Overview

- Types of seed-borne plant pathogens
- Pathogen characteristics that influence epidemic development
- Epidemiological consequences of seed-borne infection
- Quantification of seed-borne inoculum
- Seed treatments
- Conclusions

Types of seedborne plant pathogens

There are four main types of seed contamination:

- Pathogen structures mixed in with the seeds
  - bunt balls (Tilletia caries)
  - nematode galls (Anguina tritici)
  - sclerotia (Sclerotinia sclerotiorum or Claviceps purpurea)
  - pathogens in plant debris
- Propagules adhering to the seed coat
  - spores (Ustilago hordei, Tilletia caries)
  - bacteria (Pseudomonas spp., Xanthomonas spp., Clavibacter spp.)
- Resting hyphae or bacteria inside the seed coat
  - resting hyphae (Pyrenophora graminearum)
  - pycnidia (late blight on celery by Septoria apiicola)
  - acervuli (anthracnose on bean by Colletotrichum lindemuthianum)
  - bacila (Pseudomonas, Xanthomonas, Clavibacter)
- Pathogen deep-seated within the seed (in embryo or other tissues)
  - wheat loose smut (Ustilago nuda)
  - wheat root rot and leaf blotch (Cochliobolus sativus)
  - corn ear rot (Fusarium moniliforme)
  - bean common blight (Xanthomonas phaseoli)
  - viruses (Common Bean Mosaic on beans)
Pathogen characteristics that influence epidemic development of seedborne diseases

- Pathogen population size
  - Number of seeds infected
  - Number of propagules per seed (less important)
- Location of propagules on/in seeds
- Probability of survival of infected seeds
- Probability of spread of disease to above-ground plant parts
- Reproduction and spread among plants
- Fungicide tolerance

Pathogen transmission from seed to plants and losses

- Epidemiological consequences of seed infection

Initiation of epidemic from seed depends on:

- Inoculum potential
  - Seeding rate × level of contamination × probability of infection
- Environmental factors
  - Soil temperature
  - Soil moisture
  - Soil pH

Epidemiological consequences of seed infection

Spread of pathogens from seed to plant depends on:

- Level of contamination and probability of infection
- Spread of pathogens from seed to plant
  - Seeding decay, then spread to rest of plant and to other plants (Fusarium spp., Phoma lingam, etc.)
  - No seeding decay, but infected seed serves as primary inoculum (Septoria apiicola, Xanthomonas campestris pv. campestris, etc.)
  - Systemic infection; no plant to plant spread until flowering (Ustilago nuda, Cochliobolus graminearum)

Quantification of seedborne inoculum

Determine number of seeds to be tested

- Low percentage of infected seed can lead to severe crop loss (LMV in lettuce < 1:30,000, bacterial blight on beans < 1:16,000)
- Statistically impossible to guarantee NO contamination
- Set tolerable or acceptable level of contamination $I_{ac}$
- Set non-tolerable level $I_{nt}$

Population/sample | accept | reject
--- | --- | ---
Sample | Type 1 error or $\alpha$ | Error
Right decision | accept (Type 2 error or $\beta$) | Error

Critical value
Quantification of seed-borne inoculum

Acceptability level for seed contamination depends on:
- seed size and seed density per acre (seeding rate)
- inoculum level (incidence and severity, pathogen vigor)
- accuracy of seed health testing method
- infection probability in field, depending on:
  - susceptibility of host, transmissibility to seedling/plant,
  - environmental conditions for plant-to-plant spread
- probability of infection of subsequent crops
- relative importance of other means of transmission
- possibility of disinfecting seeds
- economic considerations

First indicate acceptable probabilities of making an error
- If you accept a seed lot, you want to have a high probability of making the right decision ($1 - \alpha = 95\%$)
- If you accept a seed lot you want to run only a very small risk of making a mistake ($\beta = 1\%$)

The chance of finding a positive seed is very small
(Poisson distribution)

The lower the number of positive testing seeds $NI$, the larger the $P$ of accepting the seed lot ($1-\alpha$ or $\beta$)

Read paper of Geng et al. 1983

Cumulative probability curves for the Poisson distribution

If you test many seeds, they can be tested in batches or samples
- $K$ = number of samples
- $N$ = Number of seeds per sample
- $Pc = probability of seed contamination (depends on I; $Pc = 1 - e^{-NI}$)
- $Ps = sensitivity of the test$
- $Pd = probability of detection ($Pd = Pc \times Ps$ in 1 sample)
- $P+ = probability of at least 1 positive result in $K$ samples ($P+ = 1 - (1 - Pd)^K$)

Direct examination
- Moist chamber methods (on paper, textile, inert media)
- Incubation on agar media (surface disinfect seed; kill embryo by freezing or 2,4-D; incubation temperature; light needed?)
- Embryo test
- Emergence tests (greenhouse or field)

Indirect methods
- Washing contaminants from seeds and plating
- Serological tests (ELISA, immunofluorescence)
- PCR based methods

Quantification of seed-borne inoculum -Indirect assays

No of seeds per sample ($N$) and number of samples ($k$) for indirect assays at various sensitivities ($Ps$) and tolerable levels ($I$)
## Quantification of seedborne inoculum

- **Criteria for choice of method**
  - purpose of test
  - sensitivity of test
  - costs
- **Statistical considerations for seed health testing**
  - sampling (number of samples per seed lot, number of seeds per sample)
  - probability of detection
  - Assessment of results (probability of errors a and b)

## Seed treatments

- **Hot water treatment** (nematodes and smuts)
- **Salt water treatment**: brining (bunt)
- **Acid treatment** (bacterial canker of tomato)
- **Coating with biological control agents**
- **Chemical treatments**
  - systemic fungicides: carboxin for control of smuts; benomyl for control of Oomycetes; metalaxyl for control of Oomycetes
  - non-systemic fungicides: copper compounds for control of bacteria and fungi; captan, dithiordan and maneb broad spectrum

## Summary

- Many pathogen characteristics determine potential for epidemic development from seedborne inoculum
  - Which factors?
- There are many seed health assays
  - What are the sampling considerations?
  - Which technique would you choose?
    - Depends on: