# Local Malting Barley for Northeast Craft Beverage Markets: What's FHB Got to Do with It?

*Gary C. Bergstrom*
Plant Pathology & Plant-Microbe Biology Section
Cornell University

National Fusarium Head Blight Forum
December 9, 2020

# Acknowledgements


*Cornell Field Crops Pathology Lab members:*

***Jen Starr*, *Kevin Myers*, *Jaime Cummings*,** *Alyssa Blachez, Michael Fulcher,* ***Andrea Lugo-Torres***

*Cornell collaborators:* ***Mark Sorrells*,** *David Benscher, Amy Fox,* ***Daniel Sweeney*,** *Karl Kunze, Paul Stachowski*

*Cornell Malting Barley Extension Team:*

*Aaron Gabriel, Kevin Ganoe, John Hanchar, Christian Malsatzki, Justin O'Dea, Mike Stanyard, Cheryl Thayer, Bill Verbeten*

*Extramural collaborators:*

***Yanhong Dong*, *Paul Schwarz*,** *Aaron MacLeod, Pierce Paul, Christina Cowger, Hannah Turner, Heather Darby, Andrew Friskop*

*The malting barley growers of New York State – Thanks!*

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*USDA-NIFA Cornell Hatch Project*

*USDA-ARS US Wheat and Barley Scab Research Initiative*



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# Outline

- Rebirth of a crop and creation of a value chain since 2012
- Progress toward consistent grain quality
- Fusarium head blight and DON toxin
  – barley enemy # 1
- Grain fungal flora and mycotoxin profiles
- Other diseases affecting yield and/or grain quality
- Integrated management of diseases and mycotoxins
  - ➢ Good agronomy, harvest, drying, cleaning
  - ➢ Varieties and breeding
  - ➢ Fungicides
  - ➢ Storage management

# Surveys for grain quality in NYS commercial barley fields


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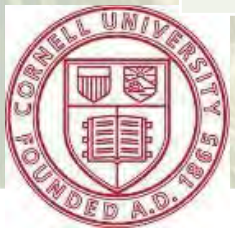
# Commercial barley field surveys

| | % of Barley Grain Lots Making Malt Grade for: | | |
|---|---|---|---|
| Year | DON < 1 ppm | Germ > 95 (72 hr) | Protein (9-12%) |
| 2014 | 59 | NA | 55 |
| 2015 | 38 | 52 | 40 |
| 2016 | 100 | 51 | 92 |
| 2017 | 77 | 81 | 77 |
| 2018 | 96 | 50 | 75 |
| 2019 | 94 | 71 | 82 |
| 2020 | 100 | 94 | 88 |

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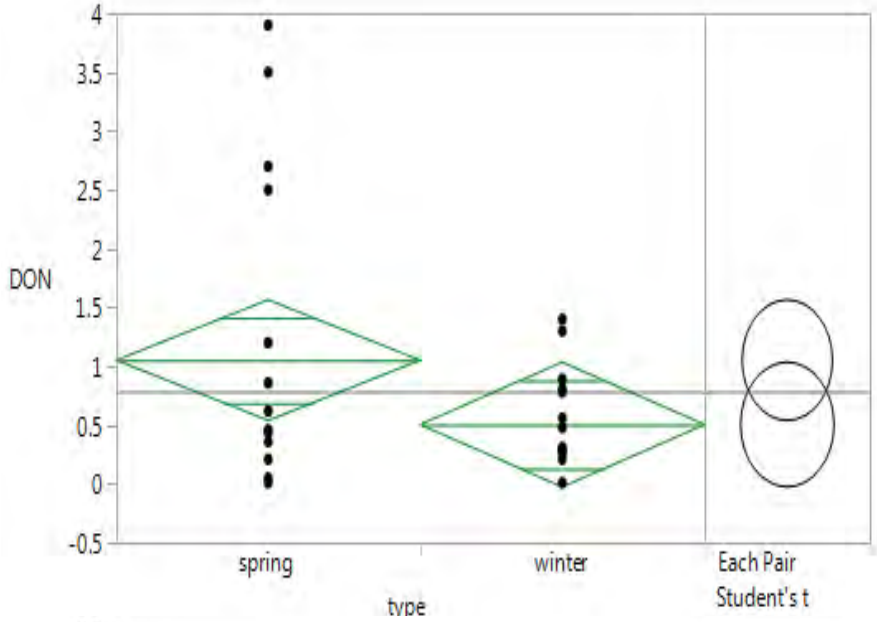
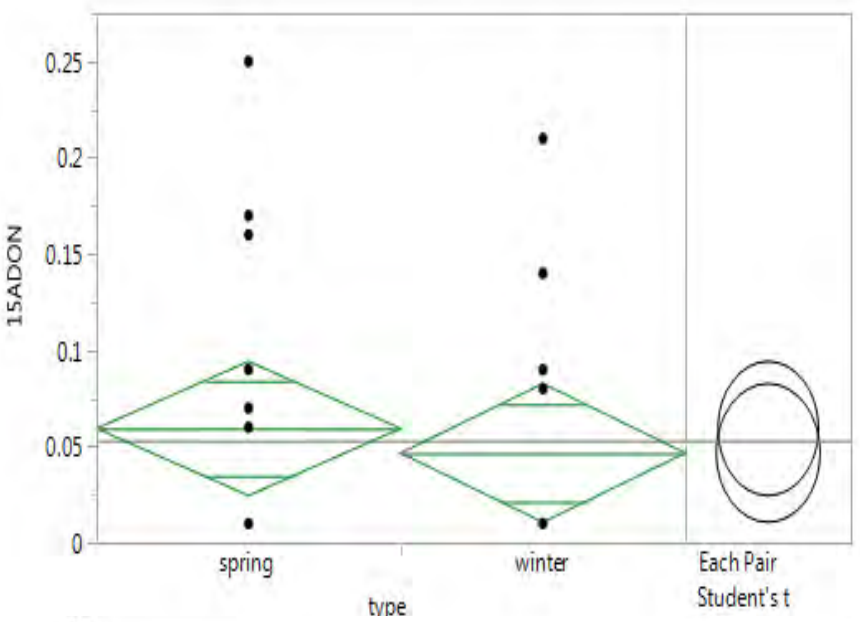
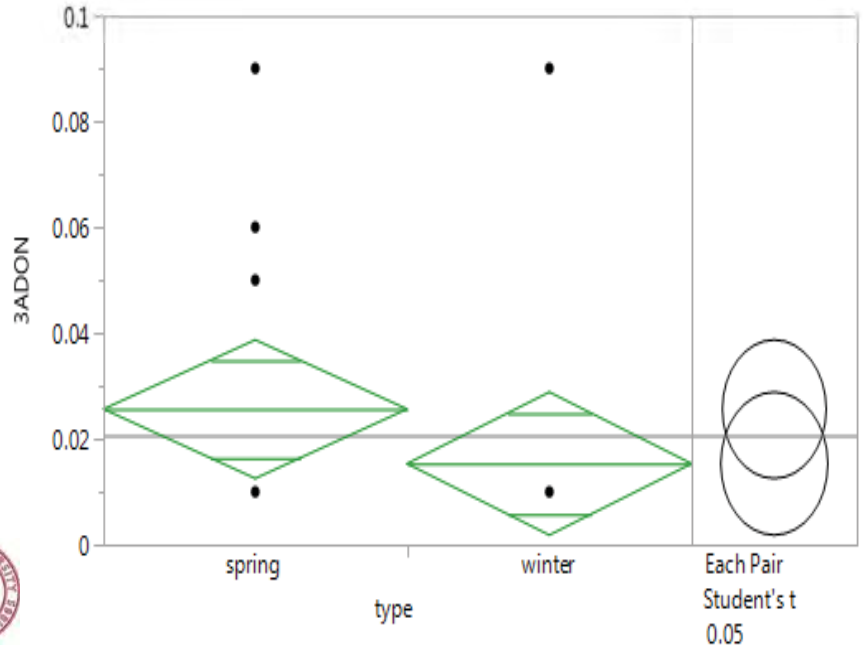
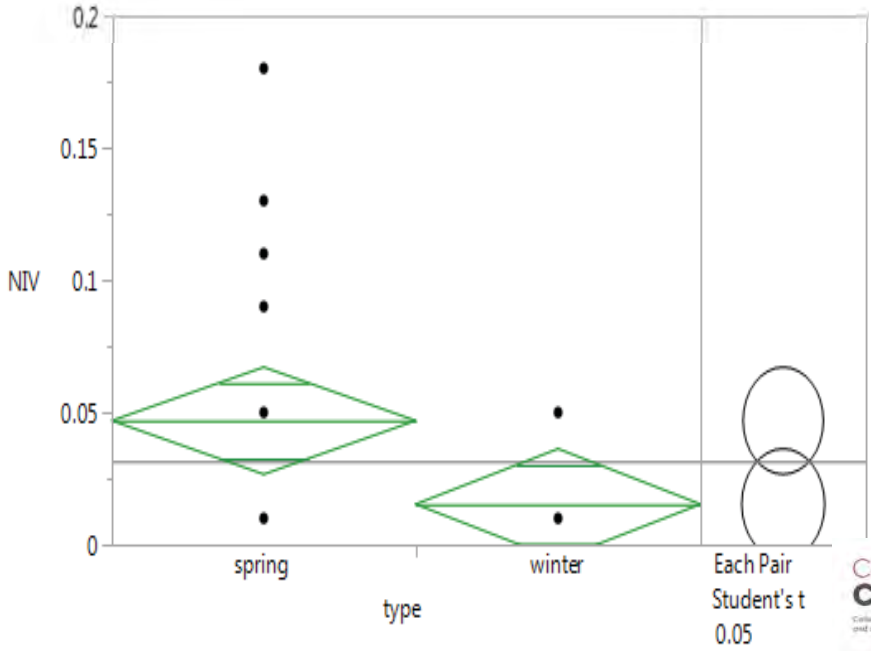
# Mycotoxins in 2017 barley grain

All 31 samples, all 13 varieties (16 spring & 15 winter)



# Fusarium Head Blight is Malt Barley Enemy # 1

# Why is DON important in malting barley?

## DON in beer

Safety concern

Public perception

## Beer Gushing

Caused by hydrophobins produced by *Fusarium*, as well as other fungal species

## Distilling

DON is not transferred to distillate but will remain with the spent mash

Courtesy of Paul Schwarz, NDSU

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# DON in malting

Courtesy of Paul Schwarz, NDSU

Viable *Fusarium* in kernels may produce more DON during malting

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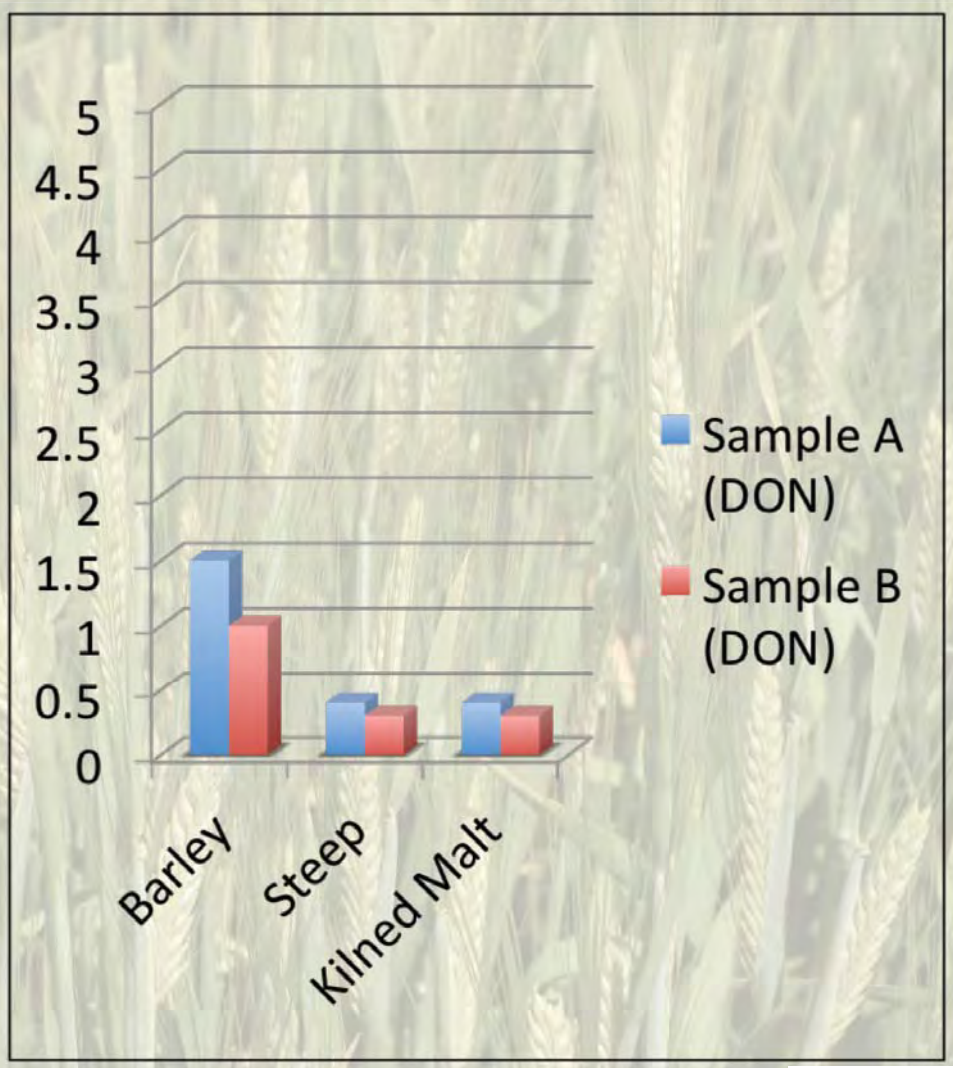
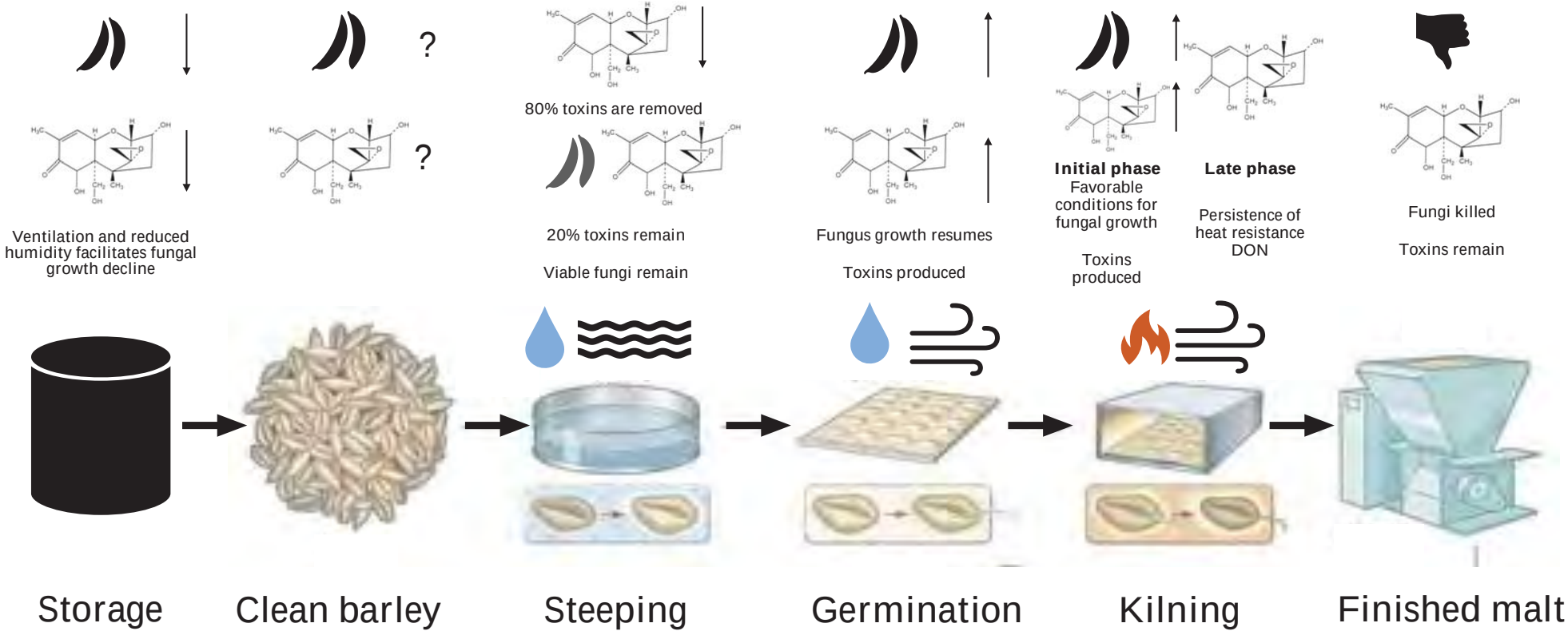
# DON in malting

- The normal pattern is to see DON decrease in the steep, and remain low on the finished malt.
- DON levels in more heavily infected samples generally will not be reduced to satisfactory levels by steeping.




Courtesy of Paul Schwarz, NDSU

# Fate of Fusaria and toxins through malting




*Fusarium*= Type B trichothecenes/deoxynivalenol & acetylated DON (DON)(3ADON-15ADON)(NIV)=

Lugo-Torres, Andrea. M.S. Thesis, Cornell University, August 2020.

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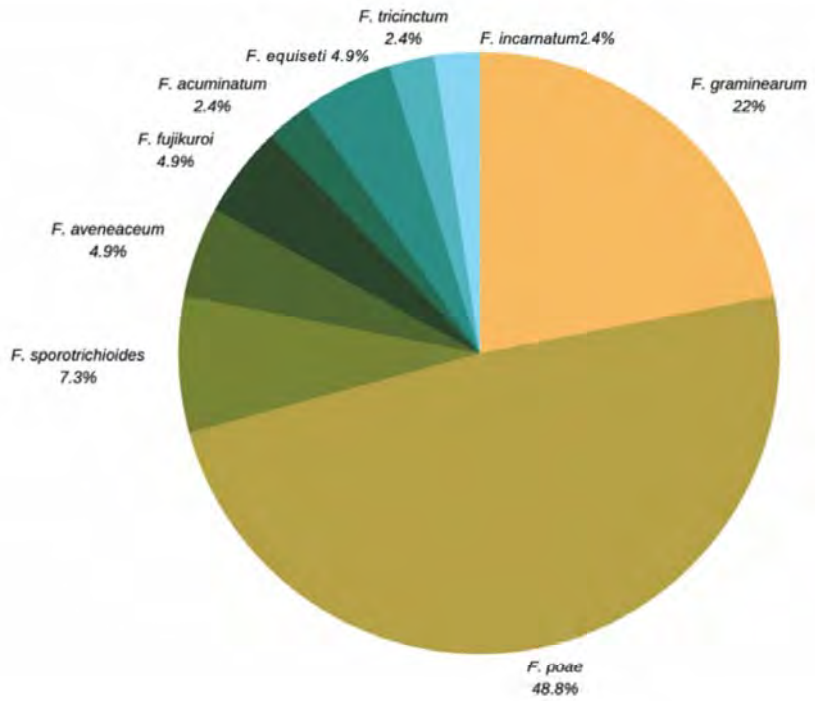
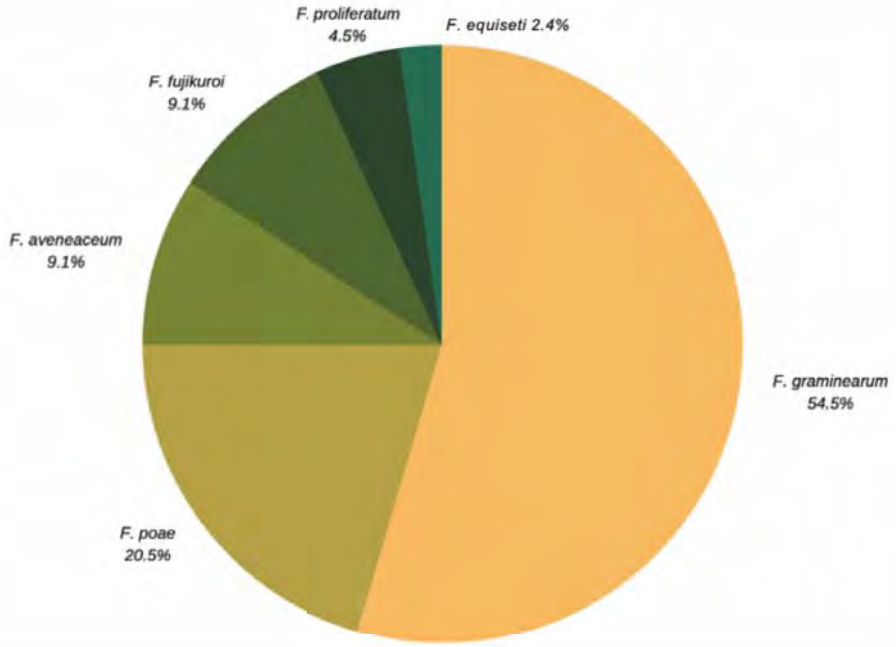
# *Fusarium graminearum* and *Fusarium poae* predominated in barley grain in 2018




Spring MB

Winter MB

Lugo-Torres, Andrea. M.S. Thesis, Cornell University, May 2020.

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# Mycotoxins produced by Fusaria infecting barley grain

| *Fusarium* spp. | Fumonisins | Moniliformin | Deoxynivalenol (DON) | 3- & 15-ADON | Nivalenol | HT-2 | T-2 | Zearalenone |
|---|---|---|---|---|---|---|---|---|
| *F. acuminatum (FTSC)* | | x | | | | x | x | |
| *F. aveneaceum (FTSC)* | | x | | | | | | |
| *F. equiseti (FEISC)* | | x | | | x | | x | x |
| *F. fujikuroi (FFSC)* | x | x | | | | | | |
| *F. graminearum (FGSC)* | | | x | x | x | | | x |
| *F. poae* | | | | | x | x | x | |
| *F. proliferatum (FFSC)* | x | x | | | | | | |
| *F. sporotrichioides* | | x | | | | x | x | |
| *F. tricinctum (FTSC)* | | x | | | | | | |
| *Fusarium incarnatum (FEISC)* | x | | | | | | | x |

Lugo-Torres, Andrea. Assessment of Mycoflora, Mycotoxin Profiles and Fungal Diseases of New York Grown Barley to Assure High Quality Malt for Craft Brewing. M.S. Thesis, Cornell University, August 2020.

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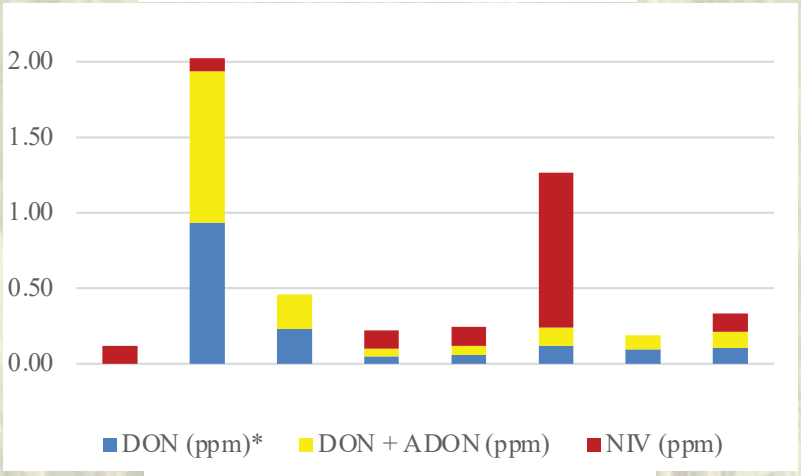
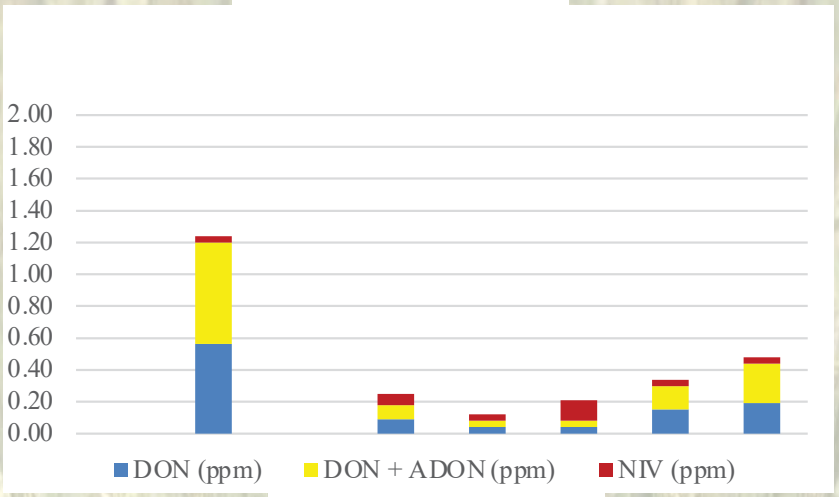
# Mycotoxins in harvested grain vs. finished malts in 2018

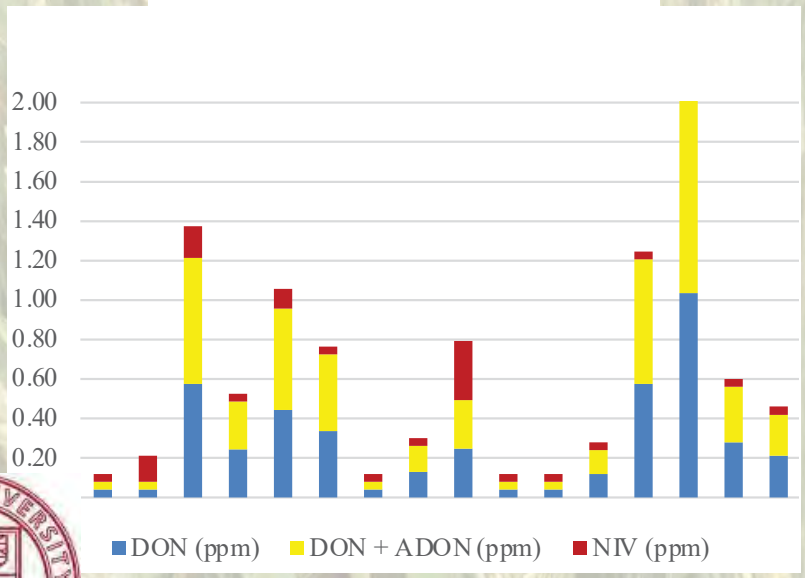
## Harvested Spring MB




## Finished Malt




## Harvested Winter MB

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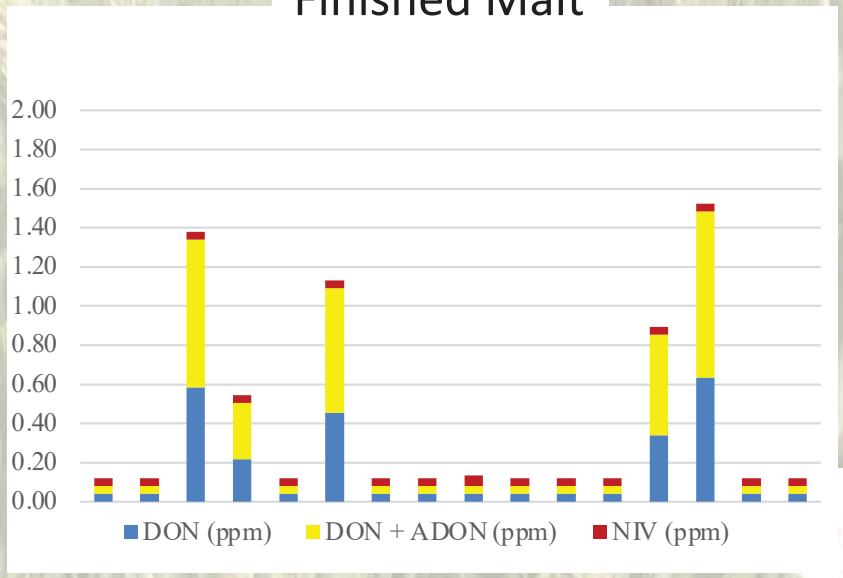


Lugo-Torres, Andrea. M.S. Thesis, Cornell University, August 2020.

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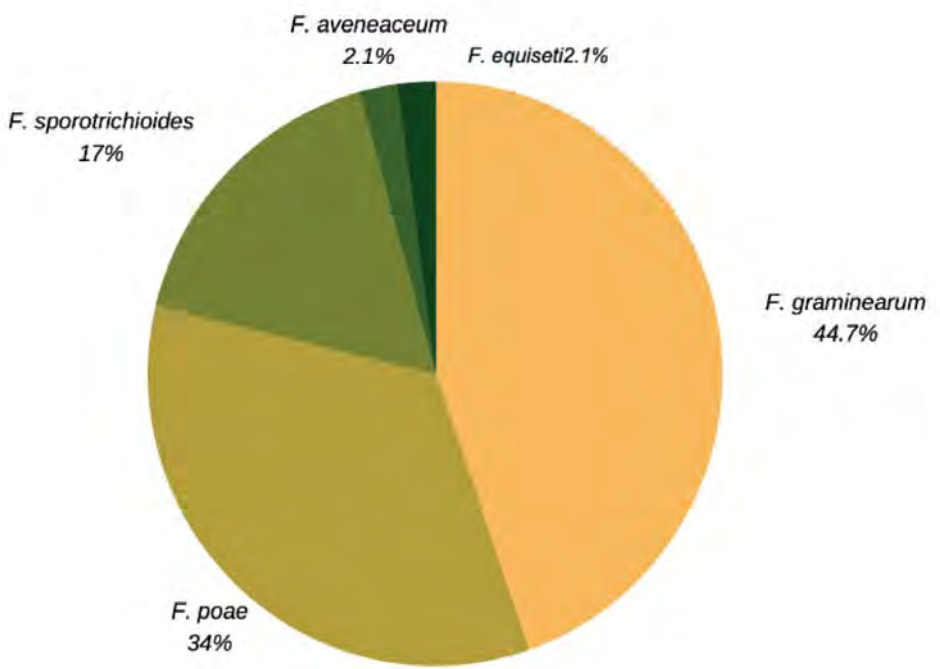


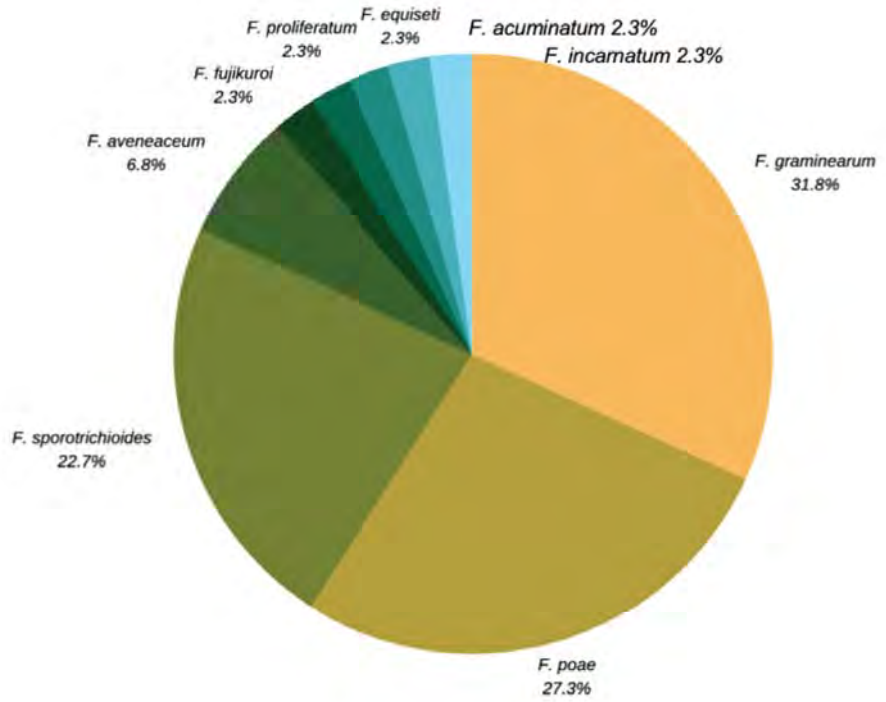




Spring MB

Winter MB

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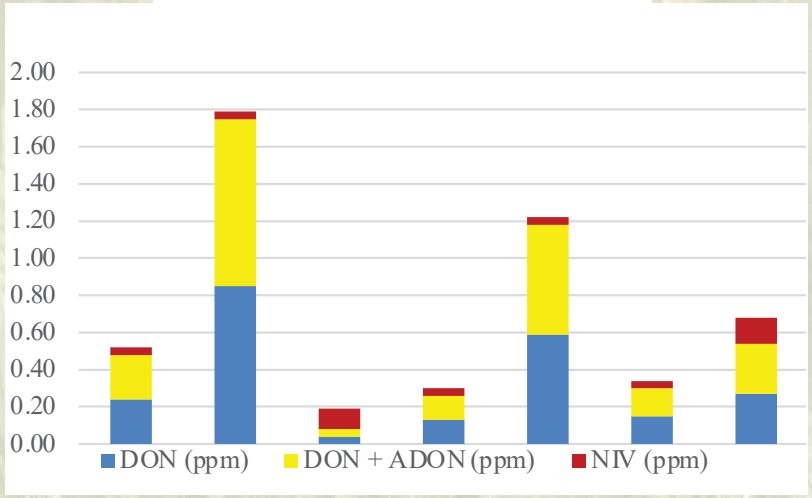
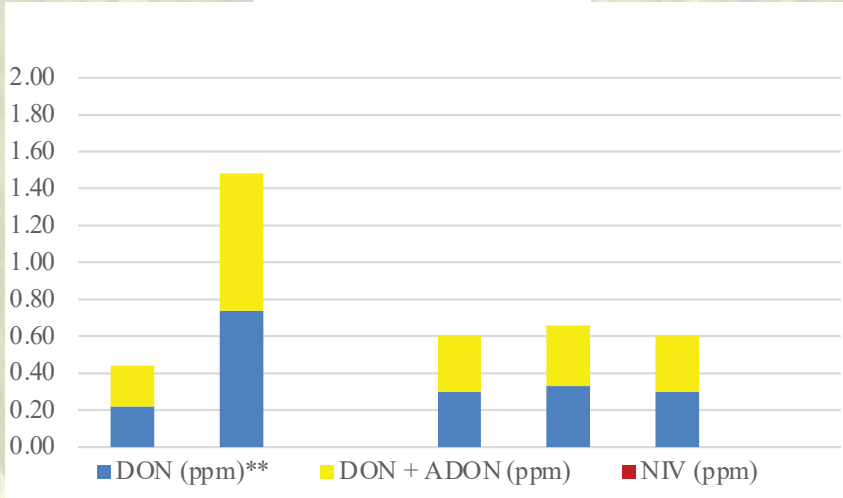
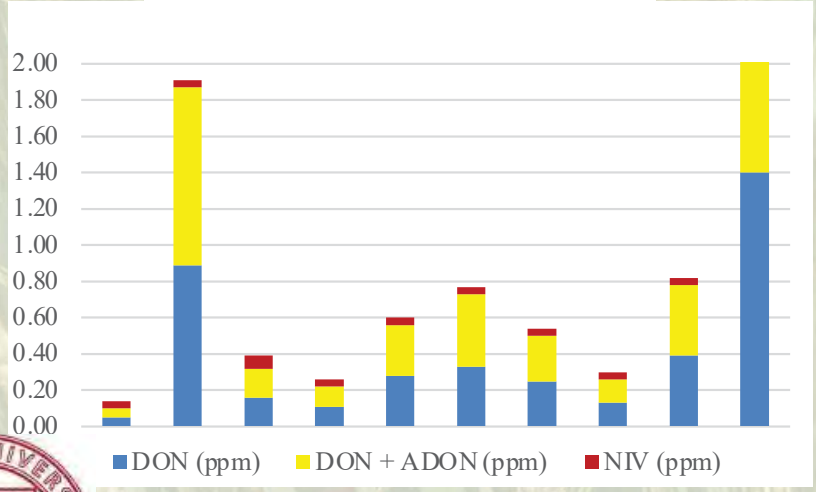



## Finished Malt




## Harvested Winter MB

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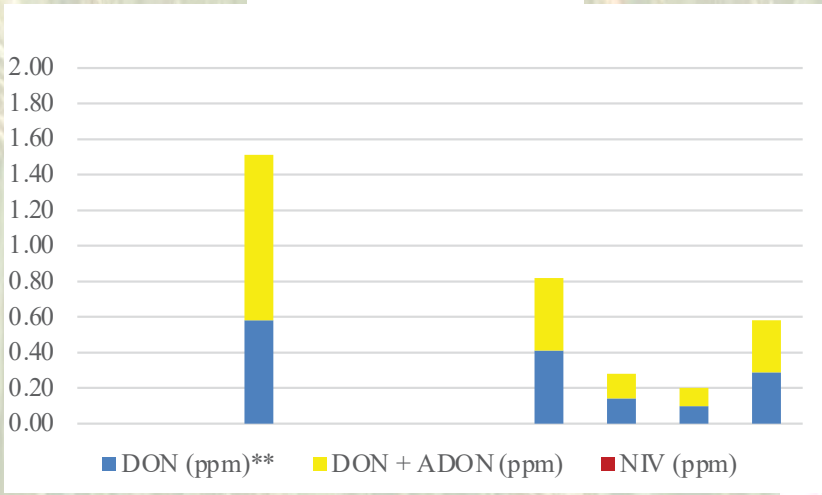


Lugo-Torres, Andrea. M.S. Thesis, Cornell University, August 2020.

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# Predicted chemotypes of *Fusarium graminearum* isolates in 2018-2019 based on TRI12

| | 15 ADON | 3 ADON | NIV |
|---|---|---|---|
| **2018** | 23 | 2 | 0 |
| **2019** | 19 | 9 | 2 |

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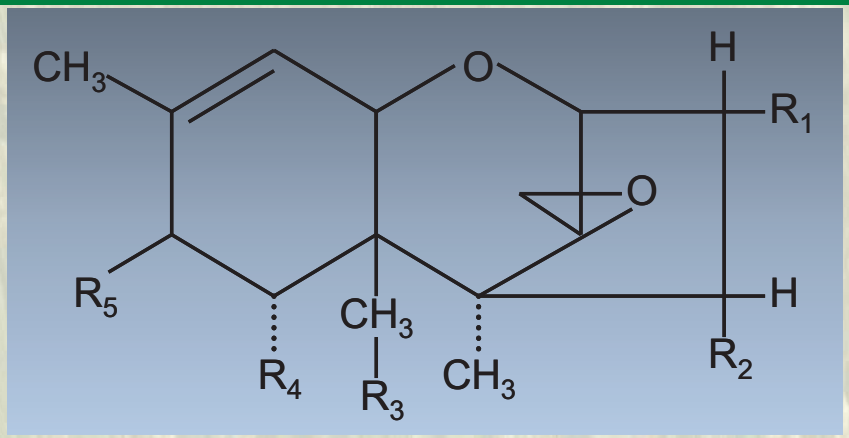
# Relative toxicity of deoxynivalenol (DON) and related beta-trichothecene toxins




1 mg toxin/kg of body weight = 1 ppm = 1,000 ppb

| | | $LD_{50}$ Mouse, Oral mg/kg | $LD_{50}$ Mouse, IP mg/kg |
|---|---|---|---|
| Deoxynivalenol | DON | 46 | 43 |
| 3-Acetyldeoxynivalenol | 3-ADON | 34 | 47 |
| 15-Acetyldeoxynivalenol | 15-ADON | 34 | 113 |
| Nivalenol | NIV | 5 | 4 |

Source: Sigma-Aldrich Material Safety Data Sheets

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# Results of 2018-19 Lugo-Torres Study

- Commercial barley grain lots had lower average DON levels, but higher NIV in the very dry year than in the more normal year
- All but two commercial barley grain lots maintained individual mycotoxins below 1 ppm, yet the total trichothecene load exceeded 1 ppm in some lots
- No finished malts had individual mycotoxins above 1 ppm, but some exceeded 1 ppm in total trichothecenes
- *Fusarium poae* DNA content in grain was correlated with NIV in grain lots in 2018, indicating that *F. poae* was the primary source of NIV
- *Fusarium graminearum* DNA content in grain was correlated with DON in finished malts in both years

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# Take-aways from 2018-19 Lugo-Torres Study

- An unrealized risk of NIV contamination in barley for malting that may be magnified under conditions favoring contamination of grain by *F. poae*.

- Though the incidences of *F. sporotrichioides* and *F. acuminatum* were fairly low, their presence, which may be elevated in other years, bears scrutiny as these molds produce the very serious mycotoxins T-2 and HT-2

- Finding of low levels of fumonisin- and moniliformin-producing *Fusarium* spp. in barley also justify future surveillance for these molds and mycotoxins in barley


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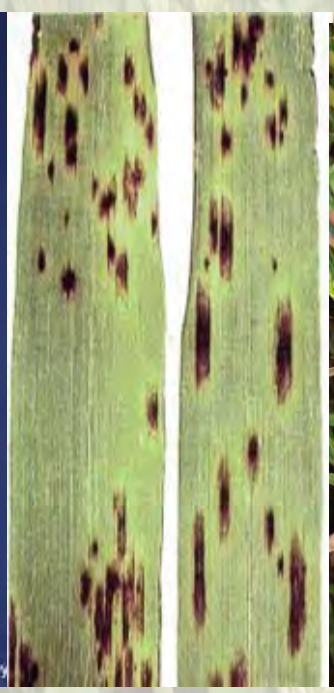
# Diseases occurring in NYS

## 15 Barley Diseases Diagnosed in NYS since 2014

Barley yellow dwarf, halo spot, loose smut, bacterial blight, Fusarium root rot, net blotch, snow mold, **scald**, **spot blotch**, anthracnose, powdery mildew, **Fusarium head blight**, Rhizoctonia root rot, leaf rust, ergot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# Foliar diseases




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# Ergot


Issue in barley following grass hay or fallow

# Loose smut


Serious issue in organic barley production

# 2017 Spring Malting Barley Integrated Management Trial

| Cultivar mean | Leaf Rust | Leaf Blotch | Scald | FHB Index | DON | Test Weight | Yield |
|---|---|---|---|---|---|---|---|
| ND Genesis | 0.1 | 5.1 a | 2.9 | **5.0 a** | **3.2 b** | 44.1 a | 68.2 |
| Newdale | 0.1 | 3.0 ab | 1.5 | **0.9 b** | **3.0 b** | 42.1 b | 69.2 |
| AAC Synergy | 0.0 | 2.3 b | 1.2 | **0.7 b** | **3.9 b** | 42.6 b | 63.3 |
| KWS Tinka | 0.1 | 4.2 ab | 2.4 | **0.7 b** | **7.4 a** | 42.9 b | 60.4 |
| HSD (P=0.05) | NS | 2.66 | NS | 0.95 | 1.72 | 1.04 | NS |
| CV (%) | 206.7 | 102.6 | 127.1 | 128.9 | 65.5 | 3.7 | 21.6 |

Jaime Cummings, Paul Stachowski, and Gary Bergstrom

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# 2018 Winter Malting Barley Integrated Management Trial

| Cultivar mean | Spot Blotch | Scald | DON | Test Weight | Yield |
|---|---|---|---|---|---|
| LCS Calypso | 0.5 b | 0.3 b | 0.1 a | 46.4 ab | 82.6 b |
| AC Flavia | 3.2 a | **43.0 a** | 0.0 a | 48.9 a | 81.1 b |
| KWS Scala | 3.4 a | **40.5 a** | 0.1 a | 43.9 b | 72.5 b |
| KWS Somerset | 0.4 b | 1.6 b | 0.1 a | 45.3 b | **96.9 a** |
| HSD (P=0.05) | 1.37 | 15.7 | NS | 2.72 | 12.02 |
| CV (%) | 100.5 | 118.9 | 96.8 | 6.6 | 16.6 |

Jen Starr, Jaime Cummings, Paul Stachowski, and Gary Bergstrom

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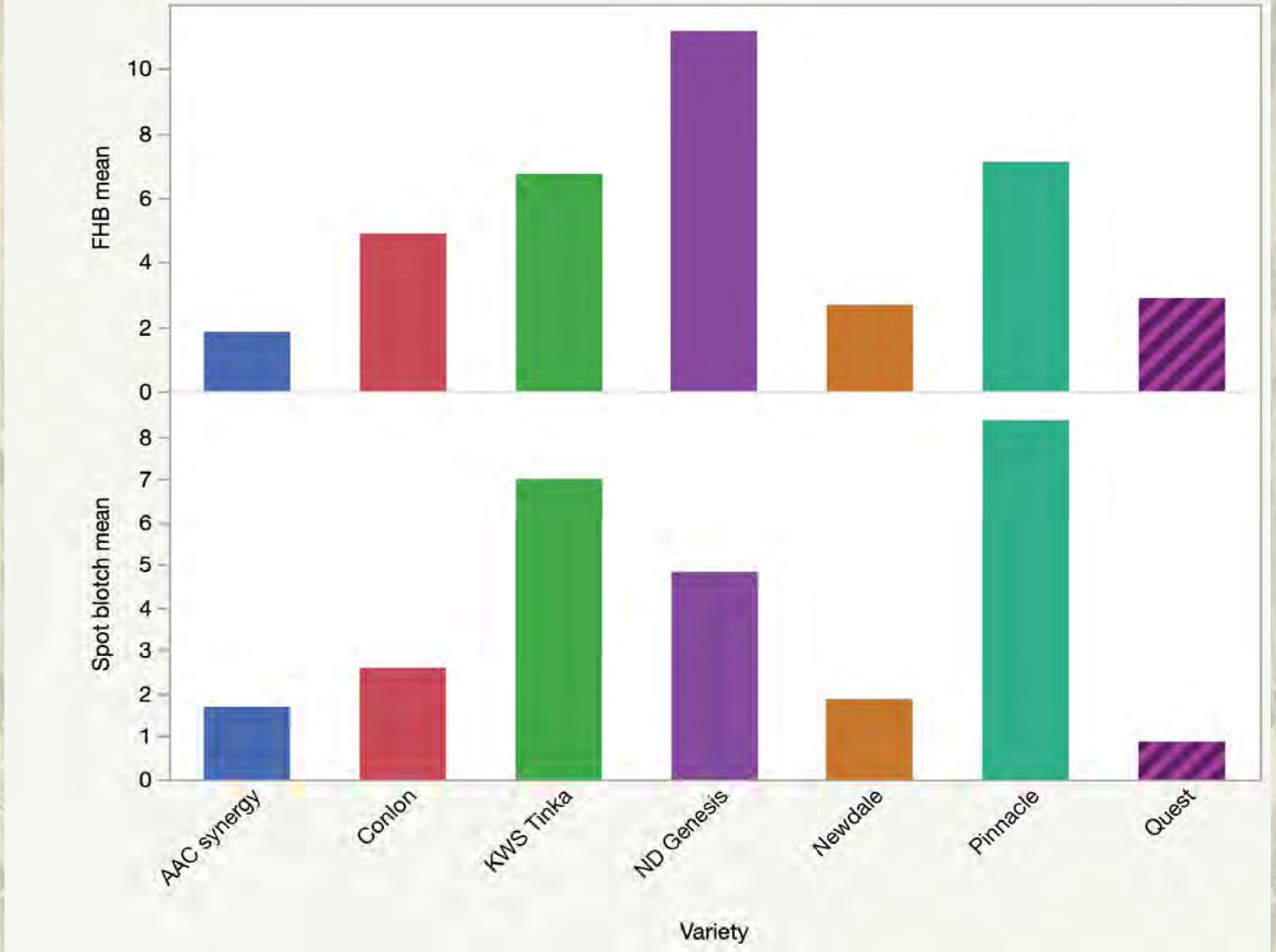
# FHB Incidence and Spot Blotch Severity in Spring Barley Regional Trials

Multiple linear regression model for (year x location x variety) on the response of spot blotch incidence (%) and FHB incidence (%)

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# Spring Barley Disease Reactions

| Varieties ( | Rows | Spot Blotch | Leaf Rust | Powdery Mildew | Fusarium Head Blight |
|---|---|---|---|---|---|
| AAC Synergy | 2 | R | MS | MR | MS-MR |
| Cerveza | 2 | MR | MR | MR | MS-MR |
| Conlon | 2 | MS-MR | MS | R | MR (MS*) |
| Craft | 2 | MR | MS-MR | MS | MS-MR |
| KWS Tinka | 2 | S | MR | R | MS |
| ND Genesis | 2 | MS | MR | R | MR |
| Newdale | 2 | MR | MR | R | MR |
| Pinnacle | 2 | S | MR | R | MS (S*) |
| Quest | 6 | R | MS | S | MR (MS*) |

*(S, MS) rating by Andrew Friskop, NDSU

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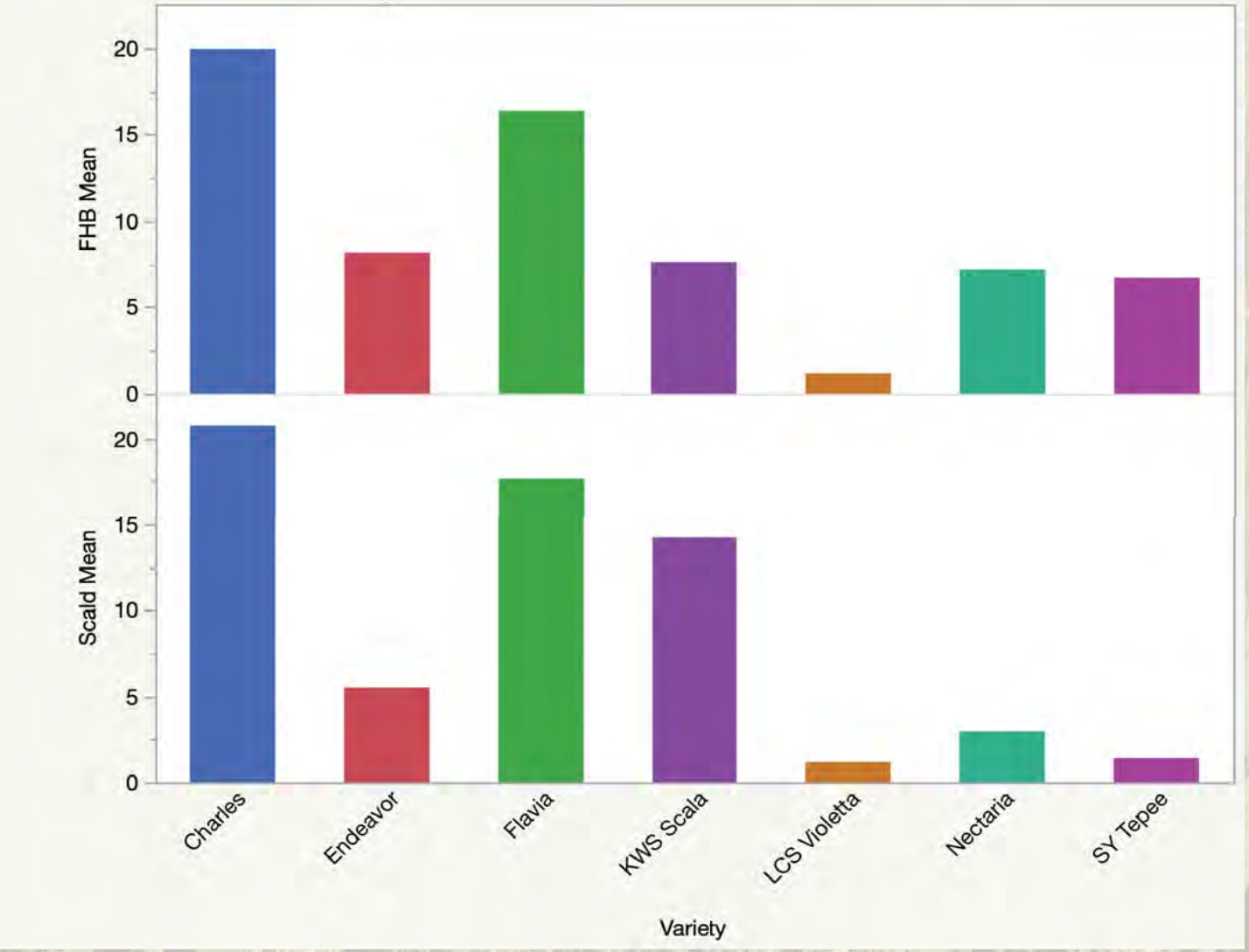


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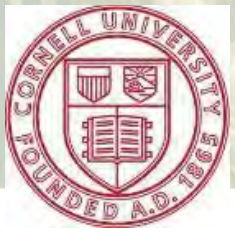
# Winter Barley Disease Reactions

| Variety | Rows | Scald | Leaf Rust | Powdery Mildew | Fusarium Head Blight |
|---|---|---|---|---|---|
| Charles (Ck) | 2 | S | S | R | MS-MR |
| LCS Calypso | 2 | R | NA | R | MR |
| Endeavor | 2 | MR-R | R | MR-R | MR |
| Flavia | 2 | S | R | R | S-MS |
| KWS Scala | 2 | S | R | MR-R | MS-MR |
| KWS Somerset | 2 | R | NA | R | MS |
| Nectaria | 2 | R | R | S | MS |
| SY Tepee | 2 | R | R | R | MS |
| LCS Violetta | 2 | R | NA | R | MS-MR |

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# Born, Bred, and Brewed in New York Breeding Project

## Cornell University barley FHB resistance breeding efforts

- Two-row spring malting barley breeding initiated in 2016, two-row winter in 2018
- Additional breeding of winter naked multi-use barley
- Winter breeding lines have not yet been evaluated for FHB
- Recent new spring crosses for FHB resistance

See BAR-CP Poster:
Five Years in: Outlook for Breeding for FHB Resistance in Barley in New York.

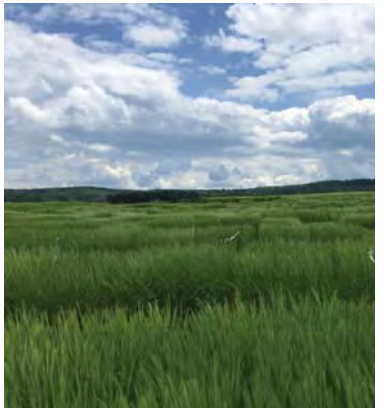
*Daniel Sweeney, James Tanaka, David Benscher, and Mark Sorrells*

Cornell University
Department of Plant Breeding & Genetics

***Excellence in Plant Breeding Since 1907***

# Born, Bred, and Brewed in New York Breeding Project

## Two-row spring malting program has progressed rapidly
## CU-31 will be named on Dec 16, 2020

| Spring 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
|  |  |  |  |  |
| First crosses | 1340 lines, 2 locations | 100 lines, 5 locations | 60 lines, 5 locations | Foundation seed increase |
| | FHB | | FHB | FHB |

Courtesy of Mark Sorrells and Daniel Sweeney

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# Best fungicidal suppression of FHB and DON in barley

## Fungicides:

CARAMBA™ FUNGICIDE

metconazole (8.6%)

FRAC Group 3 - DMI

PROSARO®

prothioconazole (19%)
& tebuconazole (19%)

FRAC Group 3 - DMI

Miravis® Ace

pydiflumetofen
(13.7%)
& propiconazolee
(11.4%)

FRAC Groups 3 & 7 –
DMI &SDHI

## Timing:

Best: Majority of primary tillers with heads completely emerged from boot (Feekes GS 10.5).

Good: Next 5-7 days after full head emergence

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# 2017 Spring Malting Barley Integrated Management Trial

| Treatment mean | Leaf Rust | Leaf Blotch | Scald | FHB Index | DON | Test Weight | Yield |
|---|---|---|---|---|---|---|---|
| Non-sprayed | 0.3 a | 7.5 a | 4.0 a | 2.9 a | 6.8 a | 42.1 c | 64.3 |
| Prosaro FGS 10.5 | 0.1 b | 2.5 b | 1.7 b | 1.4 ab | 4.3 b | 43.2 ab | 66.8 |
| Caramba FGS 10.5 | 0.0 b | 2.7 b | 1.4 b | 1.7 ab | 4.2 b | 42.6 bc | 64.0 |
| Prosaro FGS 10.5, followed by Caramba 7 days later | 0.0 b | 1.9 b | 0.8 b | 1.2 b | 1.9 c | 43.7 a | 65.7 |
| HSD (P=0.05) | 0.13 | 2.14 | 1.66 | 1.68 | 1.71 | 1.10 | NS |
| CV (%) | 206.7 | 102.6 | 127.1 | 128.9 | 65.1 | 3.7 | 21.6 |

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# 2018 Spring Malting Barley Fungicide and Organic Treatment Trial at Alburgh, VT

Data courtesy of Heather Darby and Erica Cummings, University of Vermont

| Spray at full head emergence: | DON |
|---|---|
| non-sprayed | 7.91 |
| Caramba | 4.80 |
| Prosaro | 3.68 |
| ChampION (copper hydroxide) | 5.74 |
| Actinovate (*Streptomyces*) | 7.69 |
| Sonata (*Bacillus*) | 7.14 |

Seldom see significant reduction of DON with OMRI materials!

See Forum Proceedings Paper by Heather Darby and Hillary Emick, summarizing 3 years of tests including organic copper

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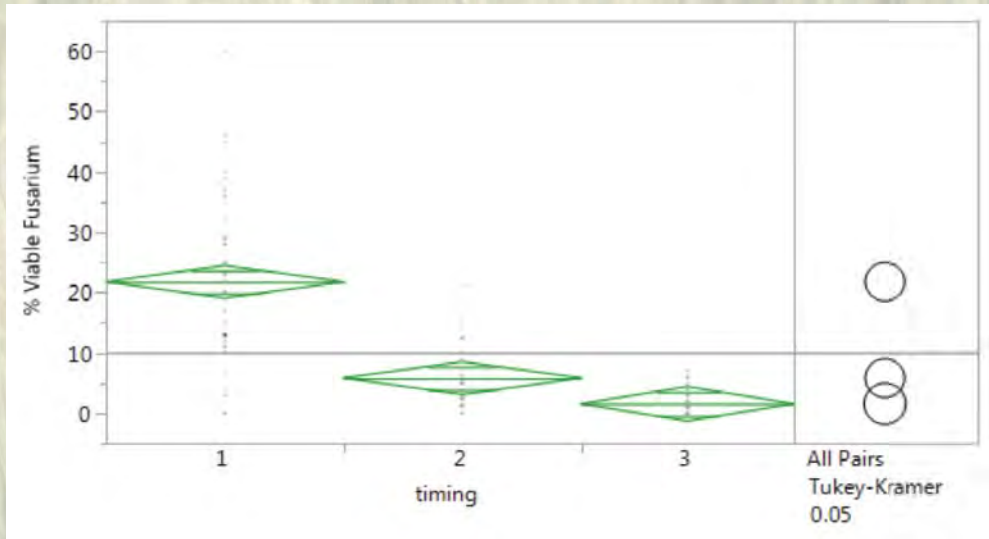
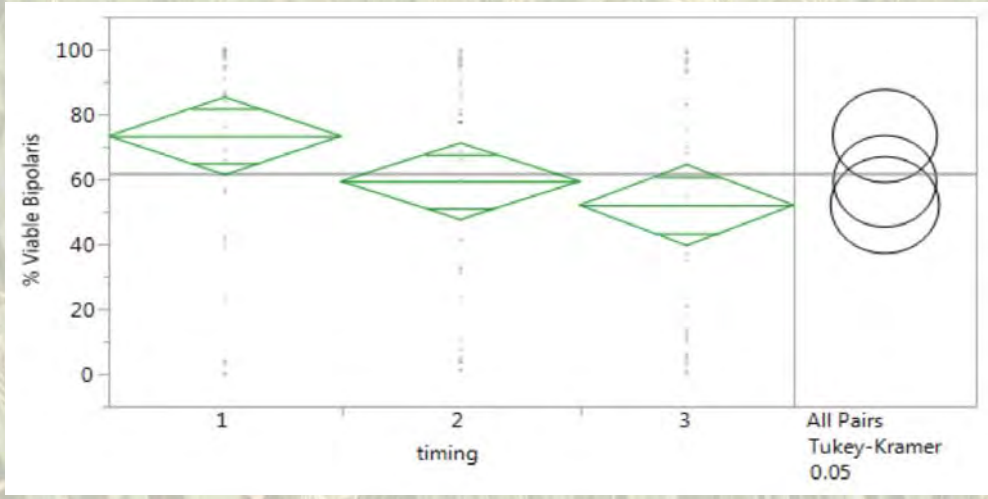
# *Fusarium* viability reduced with time in storage




Viable *Fusarium* in barley grain is significantly reduced over time




Viable *Bipolaris* in barley grain is not significantly affected

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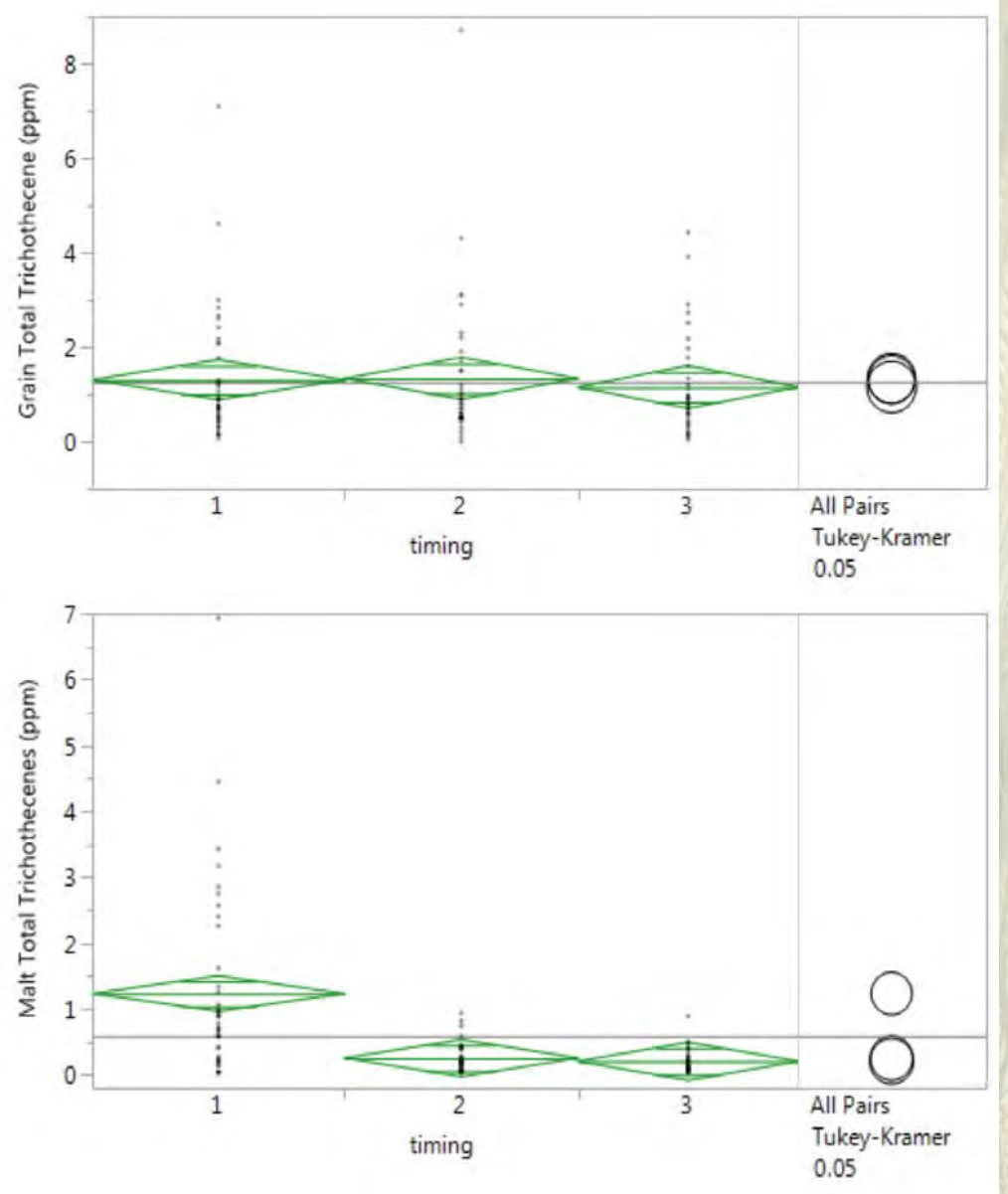
# DON concentration not reduced with time in storage




Trichothecene mycotoxins remain constant over time in grain

Trichothecene mycotoxins are significantly reduced in malt if grain is stored

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# Integrated management of diseases and mycotoxins

- Plant barley following soybean or vegetable crop; not after corn, small grain, hay or fallow with grasses
- Choose variety based on malt quality potential, adaptation, and disease resistance
- Sow fungicide-treated, certified seed
- Apply Caramba, Prosaro, or Miravis Ace fungicide at full head emergence or up to 7 days later
- Additional fungicide application (mixed mode of action best) prior to flag leaf emergence if warranted by early season foliar diseases or susceptibility of variety

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# Virtual Empire State Barley and Malt Summit
# December 16, 2020

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**https://fieldcrops.cals.cornell.edu/small-grains/malting-barley/empire-state-barley-and-malt-summit/**

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