveiller, 1994

Visual assessment of disease severity

- Horsfall-Baratt scale

H-B Class	% Disease	Midpoint	Elanco Formula
0	0	0	0
1	0-3	1.5	2.34
2	3-6	4.5	4.68
3	6-12	9.0	9.37
4	12-25	18.5	18.75
5	25-50	37.5	37.50
6	50-75	62.5	62.50
7	75-88	81.5	81.25
8	88-94	91.0	90.63
9	94-97	96.5	95.31
10	97-100	98.5	97.66
11	100	100	100

Shortcomings:

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

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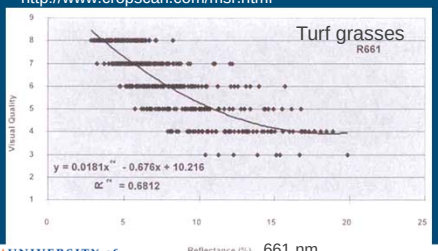
Electronic and indirect measurements

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



661 nm

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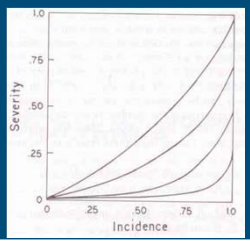
Lee et al., 2006

Electronic and indirect measurements

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



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Campbell and Madden, 1990

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

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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).

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Symbols, units, dimensions

l	m	meter	[L]
t	s	second	[T]
v	$m.s^{-1}$		$[L.T^{-1}]$
a	$m.s^{-2}$		$[L.T^{-2}]$
f	$kg.m.s^{-2}$	Newton	$[M.L.T^{-2}]$
e	$kg.m^2.s^{-2}$	Joule	$[M.L^2.T^{-2}]$
T	K	°Kelvin	[K]
N	N, n	(number)	[N]

- Use standard metric units

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Dimensions

EXAMPLE – dimension analysis

$r_t = \frac{1}{t_2 - t_1} \cdot \log_e \frac{x_2}{x_1}$

$[T^{-1}] = \frac{1}{[T]} \cdot 1 = [T^{-1}]$

Here, r stands for relative rate and

T stands for time

- Same units on left and right side of = sign

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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 $\bar{x}$, var_x

e.g. germ tube elongation — quantitative response

individual $v_i = \frac{x_2 - x_1}{t_2 - t_1}$ $\frac{[L]}{[T]} = [L.T^{-1}]$

population $v_p = \frac{\bar{x}_2 - \bar{x}_1}{t_2 - t_1}$ $\frac{[L]}{[T]} = [L.T^{-1}]$

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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.

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