Using Natural Variation to Characterize Virulence: The *TRI13* story

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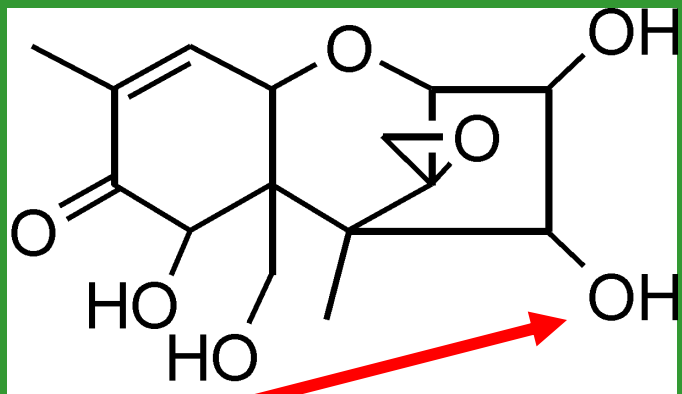
Fusarium graminearum (teleomorph *Gibberella zeae*)

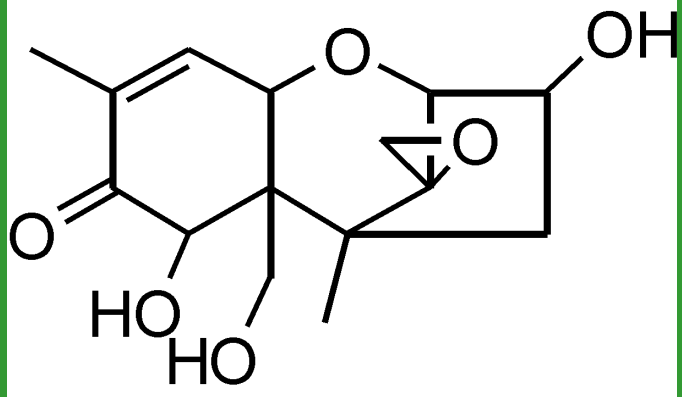
- Genetically diverse species complex, which has been subdivided into 11 species based on molecular phylogeny.
- North American population dominated by *F. graminearum* lineage that produces deoxynivalenol (DON).
- Nivalenol (NIV) producers recently detected in Louisiana.
- Concern since NIV more toxic to animals.

DON vs. NIV

- Similar compounds differing in the presence of a hydroxyl group at C-4 in NIV.
- Production of NIV determined by the presence of a functional *TRI13* gene product which oxygenates C-4.
- DON producers have non-functional gene (*ΨTRI13*) suggesting ancient origin.



Nivalenol



Deoxynivalenol

Questions:

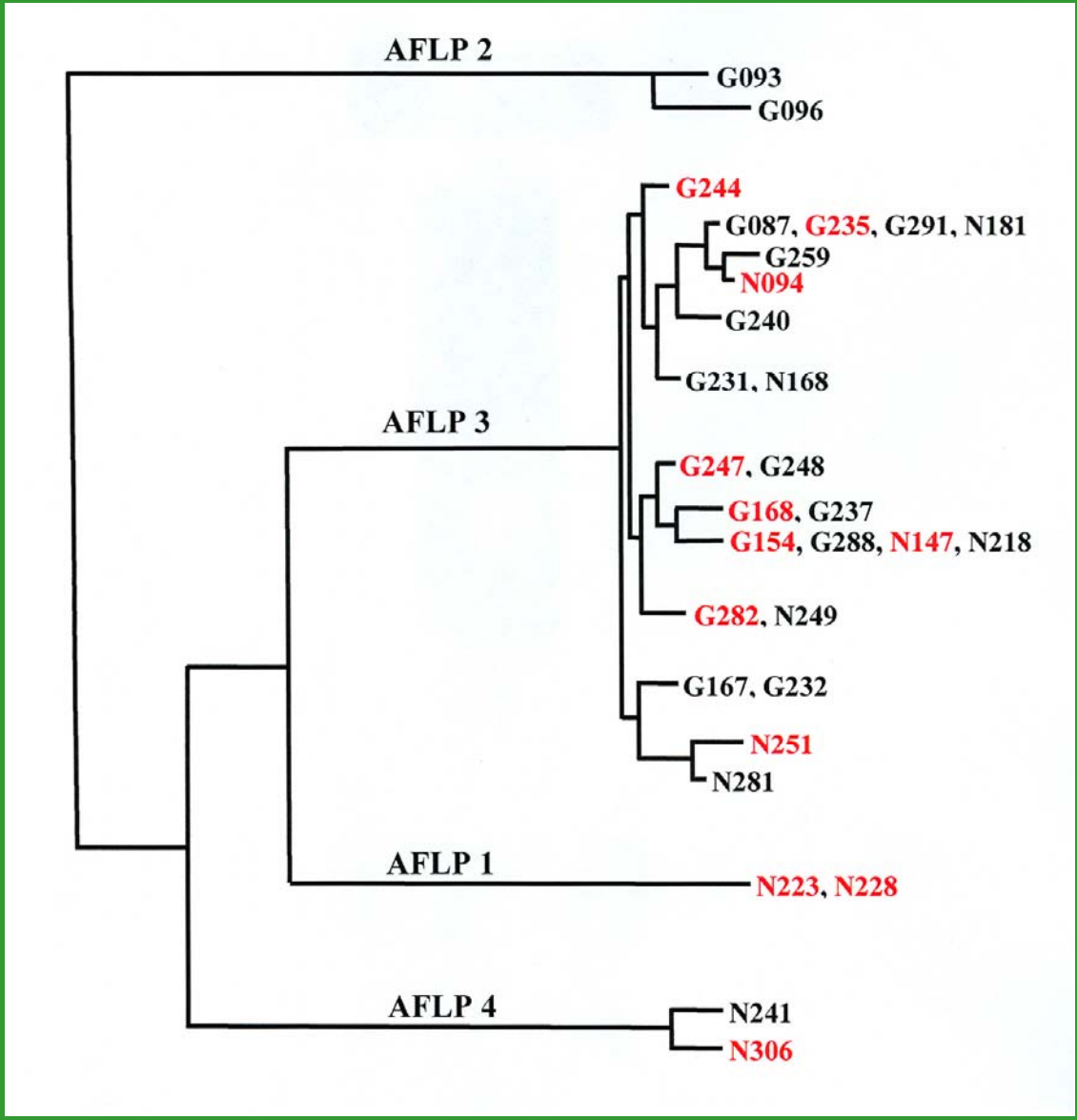
- What is the pattern of virulence and toxin accumulation in DON and NIV producing strains?

- Does the pattern hold even when the genetic background is similar between DON & NIV producers?

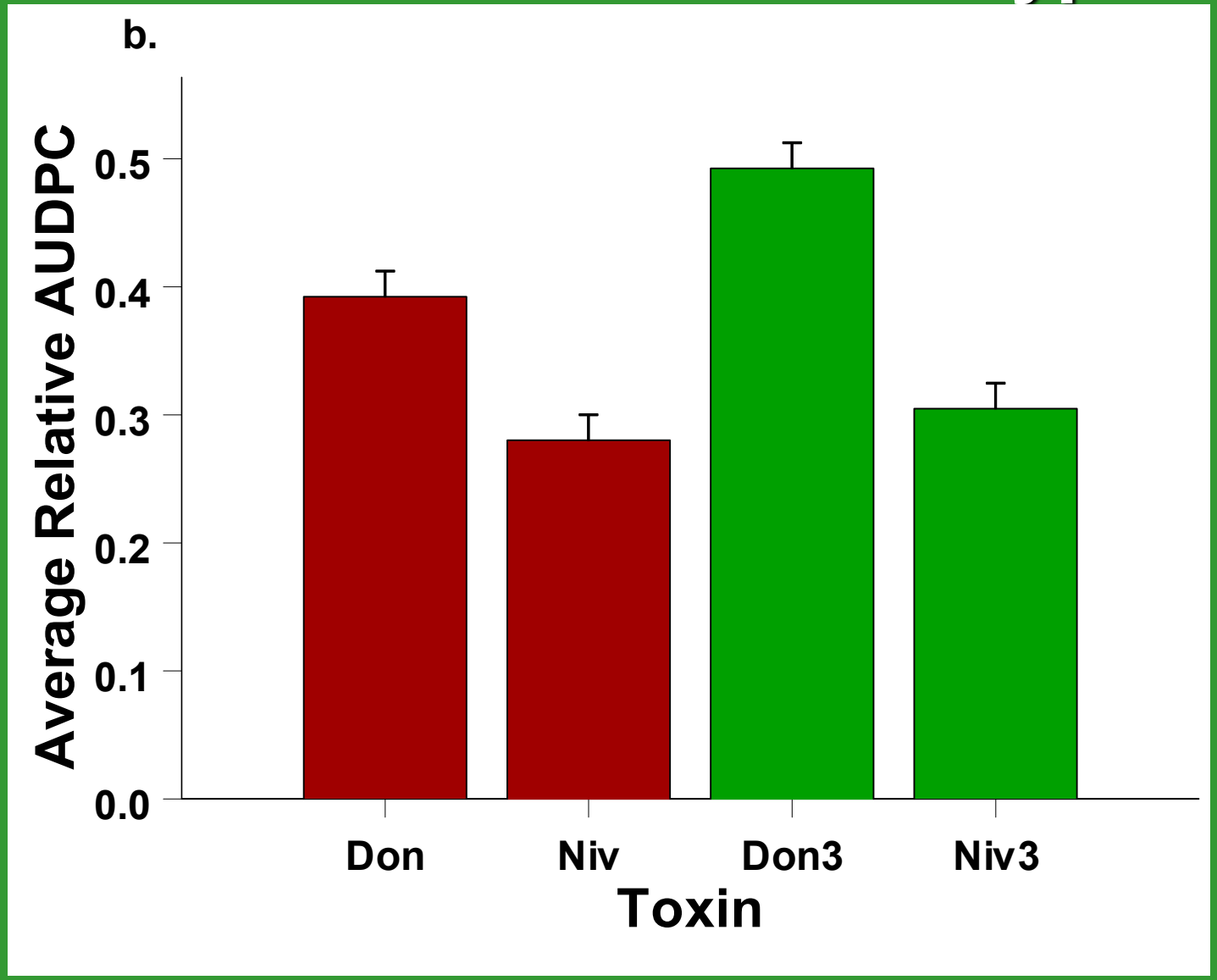
Nepal study:

- Sample *F. graminearum* across several administrative zones.
- Previous work:
  - Multiple lineages within the *F. graminearum* complex
  - Mixture of DON and NIV producers.
- Characterize isolates:
  - Population structure using AFLPs
  - Virulence on wheat & maize
  - Toxin identification & quantification using LC-MS system

- 144 isolates fell into 4 main groups
- AFLP 1, DON producers
- AFLP 2, NIV producers
- AFLP 3 & 4 contain DON & NIV producers

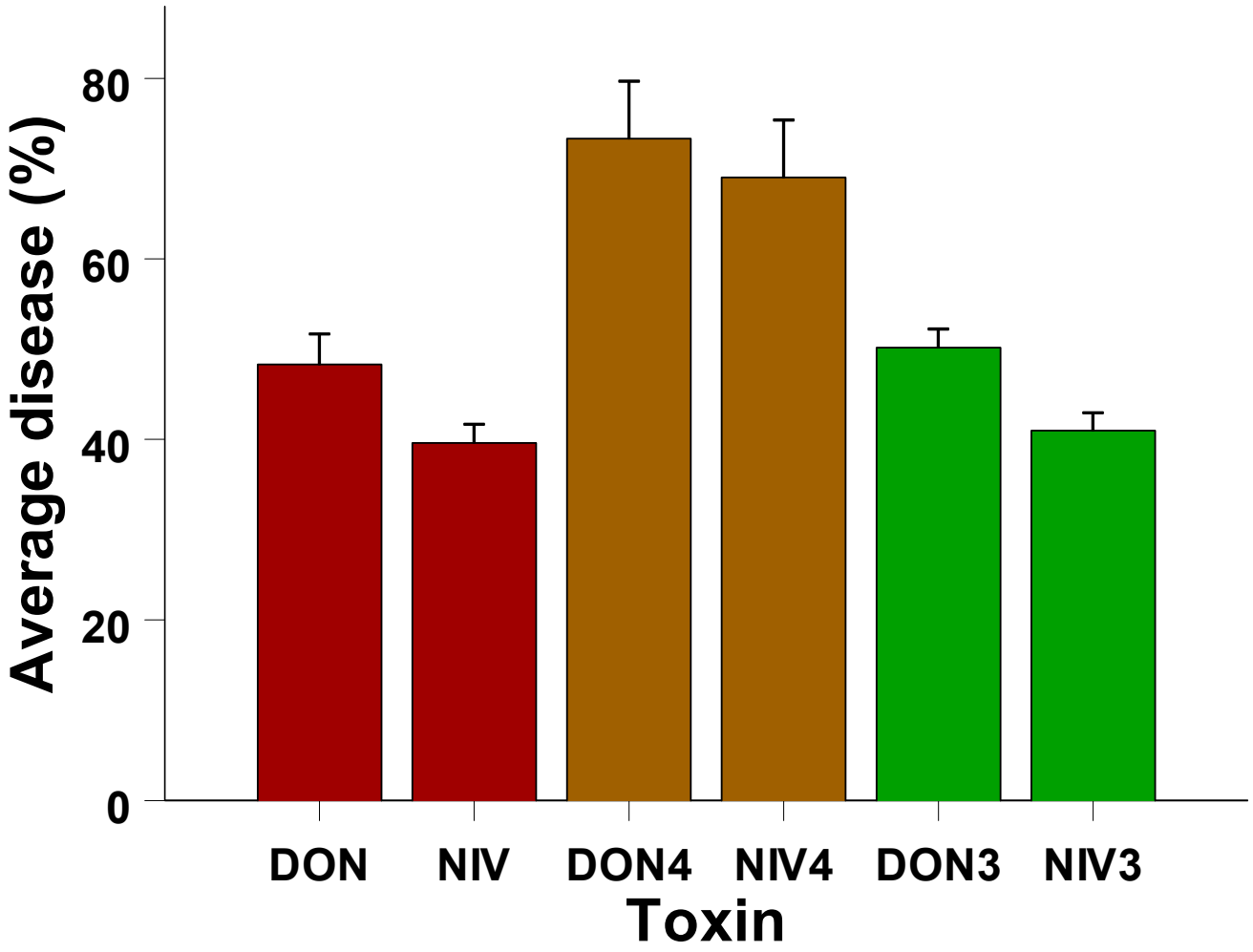


Wheat virulence & toxin type:



Desjardins et al. 2004. J. Ag. Food Chem. 52:6341-6346

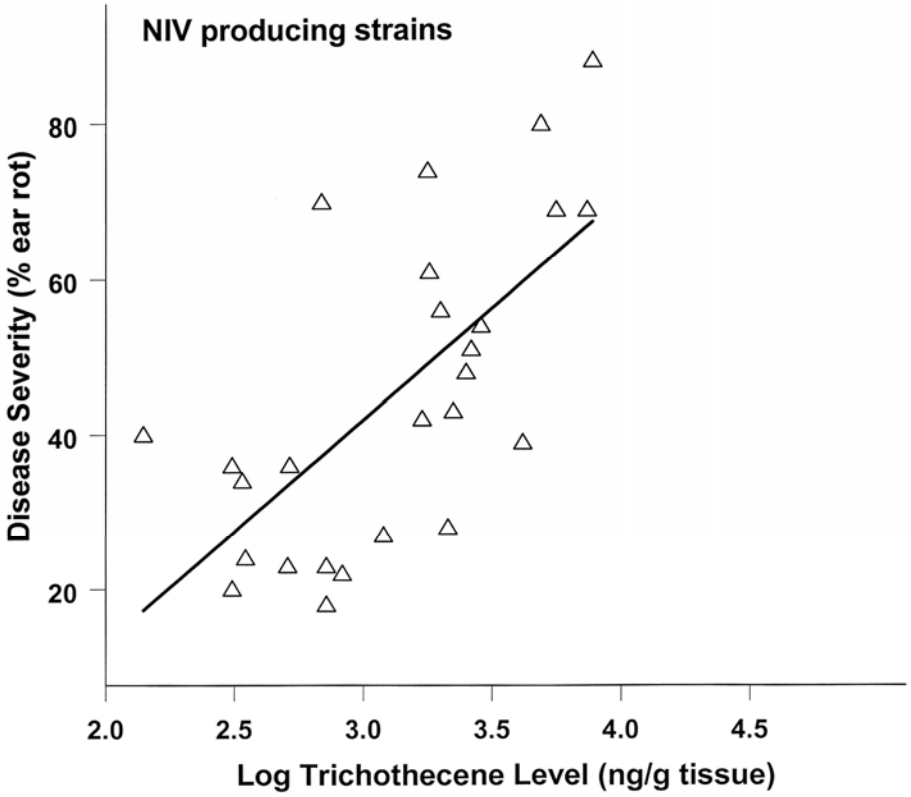
Maize virulence & toxin type:

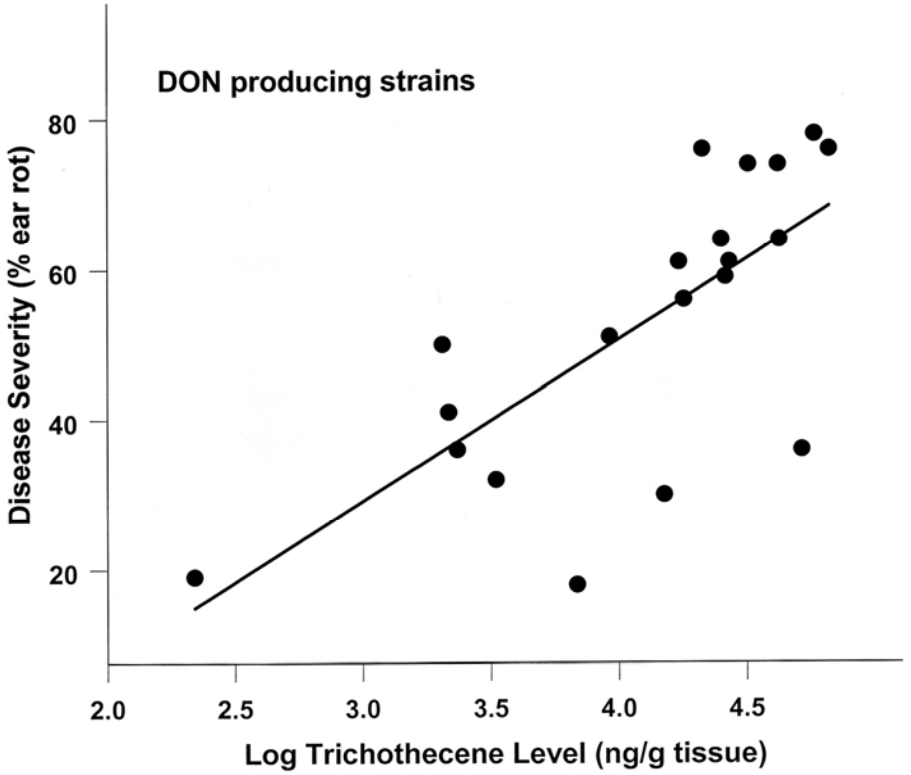


Mycotoxin concentration in maize:

- Detectable toxin (≥ 100 ng/g):
  - 78% (13 of 18) NIV producers
  - 92% (11 of 12) DON producers
- Toxin concentration for detectable samples:
  - NIV producers 2230 ± 440 (s.e.) ng/g
  - DON producers 23500 ± 4490 ng/g

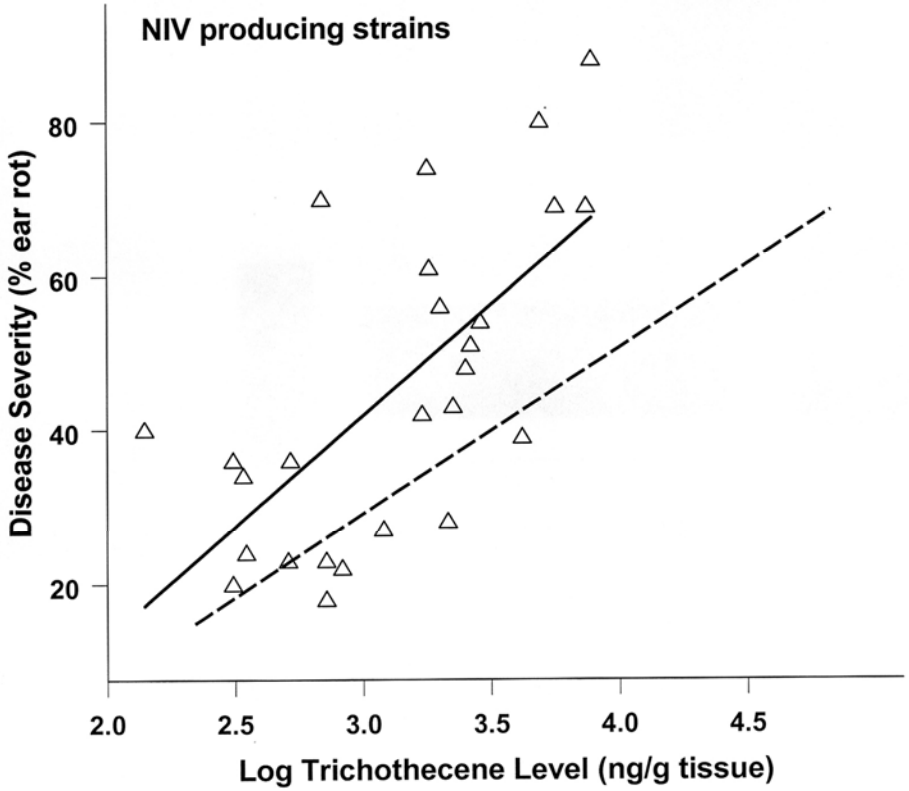
Correlations: Virulence & mycotoxin concentration

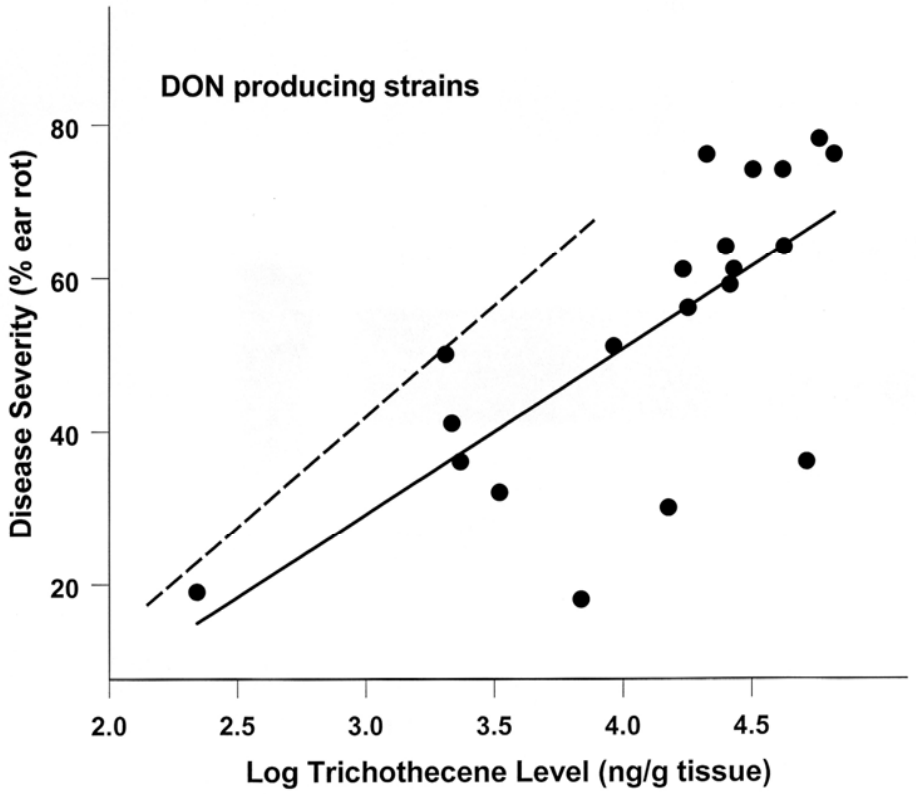




$R^2 = 0.44$, $p < 0.0001$

$R^2 = 0.51$, $p < 0.0001$





- DON producers only strains with toxin levels above 10,000 ng/g
- Slope for the NIV regression is steeper than DON.
- Suggests that NIV stronger influence on virulence, but limited by maximum of concentration.

- NEP 241 (AFLP4)
  - NIV producer
  - 69% disease
  - 5620 ng/g
- NEP 306 (AFLP4)
  - DON producer
  - 76% disease
  - 21240 ng/g
- Suggests that NIV accumulation will be less for a given level of disease.

Conclusions:

- Accumulation of NIV is lower relative to DON, even in closely related isolates.
  - Mechanism for this trend is unknown.
- NIV producing isolates generally display lower virulence.
  - Does this mean NIV isolates less fit?
- Slope of correlation suggest NIV more potent toxin than DON.
  - Contrary to other work that found NIV less toxic to plants relative to DON

Risk Assessment:

- Can NIV producers invade North America?
  - Emerging population in Canada and upper Plains region (3ADON & 15ADON) are more virulent.
  - Lower virulence of NIV producers suggest invasion unlikely, but not impossible.
- Toxicity problem if NIV producers invade?
  - NIV producers accumulate less toxin for a given level of disease.