U.S. WHEAT & BARLEY SCAB INITIATIVE

Fusarium Focus

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2020 FHB Forum: Virtual Science

Like so many events during the past year, the 2020 National Fusarium Head Blight Forum became a "virtual" affair via Zoom. Initially scheduled to take place in Cincinnati, Ohio, the FHB Forum went virtual on December 7-11 due to Covid-19.

Nearly 390 scientists, graduate students, growers and industry representatives from the U.S. and foreign countries tuned in to the Forum's sessions. The event featured stakeholder and scientific invited speaker presentations, plus focused group discussions. "Q&A" sessions with poster presenters were on the docket as well, with primary authors available to discuss their research. Also, postdoctoral scientists and graduate students participated in daily "Flash & Dash" virtual sessions in which they provided mini-oral presentations on their prepared posters.

In a special Monday afternoon segment, Carl Schwinke of Siemer Milling Company hosted the USWBSI Forum audience for a virtual tour of his company's Whitewater Mill at West Harrison, Ind.

In her opening remarks to the Forum audience on December 7, University of Minnesota plant pathologist and USWBSI co-chair Ruth Dill-Macky spoke to the past year's highlights for the Initiative. She pointed to the number of newly released wheat and barley varieties developed with support from USWBSI; the expanding and increasingly collaborative work of the nation's mycotoxin analysis labs, again supported by the USWBSI; the second year of multi-state testing of the new fungicide, Miravis®Ace; and the CrisperCas 9 gene editing progress in wheat.

Ruth Dill-Macky

"We're still making much great progress in the Initiative," Dill-Macky affirmed.

The USWBSI co-chair later singled out the format of the 2020 Forum's FHB Management virtual session. "We were able to turn this from the type of research reporting that we generally see at the Forum to an outward-facing session where we provided FHB management information to crop advisors," she noted. "We further were able to get this session approved for continuing education unit credits at a time when other options for CEU credits were limited.

"I think this session went really well and allowed us to broaden the audience we reach with best management practices for FHB. I expect we will see similar efforts in the future, irrespective of the Forum format."

Phil Bregitzer

The USWBSI co-chair additionally paid tribute in her opening statements to the late Phil Bregitzer, who died in a tragic skiing accident in Idaho on March 15, 2020. Bregitzer worked as a barley geneticist with the USDA-ARS Small Grains and Potato Germplasm Research Laboratory at Aberdeen, Idaho, for three decades. His professional achievements and vibrant personality were well known in the USWBSI community.

Also paying tribute to Bregitzer during their respective Forum presentations were Juliet Marshall and Tom Baldwin. Both worked closely with Bregitzer during their careers. Marshall is a cereal specialist and pathologist for the University of Idaho; Baldwin, now at North Dakota State University, previously was an ARS postdoctoral fellow in the Bregitzer lab.

Organized/hosted by the U.S. Wheat & Barley Scab Initiative (USWBSI), the annual FHB Forum provides a central venue for reports on the latest research on Fusarium Head Blight (scab) and deoxynivalenol (DON), the mycotoxin produced by scab infection in grains.

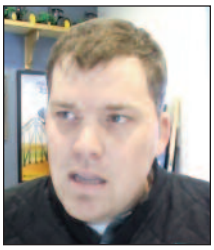
The 2021 National Fusarium Head Blight Forum is scheduled to be another "in-person" event. It will take place December 5-7 at the Hilton Cincinnati Netherland Plaza in downtown Cincinnati. Check the USWBSI website — www.scabusa.org — for updates.

The following pages contain talk summaries from several of the invited speaker presentations at the 2020 Forum. PDF copies of some of these presentations — and several others — are posted on the USWBSI website. Proceedings of the 2020 National Fusarium Head Blight Forum, consisting mainly of research paper abstracts, are also posted on the Initiative's website. ✦

— 2020 FHB Forum —

Striving for Top Wheat Yields in the Short Season of Northern Minnesota

Tony Brateng started off the 2020 National Fusarium Head Blight Forum's first virtual session with his presentation titled "Pushing Yields on Spring Wheat in Northern Minnesota." Brateng farms near Roseau, Minn., located close to the Canadian border. His operation, South 89 Farms, encompasses 5,000 acres of cropland plus a seed/ag retail business. On average, his area experiences just 112 frost-free days annually. The Brateng crop rotation includes spring wheat, soybeans, canola and corn, as well as Kentucky bluegrass and perennial ryegrass turf seed.



Tony Brateng

Brateng, a member of the Minnesota Wheat Research & Promotion Council, walked his virtual Forum audience through a typical crop year on his farm. Months prior to spring planting, that includes decisions on crop acreage and rotation sequence, field drainage, field operations such as chisel plowing and vertical tillage, soil sampling to determine fertility needs for the upcoming crops, varietal selection (with particular attention to disease resistance, straw strength, yield capacity and quality), and servicing equipment for the upcoming season.

Given his short growing season, Brateng plants as early as soil conditions allow. Planting follows on the heels of a light tillage pass, with the seeds going in at a depth of about 1.5 inches. He plants certified seed that has been treated for disease protection. Like many of today's producers, precision planting technology aids with his seed placement accuracy and consistency. For wheat, he'll use between 90 to 120 pounds of seed per acre (1.4-1.6 million seeds).

Brateng's wheat crop protection program involves several elements: weed control, tissue sampling, streaming on fertilizer (at the five-leaf stage), a well-timed fungicide/herbicide tank mix — and applying a fungicide at flowering to control Fusarium Head Blight (scab). Field scouting is a key component when implementing these practices.

At harvest, the wheat is either straight cut or first swathed and then combined later. Brateng employs an on-board protein analyzer and yield maps for analysis and future planning.

Wheat yields on South 89 Farms have shown a very positive trend line across the past 15 years, averaging about 2.3 bushels more per acre each year. That's significantly above the average increase for his region of northwestern Minnesota.

Brateng also spoke to several of the most significant changes he's experienced with his farming operation across the past couple decades. One has been the expansion of his rotation to include canola and early maturity soybeans; another, the improvement of wheat variety tolerance to scab and other diseases. Advances in machinery (*e.g.*, seeding technology, precision ag) have been key, as have fungicide efficacy (Prosaro, Caramba, Miravis Ace) and application technology (*e.g.*, nozzle improvements).

As to future needs for himself and other producers, Brateng emphasized continued promotion of good crop rotations, continually improving management of top varieties for yield and quality, continued progress in fungicide availability and efficacy — and lots of plot data.

"It all comes down to economics," he concluded. ✦

Update: GE Crops

Regulatory Policy & Consumer Acceptance

"Policy and Consumer Acceptance Consideration for Genetically Engineered Crops" was the title of Greg Jaffe's virtual presentation to the 2020 National FHB Forum audience. Jaffe is Director of the Project on Biotechnology for the Center for Science in the Public Interest (CSPI) and, as well, serves an adjunct professor of law at Cornell University.

Jaffe was a member of the Secretary of Agriculture's Advisory Committee on Agricultural Biotechnology and 21st Century Agriculture during 2000-08 and was reappointed to a new term from 2011 to 2016. His areas of expertise include environmental law and policy, food and agriculture law and regulation, and agricultural biotechnology and biosafety law.

Greg Jaffe

Jaffe noted that a number of commercially important crops currently possess, to some degree, geneticially modified seed. The list is led by corn, soybeans, cotton and sugarbeets — all of which, in terms of seed volume sold and planted, rank above 90% GMO. As yet, no GMO wheat is grown commercially in the United States.

Jaffe provided a quick overview of how the U.S. government is involved in the regulation of GMO plants and seeds. The U.S. coordinated framework, established in 1986 and revised in 2017, set forth a policy that multiple agencies would regulate the products of biotechnology. The USDA's primary role is to protect plant health; that of the FDA, to ensure that GMO products are safe for use as food and/or feed; and that of EPA, to make sure that plants engineered to produce a

pesticidal substance are safe. Products that have been reviewed by that regulatory system include engineered traits like insect resistance (*e.g.*, Bt corn) and herbicide tolerance (*e.g.*, glyphosate tolerance).

More recently, new types of gene editing tools — CRISPR being a prime example, both in agriculture and medicine — have been developed, and the federal agencies currently are determining how products made using gene editing techniques should be regulated. So far, only USDA has established regulations for gene edited products. Their 2020 regulation, called the SECURE rule, provides three exemptions from oversight for gene edited products that could otherwise be achieved through conventional breeding.

These three exemptions cover a single genetic modification to any plant species which is either: (1) a change resulting from cellular repair of a targeted DNA break in the absence of an externally provided repair template; (2) a targeted single base pair substitution; and (3) introduction of a gene known to occur in the plant's gene pool — or, a change in a targeted sequence to correspond to a known allele of such a gene or to a known structural variation present in the gene pool.

The impacts of this USDA "final rule" will likely change the regulation of genetically engineered and gene edited products in the following ways, Jaffe observed:

- The universe of regulated products will be greatly reduced. There would be automatic exemptions for some gene-edited plants, with most gene-edited plants not requiring regulation. Most GMO plants that use agrobacterium will not longer be regulated, and almost all field trials will no longer be regulated (which implies no confinement conditions).
- There will be no public list of genetically engineered products being marketed. That, of course, carries ramifications for marketing, including labeling/disclosure.
- No more special treatment for wheat, *i.e.*, most GMO and genome-edited wheat will not be regulated. ✦

'Going Down the Rabbit Hole'

A Discussion of Climate Change & Agriculture

Given its title — "Going Down the Rabbit Hole: Effect of Climate Change on FHB and Small Grains" — Juliet Marshall's presentation to the 2020 National FHB Forum virtual audience was destined to intrigue. Marshall, based at Idaho Falls, serves as cereal specialist and pathologist for the University of Idaho.

Juliet Marshall

While differences abound on the causes and impacts of climate change, its reality as it pertains to agriculture cannot be ignored, Marshall emphasized. Referencing Idaho, she pointed out that 28% of the state's economy is directly based on agriculture, with the Idaho producing about one-third of the total U.S. potato crop and also ranking first in malt barley production.

The past three to four decades have brought very notable changes to the Pacific Northwest's agricultural environment — changes in cropping systems, changes in irrigation technology and practices, and changes in climate. For example, corn acreage has grown dramatically in concert with an expansion of dairy herd numbers. That, in turn, has contributed to more Fusarium Head Blight in wheat and barley since corn residue acts as a host for this disease.

Increasing temperatures have resulted in higher frequency of FHB occurrence. Surveys of dominant *Fusarium* species causing FHB in Idaho spring wheat for 1989 and 2011, respectively, showed that *F. graminearum* increased from just 2% in 1989 to 78% of the isolates from affected sites in 2011.

Marshall turned to a discussion of climate prediction models showing a dramatic increase in global atmospheric CO_2 levels. Those changes portend both "pros" and "cons" in terms of future crop yields. For example, she noted, they suggest increased yields of corn, cotton, soybeans, sorghum, barley, sugarbeets, pastures and citrus. But, on the flip side, the CO_2 changes imply neutral to negative yield effects on such crops like wheat, rice, oats, hay, sugarcane, potatoes and tomatoes. Among the likely impacts on crop quality would be a decline in bread wheat quality characteristics, she added.

Global temperatures have been rising too, of course, and Marshall outlined the trend in the Pacific Northwest specifically. The average annual temperature in that region has increased by 1.5 degrees Fahrenheit across past century, she noted, with virtually every PNW weather reporting station reflecting this warming. Extreme cold conditions have become more rare, with "low" temperatures rising faster than "high" temps. Predictions suggest even more dramatic increases, with some models forecasting temperature rises of up to 5.0 degrees F. by the dawn of the 22nd century.

For agriculture, such a change would bring more-pronounced effects during winter months and during the night, Marshall stated. She highlighted three general results: expansion of the growing season, migration of crops to the north, and the addition of new crops to PNW growers' rotations. Plus, the agricultural community could be expected to experience "increased variability associated with unpredictable anomalies," Marshall pointed out. ✦

— 2020 FHB Forum —

Update: The North American Barley Scab Evaluation Nursery

Tom Baldwin provided 2020 FHB Forum participants with an update on the North American Barley Scab Evaluation Nursery (NABSEN). Baldwin, the new barley pathologist at North Dakota State University as of 2020, manages NABSEN while also overseeing the FHB and spot blotch screening nurseries in North Dakota.

NABSEN, established in 2002, coordinates multiple nurseries — both misted and dryland — in North Dakota, Minnesota and Manitoba. It is the longest-running scab evaluation nursery in the nation and evaluates elite barley lines from both public and private breeding material. Each line is planted in three replicates with consistent checks. Corn spawn and/or macroconidia serve as inoculation sources.

FHB evaluation is determined at the Feekes 11.2 growth stage (soft to mid-dough), and scab severity and DON are measured using a robust procedure to ensure uniformity across years.

"Performance of the NABSEN nurseries varies yearly with dynamic changes in weather conditions and yearly refreshing of barley lines being evaluated," Baldwin noted. "However, a clear trend of increased FHB and DON is observable from the first nine years (2002-2010) to the second nine years (2011-2019)." Specifically, there was an increase in overall average scab severity of 41.7% and DON of 18.8%, respectively, when comparing those two time periods. Baldwin said that trend could be due in part to better strategies for inducing disease, but likely was also influenced by more-favorable climate conditions for FHB in recent years.

Tom Baldwin

Fortunately, there likewise was a trend toward improved FHB resistance among the 10 top and bottom barley lines in the second decade, compared to resistant and susceptible checks. "The top 10 lines showed 13.4% lower severity and 13.3% lower DON compared to the resistant checks" during the second nine-year period as compared to the first nine-year period, Baldwin reported. Meanwhile, the bottom 10 lines during 2011-2019 showed 5.7% lower severity and 18.3% lower DON compared to susceptible checks during the 2002-2010 period. "These are encouraging results, despite the increased disease pressure," Baldwin affirmed.

Going forward, Baldwin said the NABSEN coordinated program will focus on "providing even better FHB evaluation using advanced screening tools — such as biomass and hyperspectral measurements— to aid barley breeders in developing FHB resistance in their elite barley lines well into the future." ✦

Diversity & Aggressiveness of *F. graminearum* in Illinois

University of Illinois research plant pathologist Santiago Mideros reported to the 2020 National FHB Forum audience on his team's research into the diversity and aggressiveness of *Fusarium graminearum* in Illinois wheat. "Changes in *F. graminearum* population diversity can have a huge impact," he noted, "with the emergence of new pathogen populations with potentially higher resistance to fungicides, greater aggressiveness or increased mycotoxin production." Such changes have critical implications for wheat growers, breeders and food safety specialists.

Santiago Mideros

In 2016, Mideros and his team surveyed the diversity of the FHB causal agent on soft red winter wheat in Illinois. They collected naturally infected heads from five wheat lines with differing levels of resistance, in five locations. They found that 10% of the isolates causing FHB were not *F. graminearum*. Among that 10% were six cases of *F. acuminatum* and five cases of *F. armeniacum*, along with two of *F. reticulatum* and one of *F. circinatum*.

The U of I group used field pathogenomics to rapidly establish the population structure of the selected isolates and explore the differences in transcription on wheat lines with different resistance levels. "The population structure of isolates from different resistance level sources was the same — all belonging to the NA1 population," Mideros reported. "However, we found differential gene expression among strains causing disease on wheat lines with different resistance levels."

Several candidate genes were identified for both (1) *F. graminearum* infection specific to the level of host resistance and (2) candidate genes always required for wheat infection. In addition, "We found that isolates from the resistant wheat line have variable aggressiveness levels," Mideros observed. "However, isolates from the susceptible wheat line were all aggressive." The team is currently researching differences in aggressiveness on a larger population of *F. graminearum* isolates. ✦

— 2020 FHB Forum —

Fungicide & Integrated Management Trials In N.D. Barley — Seven Years of Data

Andrew Friskop, cereal crops extension pathologist with North Dakota State University, delivered a seven-year review of fungicide and integrated management trials in spring barley to the 2020 National FHB Forum audience.

Researchers stationed at the main NDSU campus in Fargo and at three research/extension centers collaborated on this research from 2014 through 2020 under Friskop's guidance. This USWBSI-funded effort generated data from 27 field trials, answering important questions regarding fungicide efficacy, fungicide timing and fungicide performance across two-row and six-row varieties.

The seven years of data can be broken down into three research objectives. Friskop explained.

• Research conducted in 2014 and 2015 assessed efficacy of demethylation inhibitor fungicides (DMI/triazoles) and the value of post-heading applications of fungicides. Results indicated that both Caramba and Prosaro provided deoxynivalenol (DON) control of 48-58%. With regard to timing of an application, results indicated similar levels of DON control were achieved when a fungicide was applied at full head or up to five days after full head emergence. "The results of these trials have expanded our current understanding of fungicide timing and have provided evidence for a wider window for the effective application of a triazole fungicide," Friskop stated. He also noted that greater suppression of DON was often achieved when a less-susceptible two-row or six-row variety was used.

• Research in 2016 and 2017 examined the use of sequential fungicide (double) applications during the heading process of barley. The research assessed these double fungicide programs across six two-row and six-row spring barley varieties. The research results indicated that application of Prosaro at full head followed by Caramba three to seven days later provided 35-38% more DON control than a single application of Prosaro at full head. A similar trend (55-57%) was observed with a Proline application at full head followed by Folicur (or generic tebuconazole) three to seven days later. Research results indicated that a double fungicide application tended to provide more suppression, but a more-thorough economic analysis is needed to justify feasibility, Friskop noted.

Andrew Friskop

• During the three-year time span of 2018 to 2020, a heavy emphasis was placed on the efficacy and timing of Miravis Ace, the new pre-mix fungicide containing a succinate dehydrogenase inhibitor (SDHI) and DMI. Across both efficacy and timing trials, Friskop indicated that Miravis Ace performed similarly to Prosaro and Caramba on spring barley.

"The biggest take-home message was when to apply Miravis Ace," he related. "Research examined three application timings of Miravis Ace, including half-head, full-head or three to five days after full head emergence.

"The greatest amount of DON control was achieved when a single application of Miravis Ace was applied at full-head or up to three to five days after full-head. Similar to what was observed in 2014-2015, an application of Prosaro or Miravis Ace at three to five days after full-head provided the greatest amount of DON suppression." ✦

Recent Peer-Reviewed Scab-Related Publications

Fulcher, M.R., J.B. Winans, and G.C. Bergstrom. 2021. Fusarium graminearum isolates obtained from wheat and wild grasses in northeastern New York display comparable range of phenotypes, including virulence on crop hosts. J. Plant Pathol. https://doi.org/10.1007/s42161-020-00717-w

Springer Nature SharedIT view only link: https://rdcu.be/cdDyW

Fulcher, M.R., J.B.Winans, D. Benscher, M.E. Sorrells, and G.C. Bergstrom. 2021. Triticum varieties grown as 'ancient grains' in New York differ in susceptibility to Fusarium head blight and harbor different Fusarium flora. Eur. J. Plant Pathol. https://doi.org/10.1007/s10658-020-02183-7

Springer Nature SharedIT view only link: https://rdcu.be/cdAKa

Su, W.-H.; Zhang, J.; Yang, C.; Page, R.; Szinyei, T.; Hirsch, C.D.; Steffenson, B.J. Automatic Evaluation of Wheat Resistance to Fusarium Head Blight Using Dual Mask-RCNN Deep Learning Frameworks in Computer Vision. Remote Sens. 2021, 13, 26.*

Wen-Hao Su, Ce Yang, Yanhong Dong, Ryan Johnson, Rae Page, Tamas Szinyei, Cory D. Hirsch, Brian J. Steffenson, Hyperspectral imaging and improved feature variable selection for automated determination of deoxynivalenol in various genetic lines of barley kernels for resistance screening, Food Chemistry, Volume 343, 2021, 128507, ISSN 0308-8146, https://doi.org/10.1016/j.foodchem.2020.128507.*

— 2020 FHB Forum —

Spray Equipment & Fungicide Deposition

Erdal Ozkan, agricultural engineering professor with The Ohio State University, provided 2020 Forum listeners an overview of the influence of application equipment on protecting wheat against diseases — including Fusarium Head Blight.

A variety of factors influence the efficacy of pest control in crop protection, he noted, among them: choice of pesticide, choice of application equipment, proper calibration and operation of equipment, weather conditions (before, during and after treatment) and, timing of application.

Ozkan said the most common question he is asked by producers and commercial applicators is, *"What is the best nozzle I can put on my sprayer?"* That depends on the crop being sprayed and the application objective, he said, noting that nozzle catalogs commonly provide details on the type of nozzle best suited for a given application type. For example, a nozzle rated as best for application of all contact-type pesticides (herbicides, fungicides, insecticides) may be the best nozzle type when spraying a contact-type fungicide to control scab in wheat, but will not necessarily be the best when spraying a contact-type herbicide for aphid control in soybeans.

There are plenty of key questions not answered by the manufacturers of spraying equipment and pesticides, Ozkan pointed out. For instance:

- How to achieve "uniform coverage"?
- What is the recommended "percent coverage"?
- How much pesticide deposit is required for adequate control of the pest?
- How do target canopy characteristics influence pesticide deposition and coverage on specific parts of the plant?
- Does the choice of nozzle or droplet size affect biological efficacy?
- Does spraying with air assistance improve deposition and coverage?

Two multi-year OSU studies addressed some of those key questions, with the overall goal of providing Ohio wheat producers with recommendations on the selection of application equipment for effective treatment of various wheat diseases. In the first study, conducted at the OSU research center at Hoytville (northwestern Ohio), the researchers sought to determine the influence of spray quality, nozzle type and nozzle configuration on penetration of droplets into the wheat canopy, and uniformity of spray distribution on various plant parts using water sensitive papers as artificial targets inserted in plant canopy at different heights. In the second study, conducted at OSU-Wooster (northeastern Ohio), investigators had a similar objective — but employed more treatments (*i.e.,* nozzles, and air-assisted sprayer) and collected actual plant parts in addition to water-sensitive papers.

Erdal Ozkan

After a discussion of the various nozzle types and experiment treatments used in the two studies, Ozkan reported that when it came to the mean percent spray coverage, there was significant variance among the three main target areas. Specifically, for "vertical" targets (plant heads), plant coverage ranged from 5 to 15%; for "horizontal top" (flag leaf) targets, coverage ranted from 18 to 35%; and, for "horizontal middle" targets, the plant coverage ranted between 8 to 28%.

Which spray quality — fine or medium — provided better coverage when using single-flow nozzles? Three years of comparison told the OSU research group that for "vertical" coverage, there was no significant difference, although medium was slightly better. For "horizontal top" coverage and "horizontal middle," there was no significant difference. When spraying with air assistance, a fine spray produced significantly higher coverage than medium or coarse, regardless of plant part.

The OSU studies' results showed that nozzles with twin-fan spray patterns had higher spray coverage than single-flow pattern nozzles on vertical targets representing the wheat head. However, single-flow nozzles produced slightly higher coverage on horizontal top and horizontal middle targets than did the twin-flow nozzles.

A few concluding questions/answers:

- *Does spray quality (fine, medium or coarse) matter when it comes to product deposition?* No, if the disease is on the wheat head (*e.g.*, scab).
- *When there is no air assistance, does spray angle matter?* Yes. Forward orientation is significantly better for head coverage — and 60 degrees is significantly better than a 30-degree forward orientation. There is generally lower deposition and coverage on other plant parts when using angled spray; and, the greater the angle, the lower the coverage and deposition on plant leaves.
- *Does fan speed setting when using the air-assisted sprayer matter in coverage?* Yes, if the disease is on the wheat head (scab) or on the flag leaf. Faster fan speeds tended to produce higher coverage on the head and flag leaf targets. The study showed no statistical difference, however, between "no air" and "air assisted" for flag leaf+1.
- *When using the air-assisted sprayer, does fan speed setting matter when it comes to product deposition?* Not if the disease is on the wheat head; but yes for the other plant parts.

Since there seems to be no clear advantage to using "fine" spray quality, Ozkan said nozzles producing "medium" spray quality should be used — especially when spray drift is a concern.

Finally, the OSU ag engineer recommended producers have plenty of nozzle types and sizes on the spray boom — and then switch to the nozzle best suited for the particular application conditions and target canopy characteristics. ✦

— 2020 FHB Forum —

Malting Barley for N.E. Craft Beverage Markets: The FHB Effect

Malting barley production has experienced a "rebirth" in New York state during the past decade, as craft brewing has exploded in popularity. But the state's malt barley sector has confronted — and continues to confront — a Public Enemy #1: Fusarium Head Blight (scab) and resulting DON toxins.

Cornell University plant pathologist Gary Bergstrom has been on the front lines of the battle with scab. He provided an update in his 2020 National FHB Forum virtual presentation, "Local Malting Barley for Northeast Craft Beverage Markets: What's FHB Got to Do With It?"

Commercial barley field surveys in New York across the past seven years have shown significant variation in the percentage of barley grain lots making malt grade for DON (<1.0 ppm), germ (> 95% within 72 hours) and protein (9.5-12.5%); but the trend has been toward more lots making grade, Bergstrom reported, as growers implement research-derived disease and crop management practices. At the outset of malting barley research in New York, only half or fewer of commercial lots had less than 1.0 ppm DON, whereas more than 90% have met the DON standard over the past three growing seasons.

Gary Bergstrom

Why is DON so threatening in malting barley? Bergstrom reminded his virtual Forum audience that unacceptable levels of DON cause problems both in terms of consumer safety and public perception. "Beer gushing" is caused by hydrophobins produced by *Fusarium* as well as other fungal species. And in distilling, while DON is not transferred to distillate, it does remain in the spent mash.

Normally, DON decreases in the malting steep and remains low in the finished malt. However, Bergstrom noted, "DON levels in more heavily infected samples generally will not be reduced to satisfactory levels by steeping; and/or viable *Fusarium* present at high incidence in kernels will produce more DON during the germination process."

A 2018-19 study by Cornell graduate student Andrea Lugo-Torres found that commercial barley grain lots had lower average DON levels — but, higher NIV (nivalenol) — in the very dry year than in the more-normal year. All but two of the commercial barley lots maintained individual mycotoxins below 1.0 ppm; yet the total trichothecene load exceeded 1.0 ppm in some lots. Lugo-Torres reported that 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), and that *F. graminearum* DNA content in grain was correlated with DON in finished malts in both years of her study.

Fifteen barley diseases — head and leaf — have been diagnosed in New York state since 2014, Bergstrom said. He showed a series of charts outlining levels of several key diseases (including FHB) in both spring and winter malting barley integrated management trials in 2017 and 2018, along with resistance levels shown by several commercial barley cultivars.

Bergstrom's Forum presentation also recapped progress made by the Cornell barley FHB resistance breeding program, led by Mark Sorrells. Two-row spring malting barley breeding was initiated in 2016, followed by two-row winter barley in 2018. Breeding of winter multi-use barley followed. More than 1,300 lines of spring malting barley were being tested at two locations as of 2017, with 100 select lines in 2018 and 60 select lines in 2019, both in five locations. That was followed by a foundation seed increase in 2020 — and the release of the variety CU-31 (which was named "Excelsior Gold" in December 2020).

Bergstrom concluded his presentation with a list of recommendations for New York barley producers for the integrated management of diseases and mycotoxins. Among them:

- Plant barley following a soybean or vegetable crop; not after corn, small grain, hay or fallow with grasses.
- Choose a 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 seven days later.
- Employ additional fungicide application (mixed mode of action best) prior to flag leaf emergence, if warranted by early season foliar diseases or susceptibility of variety. ✦

Proceedings of the 2020 National FHB Forum

and

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https://scabusa.org/forum2020

— 2020 FHB Forum —

Durum FHB Resistance: Austrian Update

Speaking virtually from Austria, Barbara Steiner updated 2020 FHB Forum participants on her team's research activities on the development of Fusarium resistance in durum wheat. Steiner is senior scientist with the BOKU-University of Natural Resources and Life Sciences, Vienna.

Steiner pointed out that breeding for FHB resistance in durum is hampered by the limited variation in the elite gene pool and by difficulties in efficiently combining the numerous often-small-effect resistance QTL in the same breeding line. Thus, she said, "introgressing resistance alleles from wild and cultivated relatives is a promising approach to broaden the genetic basis for FHB resistance in durum wheat."

Barbara Steiner

In that regard, the BOKU team evaluated several durum population that were derived from crosses with such relatives, as well as additional collections of tetraploid wheat. They investigated the genetic architecture of FHB resistance, the role of morphological and phenological traits as passive resistance factors — and, as well, the potential for harnessing the merit of this germplasm by genomic-assisted breeding.

The Austrian team looked at 1,000 experimental lines with resistance alleles derived from *T. aestivum*, *T. dicoccoides* and *T. dicoccum*, plus another panel of 220 elite durum wheat cultivars from an international collection. Additionally, 320 lines of the global durum and tetraploid wheat collections were phenotyped — for up to four years — for FHB resistance, plant height and anthesis date. A subset of the materials was also evaluated for the extent of retained anthers after flowering.

"Although a lack of highly resistant lines was evident for all populations, a broad variation was found for all investigated traits," Steiner reported, "including many moderately FHB-resistant experimental lines and landraces." Plant height influenced FHB resistance levels and led to co-localization of plant height and resistance QTL, she noted, while the height-independent major resistance QTL *Fhb1*, derived from hexaploid wheat, was successfully introgressed into several durum genetic backgrounds.

Interestingly, Steiner added, a major height-independent QTL also mapped close to *Fhb1* in the elite durum wheat gene pool — though haplotype analysis highlighted the distinctiveness of both QTL.

"Although the variation and extent of anther extrusion is lower in durum wheat compared to hexaploid wheat, crosses of a durum wheat cultivar exhibiting higher anther extrusion revealed a broad variation for this trait and a significant association with FHB resistance," Steiner continued. "Anther retention thus also has "the potential to serve as a secondary trait in multivariate genomic prediction models to enable an earlier identification of the most promising lines." That can result in "a much faster short-term population improvement, complementing long-term strategies with exotic resistance donors for achieving higher levels of resistance." ✦

Miravis®Ace: An Ohio Research Report

Pierce Paul, plant pathologist with The Ohio State University, Wooster, presented FHB Forum attendees with a 2020 update on the use of fungicides and integrated management for the control of scab and vomitoxin (DON) in wheat. A large part of his presentation focused on the newest addition to the scab fungicide arsenal: Maravis®Ace from Syngenta.

Pierce Paul

Paul noted that Miravis Ace is labeled for application for FHB management at Feekes 10.3 through 10.5 stages. If just as effective against scab at 10.3 as it is at 10.5, that would carry a definite benefit: the expansion of the fungicide's application window.

The first portion of Paul's report focused on three years of tests (2018-2020) comparing Miravis Ace with Prosaro and Caramba for the control of Fusarium Head Blight and DON. The testing encompassed 47 environments. The second portion of the report discussed the effect of fungicide x genetic resistance on FHB and covered 60 environments across those same three years. Finally, the third portion looked at timing of fungicide application x genetic resistance and the resulting impact on DON levels.

Paul made several points in summarizing this research:

- Both pre- and post-anthesis treatments were effective at reducing FHB.
- Miravis Ace was just as effective against FHB and DON as Caramba or Prosaro when applied at anthesis.
- Efficacy of Miravis Ace was comparable between anthesis and late applications but was less consistent with early heading application.
- Two-treatments programs — an anthesis application of Miravis Ace followed by an application of Caramba, Prosaro or Folicur four to six days later — led to the greatest reduction in DON.
- Sequential application of Miravis and a DMI fungicide to a moderately resistant cultivar resulted in the highest levels of FHB and DON control. ✦

— 2020 FHB Forum —

Novel Sources of FHB Resistance From Wild Wheat Relatives

"Novel Sources of Fusarium Head Blight Resistance Derived from Wild Wheat Relatives" was the title for Bernd Friebe's virtual presentation during the 2020 FHB Forum. Friebe is research plant pathologist with Kansas State University.

There is limited FHB resistance present in the primary and secondary gene pool of wheat, Friebe noted, with only seven FHB resistance genes having been named to date, of which three — *Fhb3*, *Fhb6* and *Fhb7* — were derived from the tertiary gene pool.

Fhb6 was derived from *Elymus tsukushiensis*. Field evaluation of BC1F6 Fhb6 introgressions into Lyman and Overland backgrounds during 2019 and 2020 showed FHB incidence ranging from 80 down to 30%. This compared to 80% with both Lyman and Overland in both years. DON in Lyman/*Fhb6* – RF19FH032, in 2018/19 and 2019/20 samples at KSU's Manhattan scab nursery, measured 11.7 ppm, compared a rating of 12.7 ppm for Lyman. With Overland, two *Fhb6* introgressions measured 10.2 ppm and 12.6 ppm DON, respectively. That compared to the "straight Overland" measurement of 22.7 ppm.

Bernd Friebe

Friebe also reported on HSD2-32, an F7 derivative of Ganmei8 produced at Harbin Normal University, China. HSD2-32 has 2n=42 chromosomes, but its genetic constitution remains unknown. Friebe and his KSU colleagues have performed point inoculation of HSD2-32 with Overley and Everest wheat, and are continuing to backcross HSD2-32 into adapted winter wheat cultivators.

Future work by the KSU group includes: (1) evaluating backcross progenies under greenhouse and field conditions for FHB resistance and DON accumulation; (2) utilizing molecular marker analysis to determine sources of FHB resistance, and (3) initiating directed chromosome engineering to produce agronomically useful introgression lines. ✦

Magnusson New Stakeholder Co-Chair

Effective January 1, Roseau, Minn., wheat producer Richard Magnusson became the stakeholder co-chair of the U.S. Wheat & Barley Scab Initiative. He replaced Doyle Lentz of Rolla, N.D., who had served in that capacity for the past five years.

Magnusson comes from a long family tradition of farming and seed production in the Roseau area. He began farming while in high school, trading his labor for the use of equipment. He then attended the University of Minnesota-Crookston and North Dakota State University, earning a degree in agronomy. After college, he returned to the family farm and entered into partnership with father Yvonne and brothers John and Robert. He currently farms in partnership with nephews Aaron and Matthew.

The Magnusson Roseau County operation produces a diversified crop mix, with an emphasis on seed production. Seed crops include wheat, soybeans, sunflower, canola, flax, Kentucky bluegrass, perennial ryegrass, timothy, Kernza, reed canary grass and several native species.

Richard Magnusson

A longtime member of commodity groups, Magnusson is a former chairman of both the Minnesota Association of Wheat Growers and the Minnesota Wheat Research and Promotion Council. He also has served on the board of the National Association of Wheat Growers. In 2013 Magnusson was recognized with the Minnesota Crop Improvement Association's highest honor, the Achievement in Crop Improvement Award.

Magnusson says he is excited to serve as co-chair of USWBSI and has a heartfelt connection to scab problems that have affected growers across the country. "In 1993, we burned our entire wheat crop and struggled to find a markets for our barley crop, due to the severe scab outbreak in northern Minnesota," he recounts.

Ruth Dill-Macky, researcher co-chair of the USWBSI, paid tribute to Lentz for his contributions and welcomed Richard Magnusson to the Initiative. "Doyle served one term as stakeholder co-chair, during which he was instrumental in securing an additional $5.55 million increase in funding in Fiscal Year 2020. That brought total funding for scab research to the fully authorized (per the Agriculture Improvement Act of 2018) amount of $15 million," Dill-Macky notes. "The USWBSI greatly appreciates Doyle for his service to the Initiative, and we look forward to working with new co-chair Richard Magnusson." ✦

— 2020 FHB Forum —

Sampling & Sample Preparation for Testing Cereals for DON
— Insights & Protocol from CGC's Winnipeg Lab —

Sheryl Tittlemier serves as program manager-grain safety with the Canadian Grain Commission's Winnipeg Grain Research Laboratory. In her remarks to 2020 FHB Forum participants, she provided insight on sampling and sample preparation for testing cereals for deoxynivalenol (DON).

Among the most challenging aspects of measuring DON in bulk wheat, Tittlenier affirmed, is the high variability that can occur. Numerous studies have confirmed this variability among drawn grain samples. There's also, she added, the variability that can occur within a given wheat field — and among individual kernels.

How can the source of this variability best be identified? Is it due to sampling volume and procedure . . . to sample processing . . . or to analytical technology and methodology?

Sheryl Tittlemier

Back in 2000, researchers at North Carolina State University addressed that very question. Tittlemier's CGC lab did so again in 2019. The 2000 study reported DON test result variance 10 times that of the total variance found in the 2019 study. In 2000, sample preparation was, by far, the main "culprit" in terms of contributing the most to total variance of DON test results in wheat. In 2019, the initial sampling step carried that designation — although, as stated, total variance was much lower than in the 2000 North Carolina study.

How can DON test result variance be reduced? The 2019 CGC study suggested three main components: increase sample size, decrease particle sizes and increase the precision of the test method. In the 2000 study, the lab sample was 0.454 kg; in the 2019 study, it was 1.0 kg. The grinder used in 2000 was a burr mill; in 2019, it was a rotor beater. Test method in 2000 was ELISA; in 2019, it was GC-MS. And again, as noted, variance in 2019 was just 1/10th of that found in the 2000 study.

To maximize sample representativeness, CGC protocol calls for (1) taking increments to prepare composite samples, (2) using proper tools and procedures when sampling and dividing, and (3) optimizing sample size. Sufficient grinding reduces distributional heterogeneity, Tittlemier emphasized. "Use proper tools and procedures when mixing and dividing whole grain," she added. "Shaking or hand mixing is not a good procedure!"

Minimizing DON test result variance minimizes the uncertainty of what the true value actually is, Tittlemier concluded, adding that the cost of achieving that objective (time, equipment, etc.) likewise needs to be balanced with the benefit of a reduction in the variance.

Tittlemier also encouraged the FHB community to review the CGC sampling guide "as one source of guidance on taking a representative sample of grain." It can be viewed at: https://www.grainscanada.gc.ca/en/grain-quality/sampling-grain/guide-taking-representative-sample/ ✦

Fusarium Focus

Fusarium Focus *is an online newsletter published periodically by the U.S. Wheat & Barley Scab Initiative. The USWBSI is a national multi-disciplinary and multi-institutional research system whose goal is to develop as quickly as possible effective control measures that minimize the threat of Fusarium Head Blight (scab), including the production of mycotoxins, for producers, processors and consumers of wheat and barley. Contact information is as follows:*

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