SWQL 57th Annual Research Review Conference

Deoxynivalenol Accumulation in Healthy-looking Wheat Grain

Dr. Pierce Paul

Dept. Plant Pathology

The Ohio State University/OSUE/OARDC

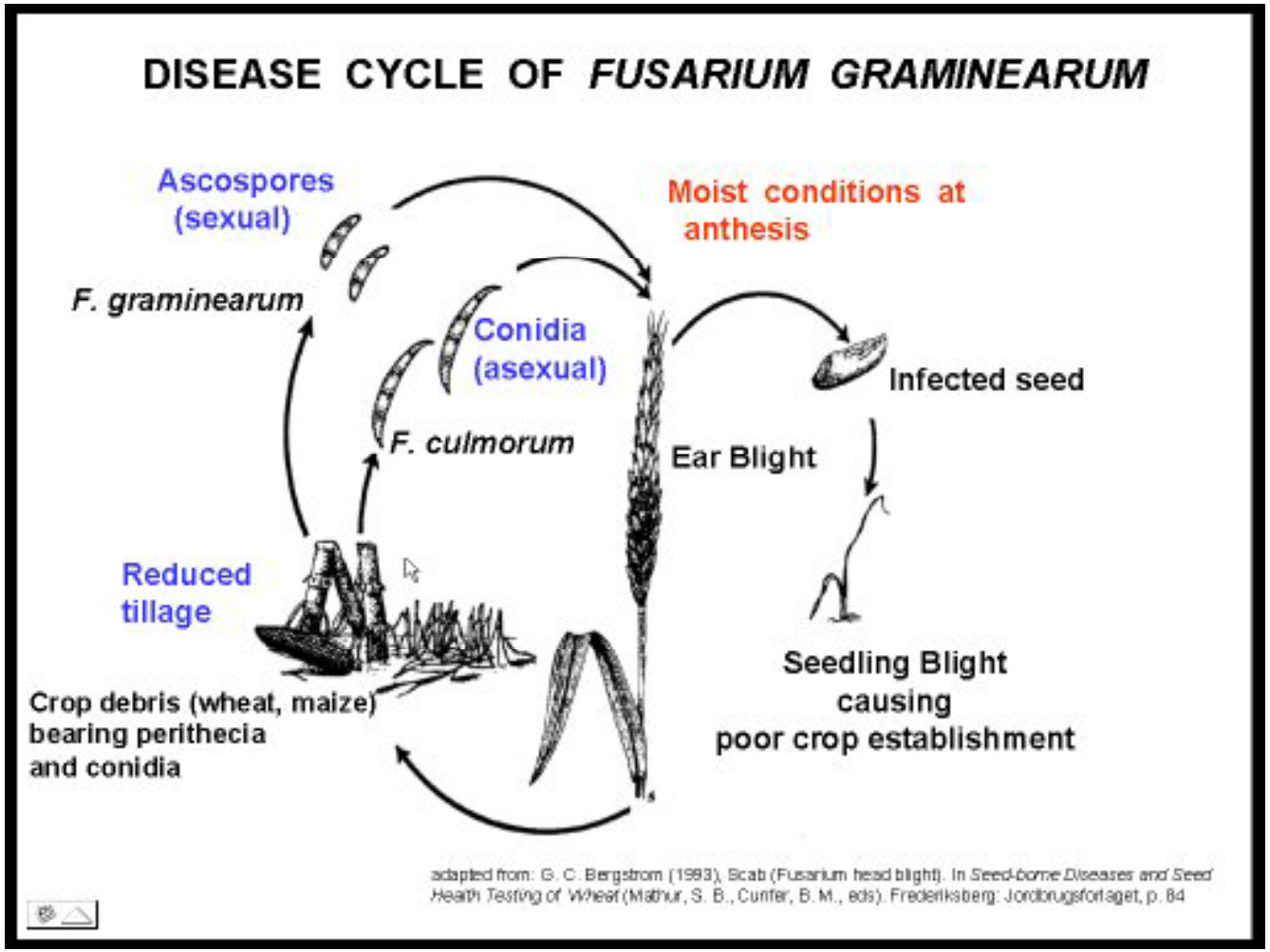
Fusarium head blight-DON-Wheat

Gibberella ear rot on whole ears.

Fusarium head scab - note partial killing of wheat heads.

Fusarium head scab - shriveled, moldy seed from diseased head.

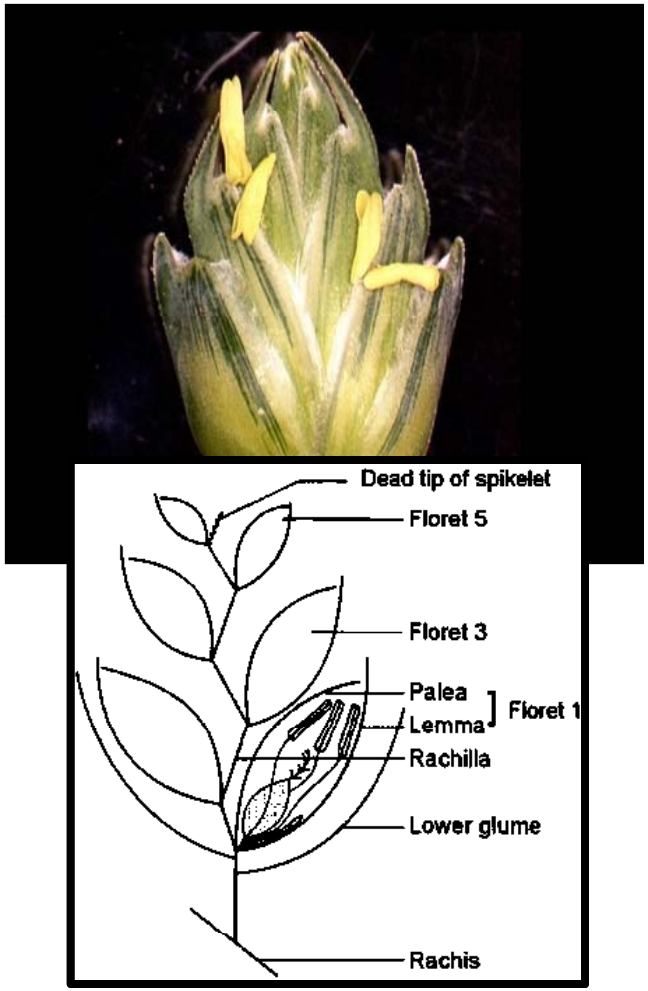
A disease/toxin complex of multiple crops

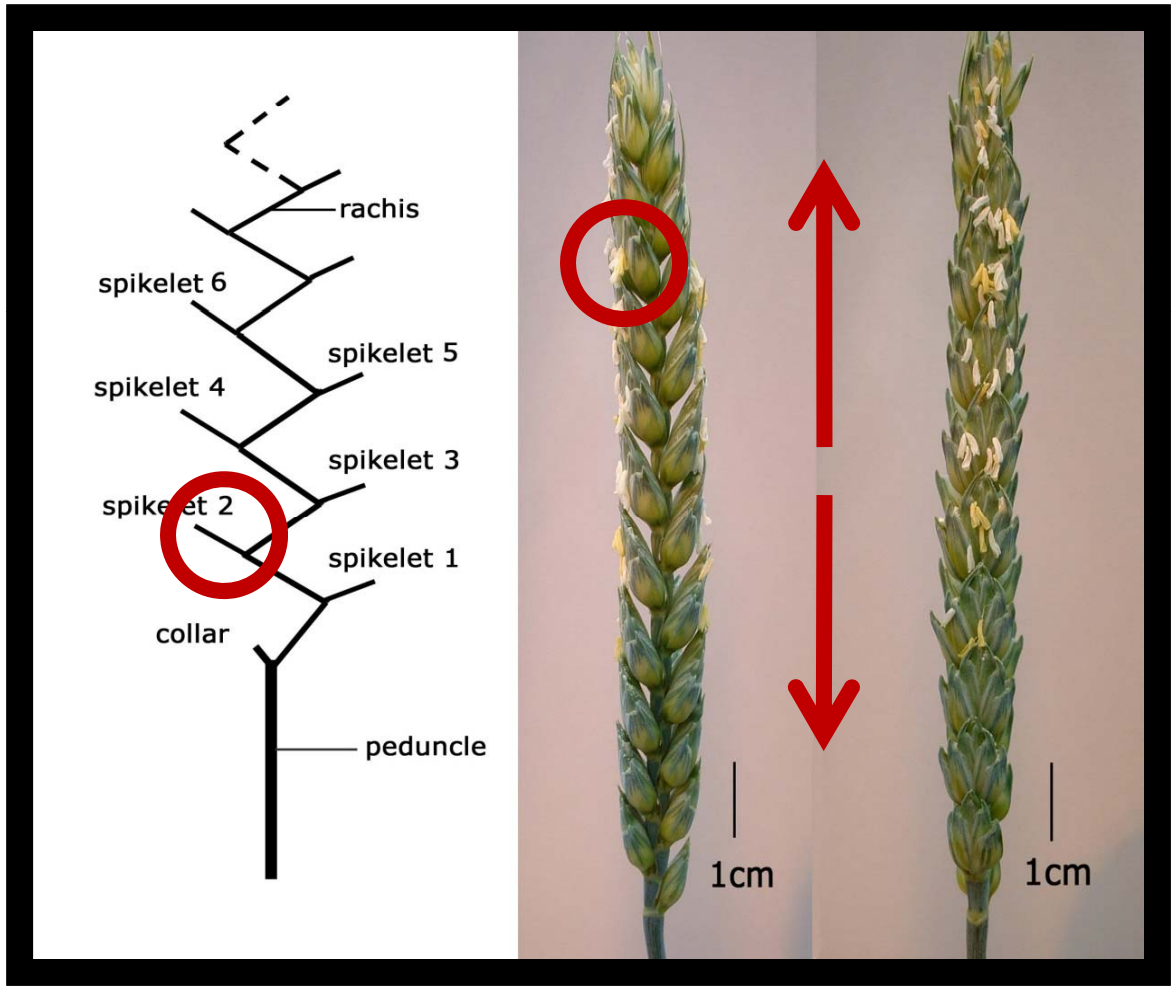


Impact and Consequences

- **Shriveled, small and light-weight kernels**
  - **Lower grain yield and test weights**
- **Seedling blight and poor stands**
  - **Lower grain production per unit area**
- **Deoxynivalenol (vomitoxin) contamination**
  - **Vomiting and feed refusal by animals**
  - **Mycotoxicosis in humans**
- **Grain rejection and price discounts**
  - **DON > 2 ppm**

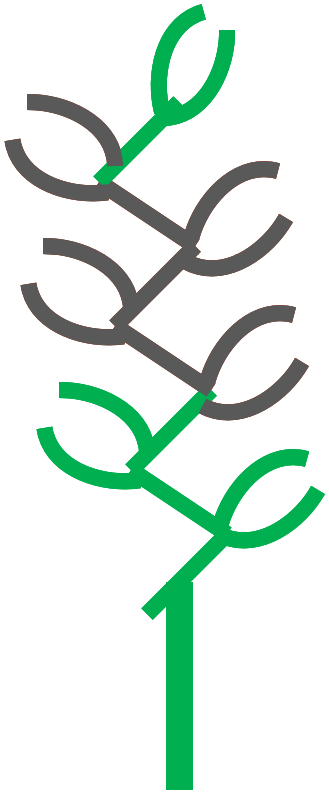
The Infection Process - Anthesis





http://www.fao.org/docrep/006/y4011e/y4011e05.htm#TopOfPage, http://www.wheatbp.net/

Infection – Standard Model

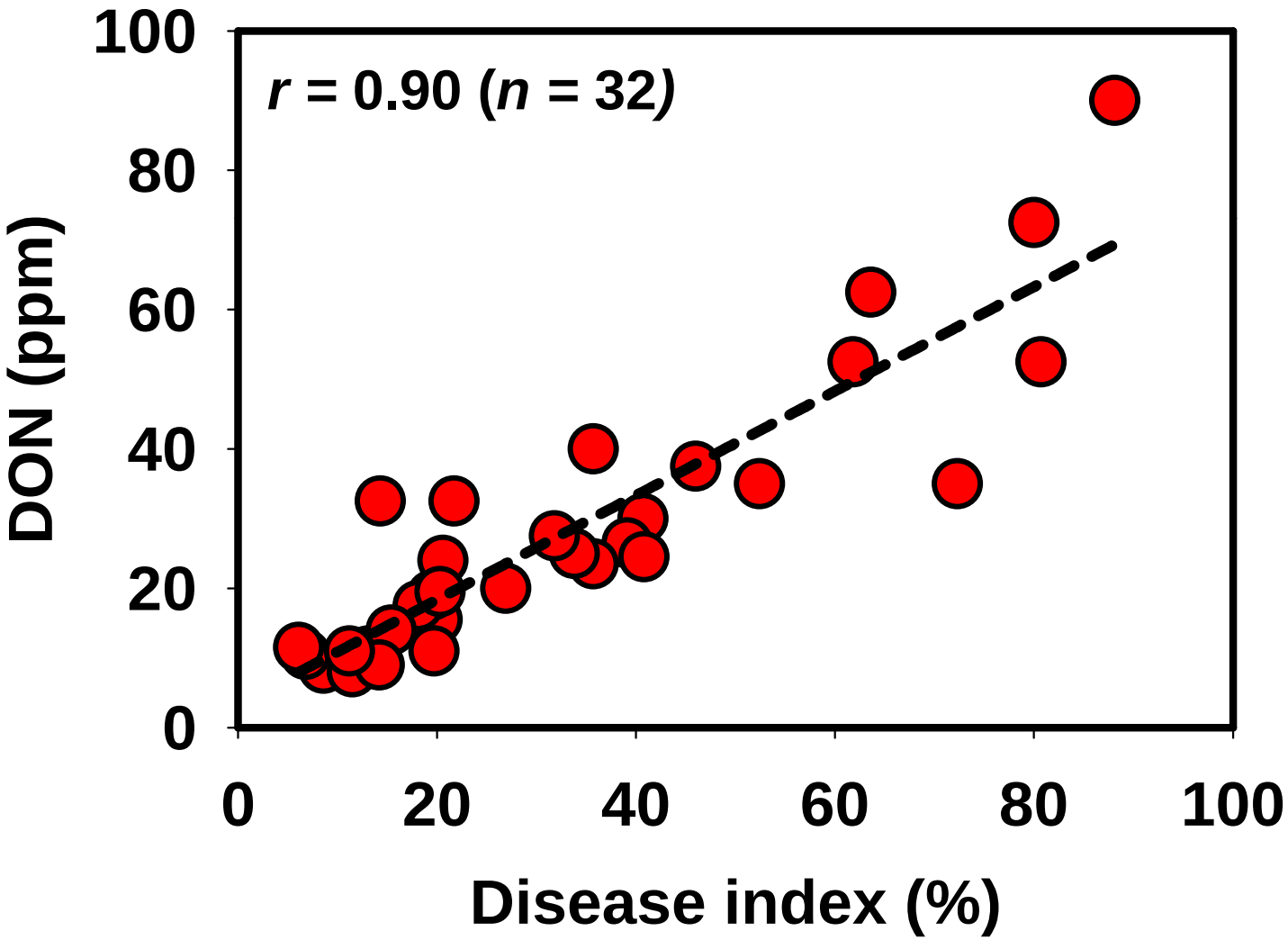


- **DON spreads ahead, followed by colonization and tissue necrosis.**
- **Trichothecene-deficient mutants of *F. gram* cause lower levels of FHB than wild-type.**
- **Restoration of wild-type virulence in tri5 disrupted mutants via mutant complementation.**

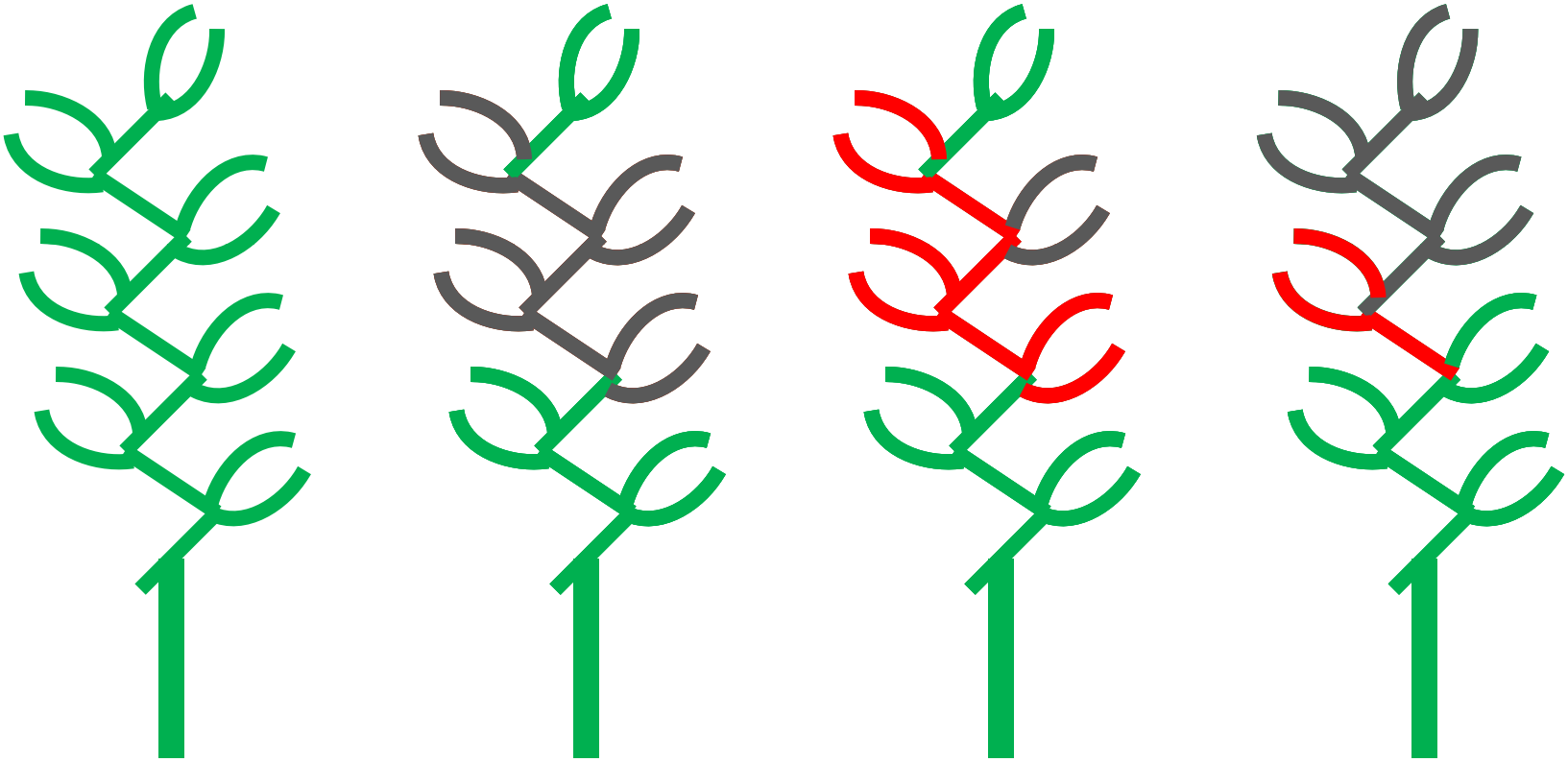
Desjardins, A. E., Proctor, R. H., Bai, G., McCormick, S. P., Shaner, G., Buechley, G., and Hohn, T. M. 1996. Mol. Plant Microbe Interact. 9:775-781.
Proctor, R. H., Hohn, T. M., and McCormick, S. P. 1997. Microbiology 143:2583-2591.

FHB/DON Relationship

The "normal" or expected association



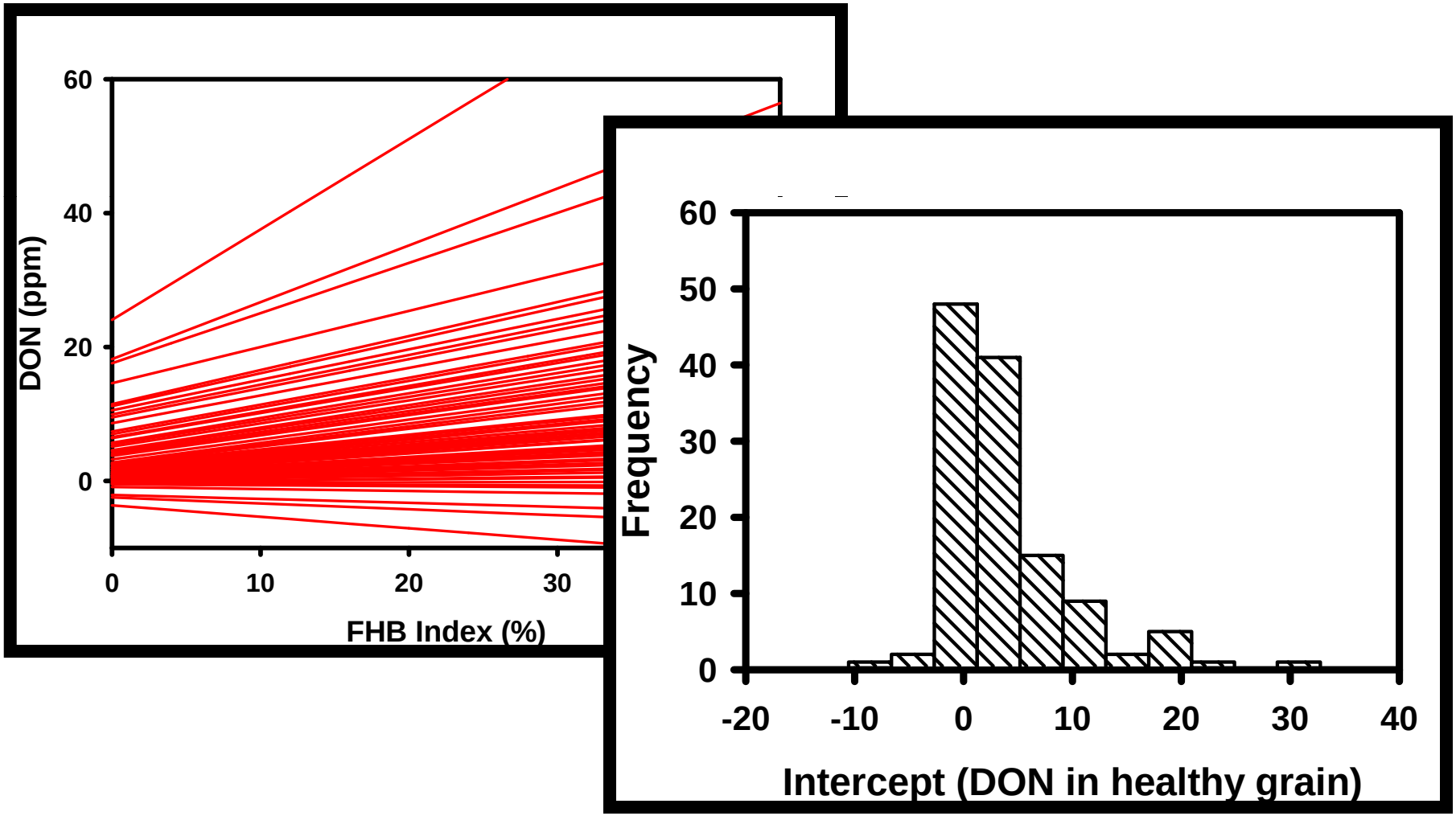
Infection – Alternate Models

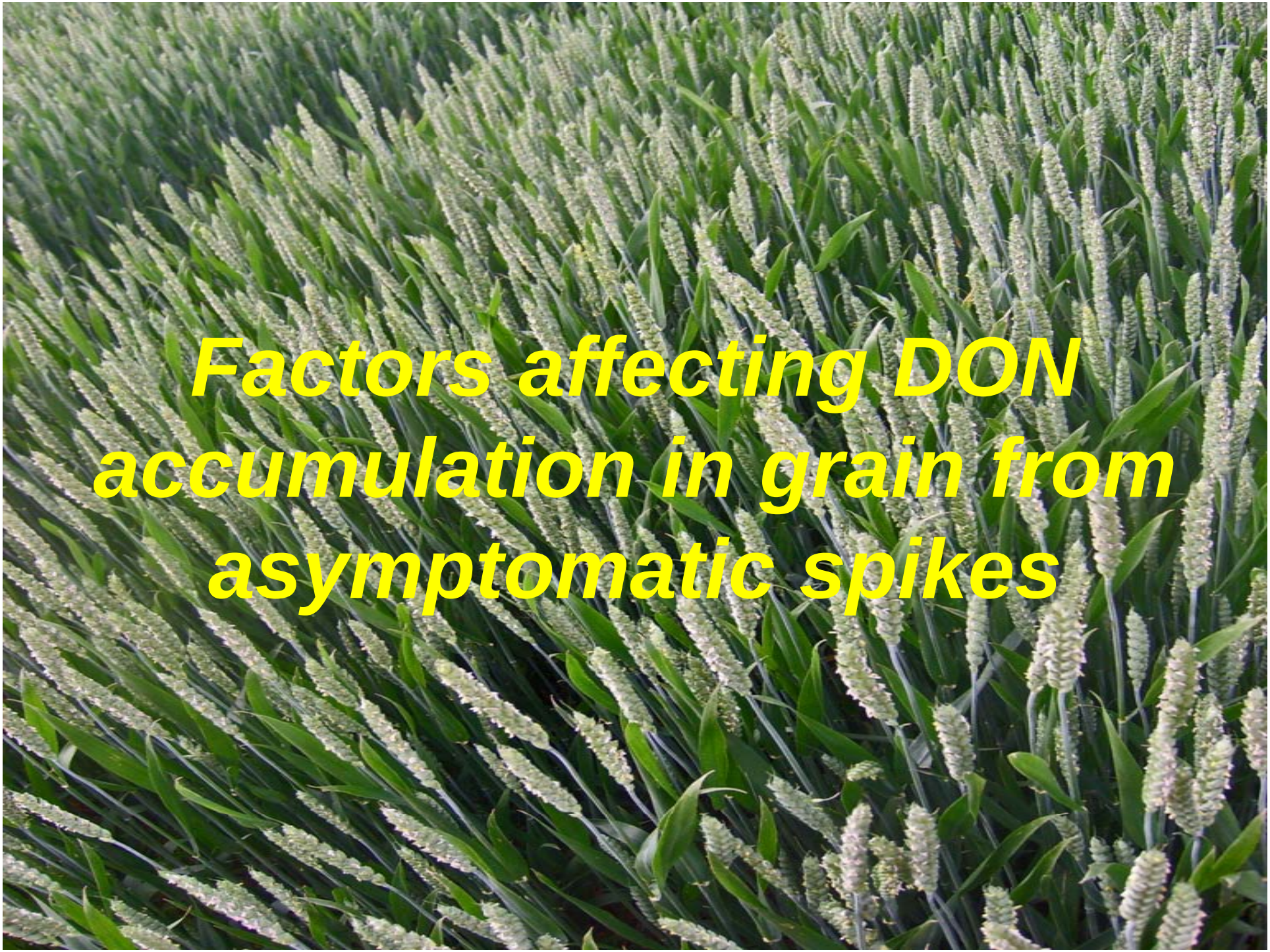


Healthy **Standard** **DON > FHB** **FHB > DON**

FHB/DON Relationship

- $DON_j = \alpha + \beta IND_j + \varepsilon_j$



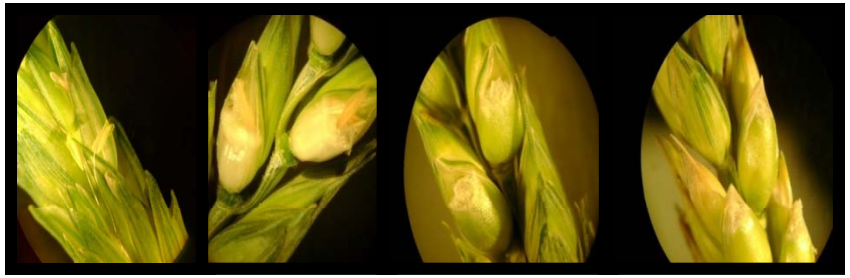


Factors affecting DON accumulation in grain from asymptomatic spikes

Questions:

- How do host resistance, growth stage of infection, and inoculum density interact to affect DON accumulation and fungal colonization in asymptomatic grain?
- When one factor is sub-optimal for infection and another is supraoptimal, is there a compensatory effect on DON production?
- Under what combination of conditions does DON in grain from asymptomatic wheat spikes exceed 2 ppm?

Methodology



Split-split-split plot design

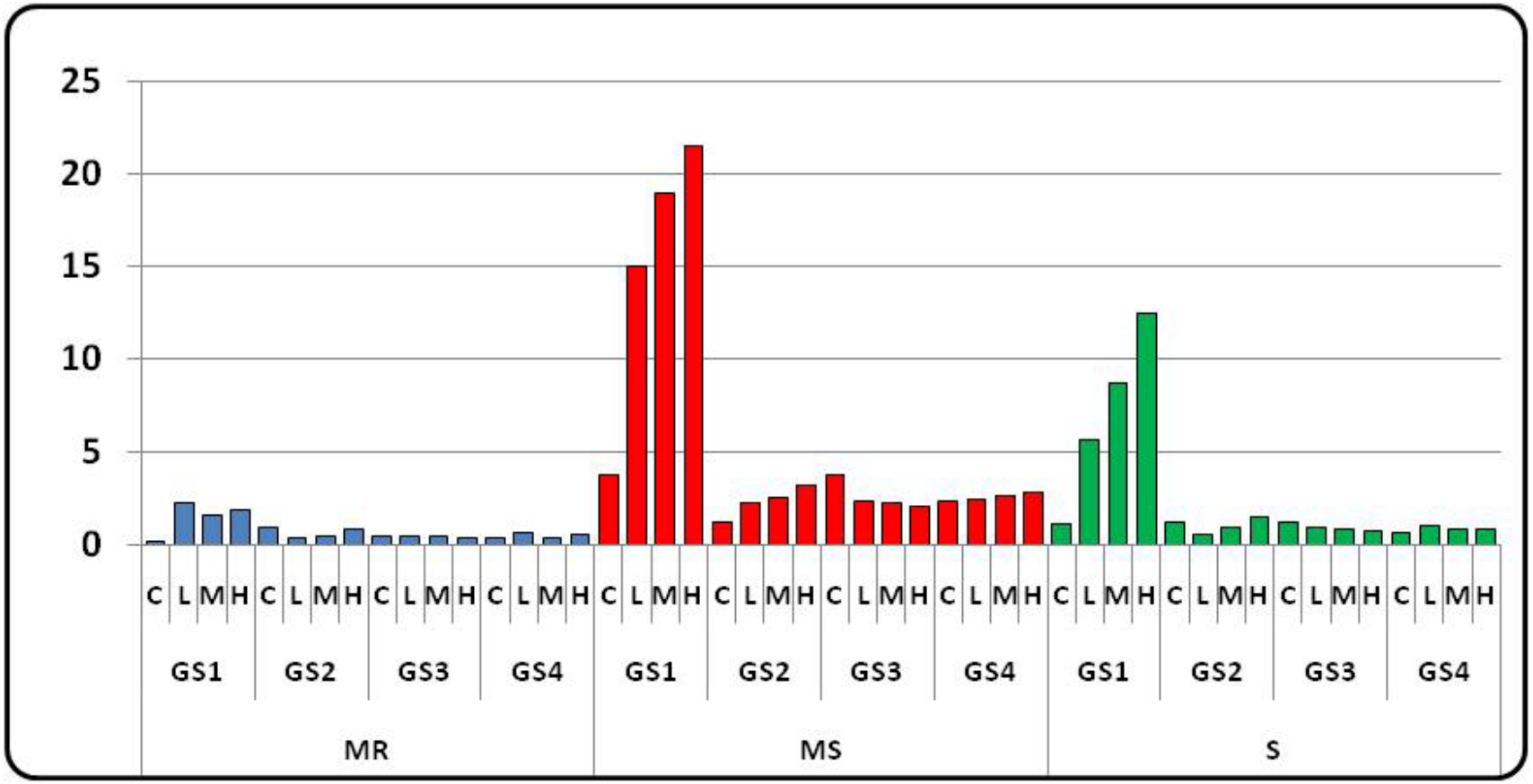
- 2 Planting Dates
- 3 Cultivars
  - Variability in resistance
  - Flowering date
- 3 Inoculum Densities and a Water Control
  - 10, 20, 30k spores/mL
- 4 Infection Times

Sampling and Processing

- 30 asymptomatic spikes
  - Tag spikes close to physiological maturity
  - Before senescence
- Post-harvest
  - Thresh
  - DON (ppm)
  - *F. graminearum* biomass
  - *Tri5* gene for trichothecene production

Results…

FHB index (%) – Environment 1



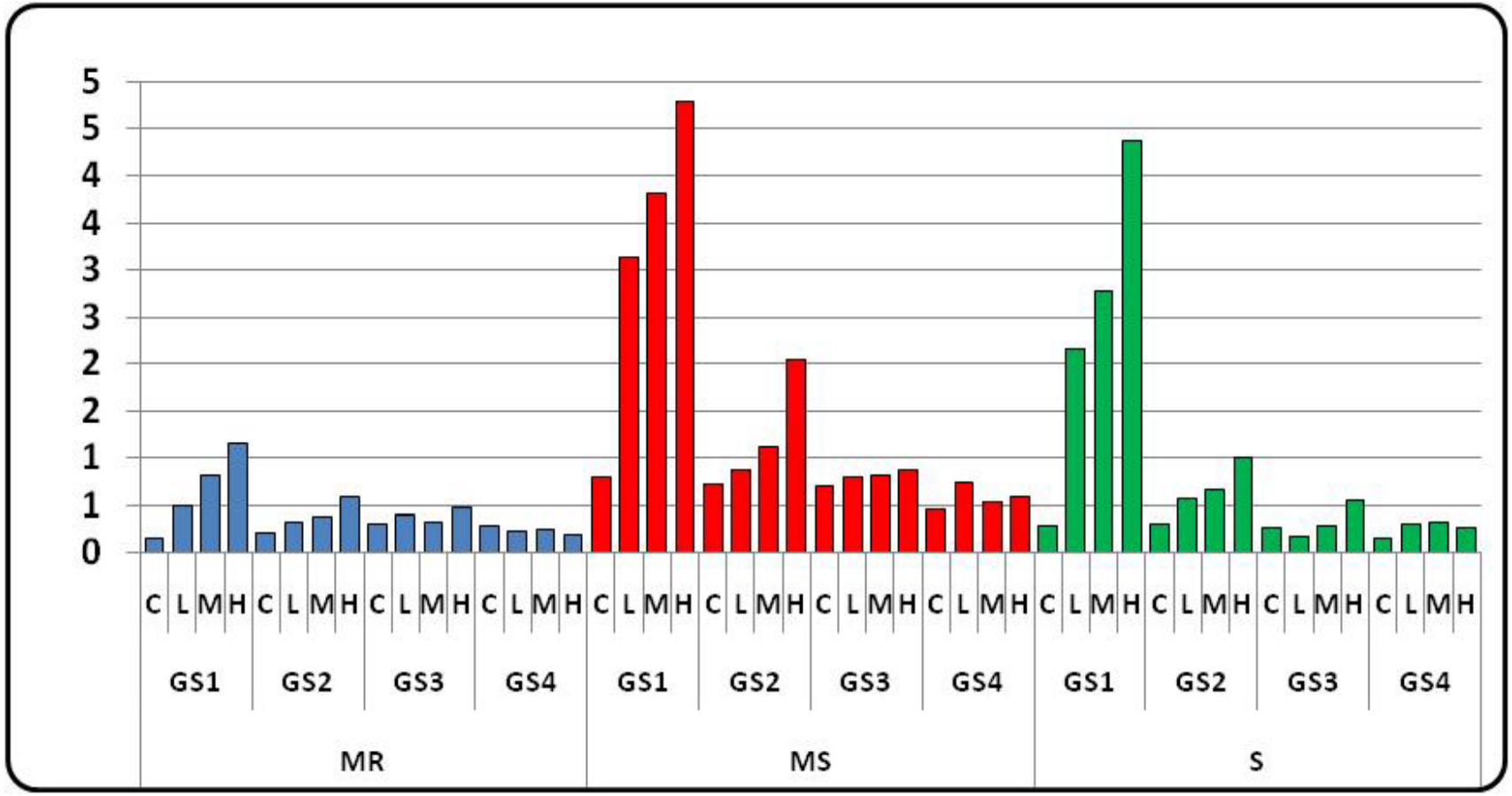
Results…

Statistical Summary

		Asymptomatic Grain	
Effects	**Index**	**DON**	**Biomass**
ENV	0.0002	<.0001	0.0106
CV	<.0001	<.0001	<.0001
ENV*CV	0.2735	<.0001	0.9768
IT	<.0001	<.0001	<.0001
ENV*IT	<.0001	<.0001	0.5448
CV*IT	<.0001	<.0001	0.0085
ENV*CV*IT	0.0511	0.0011	0.2067
ID	<.0001	<.0001	0.0002
ENV*ID	0.114	<.0001	0.0325
CV*ID	0.3106	0.8831	0.8433
ENV*CV*ID	0.1228	0.0113	0.1034
IT*ID	<.0001	<.0001	0.0045
ENV*IT*ID	<.0001	<.0001	0.0047
CV*IT*ID	0.0311	0.0107	0.1305
ENV*CV*IT*ID	0.238	0.0077	0.3567

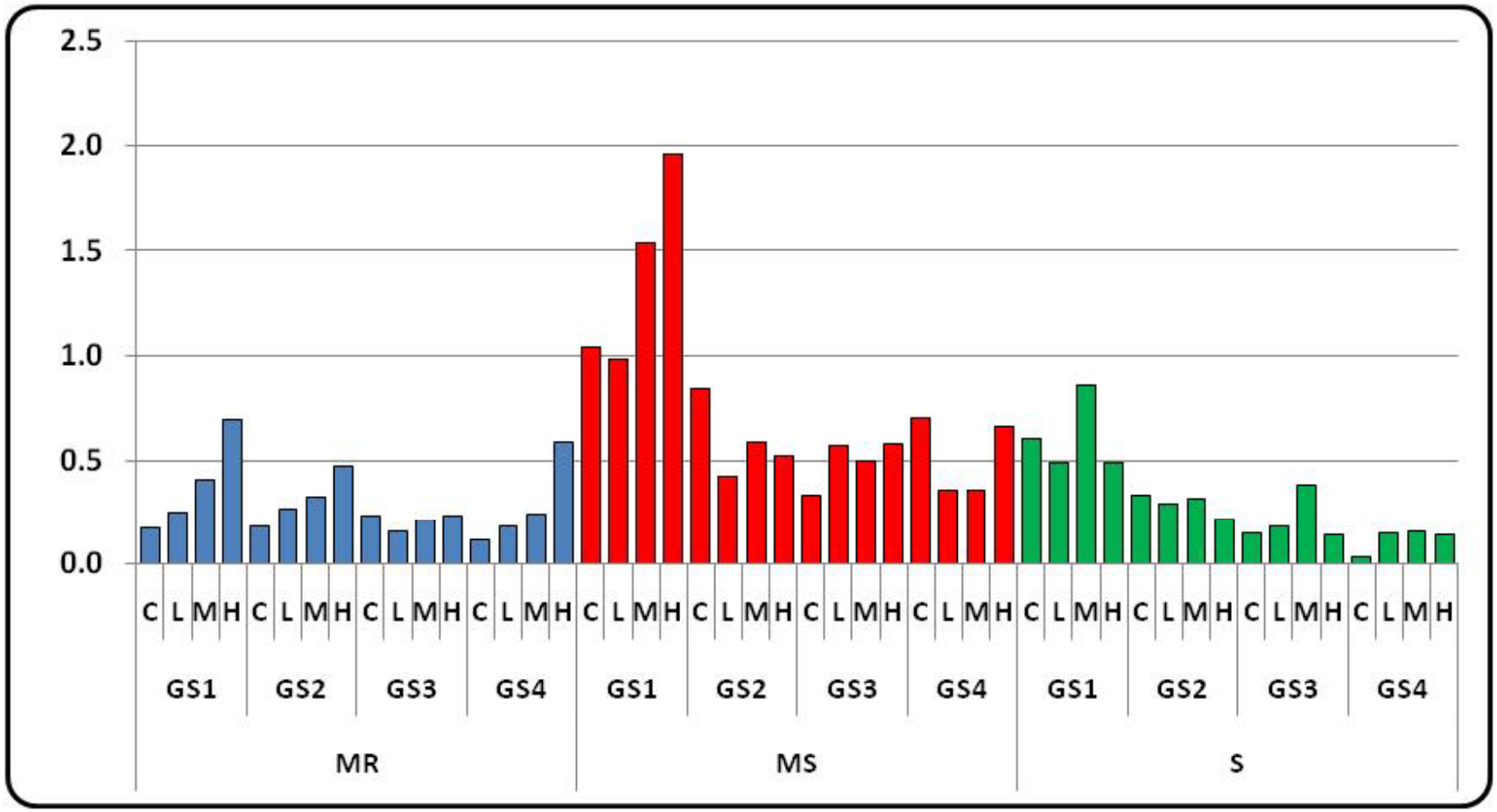
Results…

DON in grain from asymptomatic spikes – Environment 1



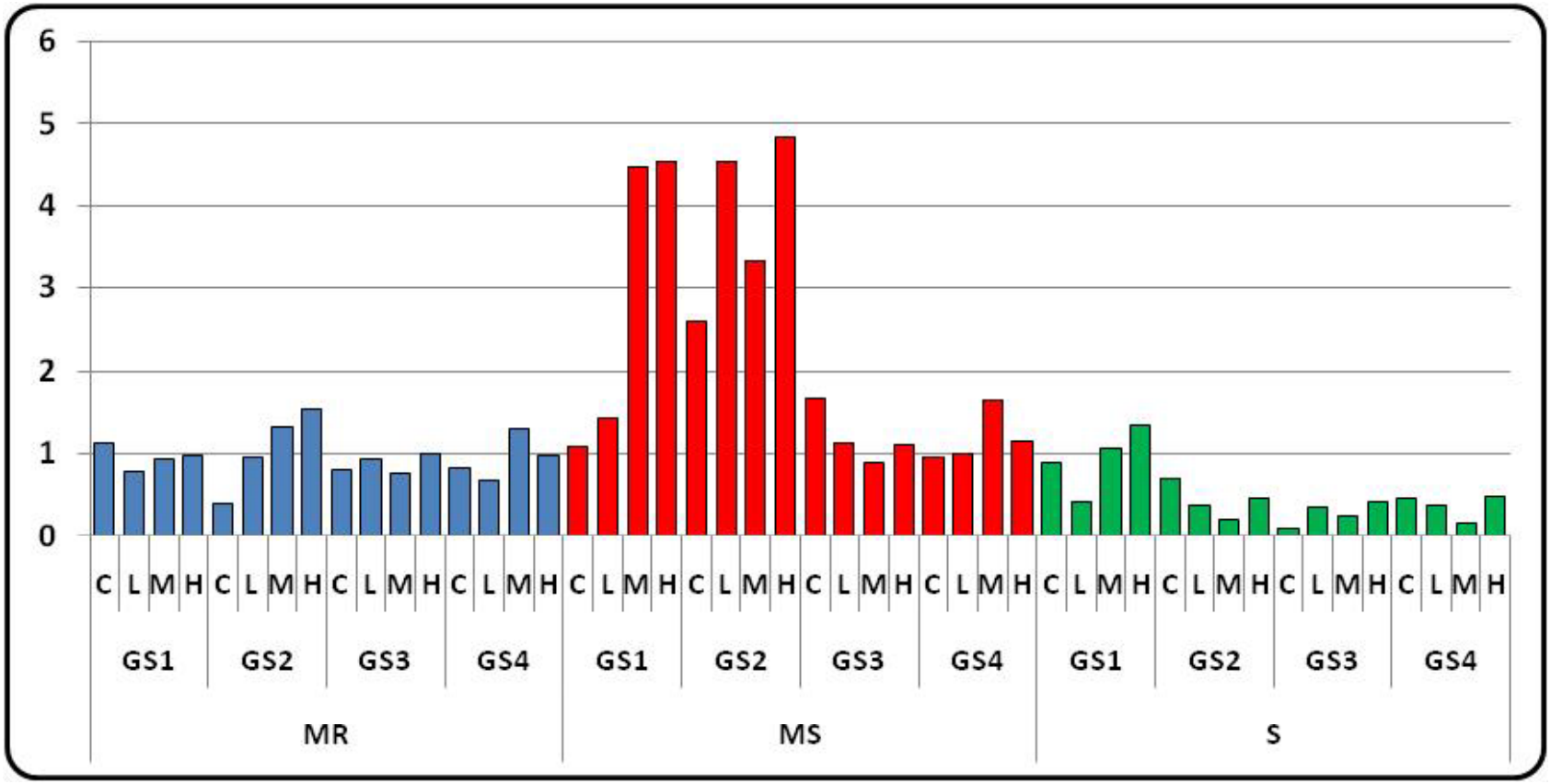
Results…

DON in grain from asymptomatic spikes – Environment 2



Results…

DON in grain from asymptomatic spikes – Environment 3



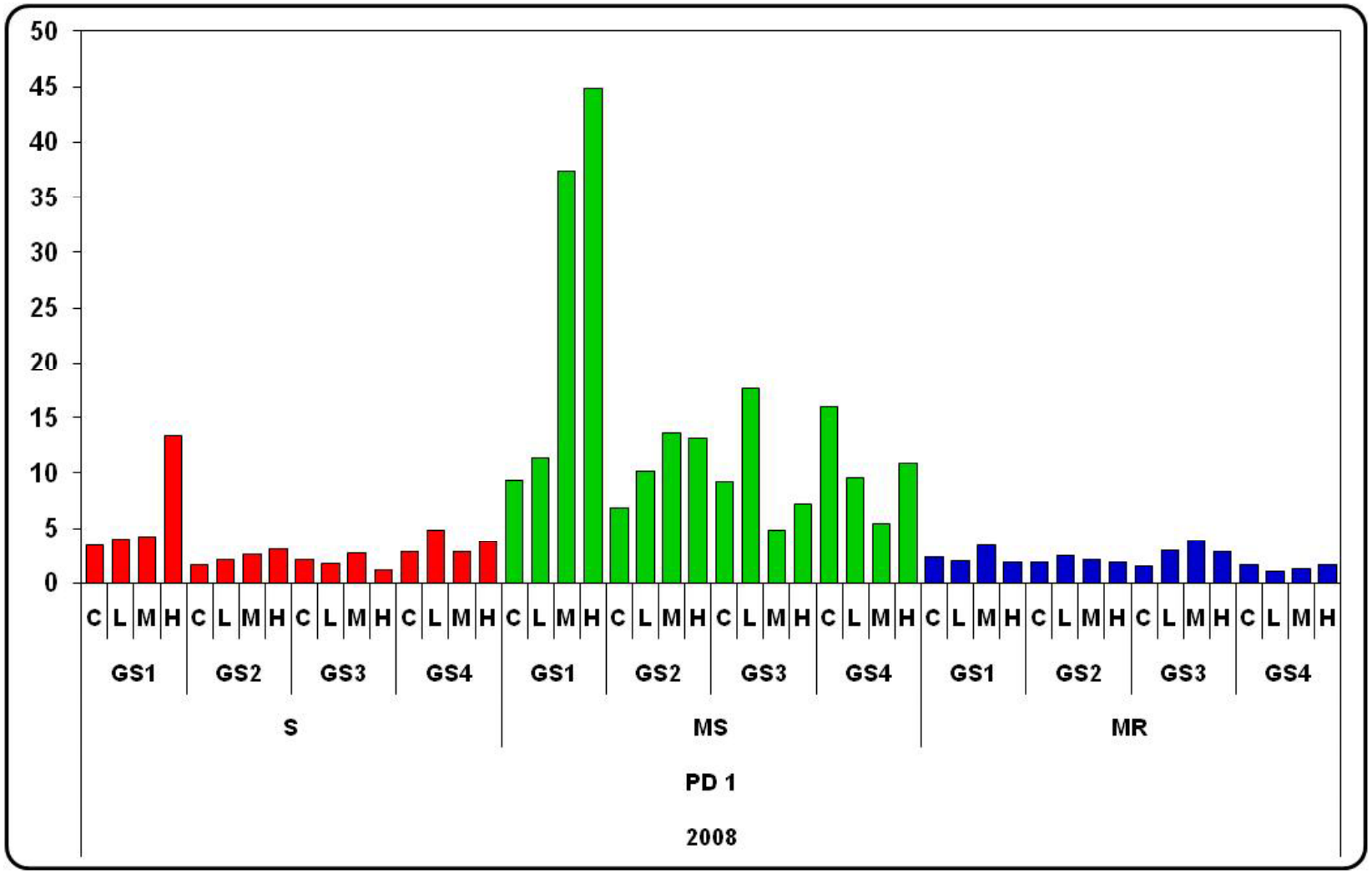
Results…

Statistical Summary

		Asymptomatic Grain	
Effects	**Index**	**DON**	**Biomass**
ENV	0.0002	<.0001	0.0106
CV	<.0001	<.0001	<.0001
ENV*CV	0.2735	<.0001	0.9768
IT	<.0001	<.0001	<.0001
ENV*IT	<.0001	<.0001	0.5448
CV*IT	<.0001	<.0001	0.0085
ENV*CV*IT	0.0511	0.0011	0.2067
ID	<.0001	<.0001	0.0002
ENV*ID	0.114	<.0001	0.0325
CV*ID	0.3106	0.8831	0.8433
ENV*CV*ID	0.1228	0.0113	0.1034
IT*ID	<.0001	<.0001	0.0045
ENV*IT*ID	<.0001	<.0001	0.0047
CV*IT*ID	0.0311	0.0107	0.1305
ENV*CV*IT*ID	0.238	0.0077	0.3567

Results…

F. graminearum biomass in asymptomatic infections – Environment 1



Results…

Statistical Summary

		Asymptomatic Grain	
Effects	**Index**	**DON**	**Biomass**
ENV	0.0002	<.0001	0.0106
CV	<.0001	<.0001	<.0001
ENV*CV	0.2735	<.0001	0.9768
IT	<.0001	<.0001	<.0001
ENV*IT	<.0001	<.0001	0.5448
CV*IT	<.0001	<.0001	0.0085
ENV*CV*IT	0.0511	0.0011	0.2067
ID	<.0001	<.0001	0.0002
ENV*ID	0.114	<.0001	0.0325
CV*ID	0.3106	0.8831	0.8433
ENV*CV*ID	0.1228	0.0113	0.1034
IT*ID	<.0001	<.0001	0.0045
ENV*IT*ID	<.0001	<.0001	0.0047
CV*IT*ID	0.0311	0.0107	0.1305
ENV*CV*IT*ID	0.238	0.0077	0.3567

What next?

- **Develop models to predict DON accumulation in asymptomatic grain**
  - **Repeat experiment at multiple locations over multiple years.**
  - **Estimate the probability of DON exceeding critical thresholds (1, 2 ppm).**
    - **Logistic regression?**
  - **Develop modules to improve the accuracy of DON prediction.**

Acknowledgments

Dr. Laurence Madden
Dr. Clay Sneller
Mary Guttieri

U.S. Wheat & Barley
Scab Initiative

Cunyu Li
Kylea Odenbach
Matthew Wallhead
Jorge Salgado
Kristen Davis