



Fusarium Focus

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2014 National FHB Forum Attracts 185

Approximately 185 scientists, growers and wheat and barley industry representatives traveled to St. Louis in early December for the 2014 National Fusarium Head Blight Forum. The 17th FHB Forum took place at the Hyatt Regency St. Louis at the Arch.

The event featured stakeholder and scientific invited speaker presentations, along with focused group discussions and various social events for attendee interaction.

Numerous research posters were on display as well, with primary authors present to discuss the projects and their findings. Also, for the second year, a number of graduate students participated in “Flash & Dash” sessions in which they provided mini-oral presentations on research posters they had at the Forum.

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

The 2015 National Head Blight Forum will be held at the same location: the Hyatt Regency St. Louis at the Arch. Dates for the event are December 6-8.

The following pages contain photos and talk summaries from several invited



speaker presentations at the 2014 FHB Forum. PDF copies of the following presentations are posted on the USWBSI’s website — www.scabusa.org — as is a copy of the full Forum Proceedings:

- *Effect of Glyphosate on Fusarium Head Blight in Wheat and Barley Under Different Soil Tillages in Eastern Canada* / Marie-Eve Bérubé, Environment Ministry of Quebec.
- *Fungicide Resistance in Fusarium graminearum* / Yiping Hou, Nanjing Agricultural University, China.
- *Identification of New QTLs for Native Resistance to FHB* / Subas Malla, Virginia Tech., Blacksburg.
- *Developing Transgenic Wheat and Barley That Exhibit Resistance to Fusarium graminearum via Glucoside Conjugation of Trichothecene Mycotoxins* / Gary Muehlbauer, University of

Minnesota, St. Paul.

- *A Producer’s Perspective and Recent Concerns with Fusarium Head Blight* / Laird Larson, Clark, S.D.

- *Triazole Sensitivity in Populations of Fusarium graminearum: Preliminary Findings, Needed Research and Implications for Management* / Gary Bergstrom, Cornell University, Ithaca, N.Y.

- *Host-Induced Gene Silencing (HIGS) to Engineer Resistance to FHB* / Karl-Heinz Kogel, Justus Liebig University Giessen, Germany.

- *Meta-analysis of 19 Years of Fungicide Trials for the Control of Fusarium Head Blight of Wheat* / Larry Madden, Ohio State University, Wooster.

- *Using Marker-Assisted Selection to Improve Hard Winter Wheat FHB Resistance* / Guihua Bai, USDA-ARS, Manhattan, Kan.

- *New Tricks of an Old Enemy: Isolates of Fusarium graminearum Produce a Novel Type A Trichothecene Mycotoxin* / Gerhard Adam, University of Natural Resources & Life Sciences, Tulln, Austria.

- *Chromosome Engineering and Next Generation Sequencing Assisted Transfer and Deployment of Alien Grass Species Resistance to FHB in Wheat* / Bikram Gill, Kansas State University, Manhattan.

- *Ground vs. Aerial Application of Fungicide Applications* / David Hooker, University of Guelph, Ridgetown, Ont.

- *Genotyping by Sequencing for Footprints of Selection in Fusarium graminearum* / Chris Toomajian, Kansas State University, Manhattan.

- *Using Near-Infrared Spectroscopy to Select for Resistance to FHB* / Floyd Dowell, USDA-ARS, Manhattan, Kan. ❖



— 2014 FHB Forum —

Don Mennel's keynote presentation at the 2014 National FHB Forum caught the audience's attention even before he began speaking. The attention getter was its mysterious title: "Deoxynivalenol: Sisyphus or Simple Sudoku?"

By way of explanation, Sisyphus was the king in Greek mythology punished for his chronic deceitfulness by being compelled to roll a huge boulder up a hill, only to watch it roll back down — and then having to repeat the process forever. While that would seem a miserable way to spend eternity, 20th century French philosopher Albert Camus concluded that "one must imagine Sisyphus happy" since "the struggle itself towards the heights is enough to fill a man's heart."

Sudoku, of course, is the very popular logic-based, combinatorial number placement puzzle. In Sudoku, there exists that "aha" moment when one finds the right number for the right square, and the rest of the puzzle then falls into place.

So, how do Sisyphus and Sudoku pertain to deoxynivalenol (DON)? Mennel, who is chairman of Fostoria, Ohio-based Mennel Milling Company, made the connection with these questions/comments:

- *Re: Sisyphus* — "Have we, as researchers, become complacent and dependent upon the monies provided by the Scab Initiative to fund our labs year in and year out? Are we content to go to work every day knowing that we have job security and that we will have 'a boulder to roll up the hill every day?' And, is this really satisfaction?"

- *Re: Sudoku* — "We are still seeking that 'aha' moment with regard to solving the puzzle regarding deoxynivalenol."

Mennel Milling operates five flour mills and 10 country grain elevators in five states (Ohio, Michigan, Illinois, Indiana and Virginia). "Over the past five years, we have been challenged with vomitoxin in our wheat in at least



one location each and every year," its chairman noted. The U.S. Food and Drug Administration presently allows up to one (1) part per million of DON in flour. The European Union has established significantly lower DON limits, however, and is hoping to impose those more-stringent limits elsewhere, accelerating this process through upcoming hearings of Codex, the United Nations- and World Health Organization-sponsored agency that sets international food standards, guidelines and codes of practice.

The U.S. grain elevator industry is able to deal with wheat having DON levels above 1.0 ppm by blending it off with lower-DON grains. That obviously would become more difficult should the EU standards be adopted. "For this reason, the grain trade is adamantly opposed to the Codex hearings," Mennel noted. "Codex does not allow blending of vomitoxin-contaminated grains. Thus, the vomitoxin-contaminated grain [would need] to be removed at the point of origin or in the grain field."

While they are harvesting, wheat producers can directly affect the amount of contaminated grain by turning up the air on the combine and blowing out the lighter DON-infected kernels. Given the current ability to blend, though, there often is no economic incentive for producers to do so, Mennel noted.

"However, what if the grower could measure the level of 'vom' in his wheat at the combine — and adjust the combine for the most opportunistic setting for the marketing of his grain?" he asked.

That's just one example of how the overall problem of DON in wheat can be confronted. But "to win this battle, we need to utilize all of the weapons in our arsenal," Mennel emphasized. "We need to promote only those wheat varieties that are resistant to Fusarium Head Blight. We cannot afford to release susceptible varieties — even if they are high-yielding varieties.

"We need to promote the use of fungicides," he continued "We need to discourage the planting of wheat after corn. And we need to do more research in the area of how to set the combines for the proper removal of contaminated wheat at the farm.

"We have the tools to help the growers and to enable them to calculate their costs and their returns on investment. There is more risk to growing wheat and barley" under the threat of FHB and DON, Mennel stated. To keep the production of these grains at adequate levels, growers need to be fully informed and adequately rewarded.

The Ohio miller told the FHB Forum audience that his company annually publishes a list of preferred wheat varieties for its growers. Along with excellent yield capacity (both in the field and at the mill), good baking quality, uniformity in size and resistance to sprouting, these preferred varieties all have at least moderate resistance to scab.

"We don't want wheat to become a crop that is grown only by contract," Mennel stated. "But if that is where we have to go, we will. We are committed to flour milling and would really like to see the eradication of this disease — though like so many others, we have proven how difficult that is.

"Perhaps we will someday move this Sisyphean task to Simple Sudoku and solve this elaborate puzzle." ❖



— 2014 FHB Forum —

Fusarium Head Blight affects no one more directly — or profoundly — than those wheat and barley producers whose crops are threatened by this disease. And, no one stands to benefit more from research advances made in the avoidance or control of scab.

So while scientists comprised most of the speaker roster at the 2014 National FHB Forum, it was appropriate — and important — for the audience to likewise hear from **Laird Larson**.

Larson has farmed near Clark, S.D., for more than four decades. A former chairman of the South Dakota Wheat Commission and the South Dakota Crop Improvement Association — and a current member of the USWBSI Steering Committee — Larson spoke to Forum attendees on the subject, “A Producer’s Perspective and Recent Concerns with Fusarium Head Blight.”

He began by displaying an image containing the terms “FHB,” “Deoxynivalenol,” “Fusarium Head Blight,” “Vomitoxin” and “Scab.” The South Dakota wheat producer told his audience, “This slide means something to each of you; but to a wheat or barley producer, it means . . . **Discounts!**” Grain quality discounts, such as those for vomitoxin, can and often do have a significant effect on the impacted farming operation’s bottom line, he reminded the audience.

While lots of very useful information on scab management is available to producers, ample communication by those who generate that information is paramount, Larson stated. The major-



ity of farmers use crop consultants and/or local agronomists to help them keep up with new research; but it’s [also] important for the scab research community to make an extra effort to “get the word out” to their grower constituencies, he stressed. “The coffee shop table is where much knowledge transfers. Maybe everyone here should make it a priority to visit a farm community coffee shop,” Larson mused. “Buy a round of coffee and introduce yourself as a scab research person. Information will begin to flow.” In his home state, cuts to university extension programs have not aided the flow of information from research to farm, he added.

“I am convinced that in Minnesota, North Dakota and South Dakota, scab resistance is a high priority in our breeding programs,” Larson continued. “[But] maybe more emphasis needs to be placed as well on varietal selections for DON resistance.”

One of the pragmatic on-farm challenges in managing scab, Larson noted, comes in the timeliness of fungicide application. With about one million acres of spring wheat planted in South Dakota each year, “there are not enough planes to spray every acre” on a timely basis in years of wide-

spread scab infection. That’s a particular issue in years when ground spray rigs struggle to get product applied due to unfavorable field conditions (e.g., excessive soil moisture).

Larson also reminded his audience that the primary purpose of a grain combine is to separate straw from seeds. “Our job is to harvest all the yield we can,” he stated. “Don’t tell me to turn up the wind on the combine to get a better seed sample, because I’ll lose too much good seed.”

While the South Dakota producer lauded the tools that are available today to react to and deal with Fusarium Head Blight and DON, “there’s still more room for improvement,” he observed. “When we get hit with a major outbreak, farmers still don’t know what to do. Don’t dwell on sayings like, ‘Turn up the wind’ and ‘Should not have planted on corn stalks,’” he encouraged. “We have increased yields in the presence of scab and learned how to better manage the problem. Now, what can we do with high DON levels?”

“We don’t need reasons to not grow wheat, *i.e.*, that it’s too complicated or has too many discounts.” ❖

Mark Your Calendar!

2015 National FHB Forum

December 6-8

**Hyatt Regency
St. Louis at the Arch
St. Louis, Mo.**

**2014
National FHB Forum
Photo Credits:**

**Dave Hane
USDA-ARS, Albany, Calif.**



— 2014 FHB Forum —

Larry Madden covered a lot of ground in his presentation at the 2014 National FHB Forum — nearly two decades, to be exact. “Meta-Analysis of 19 Years of Fungicide Trials for the Control of Fusarium Head Blight of Wheat” was the topic addressed by the Ohio State University-Wooster plant pathologist.

Madden noted that as of 20 years ago, there was considerable skepticism that Fusarium Head Blight could be controlled with fungicides. Still, that prospect led, as of the late 1990s, to the establishment of the Uniform Fungicide Trials (UFT) by the recently formed U.S. Wheat & Barley Scab Initiative. “Initially, the studies focused on the use of propiconazole (Tilt) or tebuconazole (Folicur) for reducing FHB index and DON,” Madden recounted. “In the 2000s, other DMI-active ingredients such as prothioconazole, metconazole and mixtures of actives such as tebuconazole + prothioconazole were added to the collection of fungicides being tested.” Some were tested as experimental products prior to being registered and

given trade names such as Proline®, Caramba® and Prosaro®; others were tested in only a small number of trials.

“Preliminary analyses were based on qualitative or ad hoc syntheses of the conducted trials,” Madden explained. Later, he, OSU colleague Pierce Paul and others performed quantitative research syntheses of the trials, with their meta-analyses based on trials conducted through 2005 (for FHB index and DON) and through 2007 (for yield and test weight).

“Overall, Proline, Caramba and Prosaro applied at anthesis performed much better than the other tested fungicides,” Madden noted, “and there were only minor differences in efficacy among these three.”

Still, mean percent control (percent reduction relative to the untreated control) was typically only 50% for index and 40% for DON for the best treatments. For that reason, the UFTs have been continued to: (1) determine the stability of efficacy and economics of these fungicides under a wide range of environments, (2) explore alternative fungicide treatments that may

result in higher percent control, especially for DON, and (3) allow greater flexibility in terms of the application timing.

Also, new treatments included: (1) other mixtures of triazole fungicides applied at anthesis (typically as tank mixes), (2) different timings of the best triazoles (before, at or after anthesis), (3) strobilurin fungicides (especially pyraclostrobin — Headline — applied at different times, or (4) combinations of Headline early and a triazole at anthesis.

The full data set analyzed consisted of 309 trials, from 1995 through 2013; 27 separate treatments were included as having been tested in a sufficient number of trials for the meta-analysis, according to Madden. “Trials were conducted in up to 12 states per year.

“A multivariate meta-analysis showed large variability in percent control for the different treatments, and none of the new treatments provided significantly better control of FHB index and DON than the original three treatments (Proline, Caramba and Prosaro) applied at anthesis,” the OSU plant pathologist reported. “Percent control for these three treatments remained generally stable over time, although treatment efficacy for FHB index declined somewhat for spring wheat relative to winter wheat,” Madden said.

In summary, the meta-analysis covering 19 years of fungicide trials showed “the best triazole fungicides applied at anthesis, or shortly thereafter, either alone or as a mixture, provide significant levels of control of index and DON,” Madden reported. However, “there is no evidence that substantially higher levels of control can be achieved with a single fungicide application without coupling this with other integrated control tactics.” Additional analysis is needed to characterize the impact of all the fungicide treatments, he added — especially for yield and test weight. ❖



Above: The poster sessions once again were a popular gathering venue at the National FHB Forum, with most authors present for questions and discussion. Several graduate students piqued interest in their posters by presenting mini-talks about their research at “Flash & Dash” sessions leading up to the poster sessions.



— 2014 FHB Forum —

Guihua Bai, director of the USDA Central Small Grain Genotyping Center at Kansas State University and KSU professor of agronomy, reported on research using marker-assisted selection to improve hard winter wheat (HWW) FHB resistance. He noted that while different sources — including some from Great Plains HWW — have provided quantitative trait loci (QTL) for FHB resistance, the best resistance to date has come from certain Chinese land races. To identify and validate these QTL, researchers constructed a consensus map of five mapping populations, with Chinese landraces as resistant parents, using genotyping-by-sequencing (GBS) generated single nucleotide polymorphism (SNP) markers.

“Among QTL identified, *Fhb1* is the QTL with the largest effect across the populations,” Bai noted. “By screening recombinants in *Fhb1* region using a

large segregation population derived from Ning7840/Clark through marker-assisted backcross, a small fragment cosegregating with *Fhb1* were identified.” Markers from that region were then developed for marker-assisted selection. Since *Fhb1* is not present in Great Plains HWW cultivars, the research team developed a marker-assisted backcross project to transfer *Fhb1* to U.S.-adapted HWW backgrounds.

“The lines with *Fhb1* in different U.S. winter wheat backgrounds showing a high level of type II FHB resistance were selected,” Bai continued. To date, *Fhb1* has been transferred to 17 adapted HWW cultivars. Some of the *Fhb1* lines have been used as resistant parents in various breeding programs, while others are in double haploid production and seed increasing stage, and will be distributed to breeding programs for further yield testing. ❖

Marie-Eve Bérubé of the Environment Ministry of Quebec reported on studies she and colleagues had conducted to determine whether the herbicide glyphosate had any effect on the development of Fusarium Head Blight in wheat and barley under various soil tillage regimens. The study was carried out in 2007 and 2008 at two sites in Quebec. Six trials were established at both sites, including both wheat and barley under three tillage systems: moldboard plow, spring tillage (minimum till) and direct drilling (no-till).

For each trials, glyphosate or other herbicides chosen according to weed species were applied as main plot treatments on Roundup Ready® soybeans the year preceding the cereal crops. The following year, three wheat and three barley cultivars were a distinct FHB resistance level were sown in the main herbicide plots (thus constituting the subplots). FHB index, *Fusarium*-damaged kernels (FDK) and deoxynivalenol (DON) content and *F. graminearum* inoculum production were measured at appropriate later dates.

“Glyphosate had no significant effect on FHB index, FDK or DON content,” Bérubé reported, regardless of the trial or site. The researchers noted enhanced *F. graminearum* inoculum production in only one of the 12 trials, and the relation between *F. graminearum* inoculum from soybean residues and DON content was weak.

“Therefore, it seems that glyphosate used on soybean the year preceding wheat or barley crop has no or low impact on FHB development and *F. graminearum* inoculum production under Quebec cropping conditions, whatever the tillage practices used,” she concluded. ❖



Above: Dave Van Sanford (standing), University of Kentucky wheat breeder and co-chair of the U.S. Wheat & Barley Scab Initiative, leads the Northern Soft Winter Wheat breeders-pathologists joint session. Sessions for Hard Winter Wheat, Spring Wheat/Barley/Durum and Southern Soft Winter Wheat took place concurrently.



— 2014 FHB Forum —

Cornell University plant pathologist **Gary Bergstrom** updated FHB Forum participants on “Triazole Sensitivity in Populations of *Fusarium graminearum*: Preliminary Findings, Needed Research and Implications for Management.”

As part of a broader survey effort to assess genetic and phenotypic diversity among contemporary isolates of *Fusarium graminearum* in the state of New York, Bergstrom and colleagues screened 50 isolates for sensitivity to two triazole fungicides, tebuconazole and metconazole. Their objective was to establish a baseline of sensitivity against which future, more-extensive surveys could be referenced.

“One of the 50 isolates was found to be highly resistant to tebuconazole, based on a laboratory determination of EC50 (effective concentration leading to a 50% reduction in mycelial growth) at 8.09 mg/l,” Bergstrom reported. That was not just a “laboratory phenomenon,”



he added, noting that “suppression of FHB and DON was significantly reduced when a commercial rate of tebuconazole was applied to wheat plants inoculated with the resistant isolate, as compared to plants inoculated with a sensitive isolate.”

Bergstrom noted that the tebuconazole-resistant isolate was an outlier

among the 50 screened isolates, “though a wide range of sensitivity, EC50 of 0.28 to 2.5 mg tebuconazole per l, was found among the other 49 isolates.” None of the 50 isolates was resistant to metconazole, and the range of EC50 was narrower (from 0.05 to 0.86 mg/l).

The Cornell pathologist pointed out that to date there has been no documented failure of control of Fusarium Head Blight with tebuconazole — or any other triazole fungicides — in North America. Plus, “a partial reduction in control due to fungicide resistance buildup would be very hard to discern.” He reminded his audience that it’s not uncommon to find low frequencies of fungicide resistance in native fungal populations even prior to exposure to a particular fungicide.

“We suggest that more isolates with resistance at various levels will be found as larger surveys are conducted” in the future, Bergstrom stated. ❖



Left: Coordinated Project Breakouts by research area were held for Barley (the group pictured here), Durum and Hard Winter Wheat, as well as for Variety Development & Host Resistance for each of three regions: Spring Wheat, Northern Soft Winter Wheat and Southern Soft Red Wheat.

Below: FHB Forum photographer Dave Hane, USDA-ARS, Albany, Calif., also updated attendees about the new USWBSI website during a “Flash & Dash” mini-talk. While at the podium, he took the opportunity to snap this panoramic view of his audience.



— 2014 FHB Forum —



Left: Gary Muehlbauer, University of Minnesota, speaks on “Developing Transgenic Wheat and Barley That Exhibit Resistance to *Fusarium graminearum* via Glucoside Conjugation of Trichothecene Mycotoxins.”

Below: Art Brandli, USWBSI co-chair, adjourns the 2014 National FHB Forum.



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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Recent Scab-Related Peer-Reviewed Publications

- Andersen, K. F., Madden, L. V., and Paul, P. A. 2015. Fusarium head blight development and deoxynivalenol accumulation in wheat as influenced by post-anthesis moisture patterns. *Phytopathology*: accepted (*First Look*).
- Andersen, K. F., Morris, L., Derksen, R.C., Madden, L.V., and Paul, P. A. 2014. Rainfastness of prothioconazole+tebuconazole for Fusarium head blight and deoxynivalenol management in soft red winter wheat. *Plant Dis.* 98:1396-1406.
- Bernardo, A., Bai, G., Yu, J., Kolb, F., Bockus, W., and Dong, Y. 2014. Registration of near-isogenic winter wheat germplasm contrasting in Fhb1 for Fusarium head blight resistance. *Journal of Plant Registrations* 8:106-108. (<http://krex.kstate.edu/dspace/handle/2097/17290>)
- D’Angelo, D. L., Bradley, C. A., Ames, K. A., Willyerd, K. T., Madden, L. V., and Paul, P. A. 2014. Efficacy of fungicide applications during and after anthesis against Fusarium head blight and deoxynivalenol in soft red winter wheat. *Plant Dis.* 98:1387-1397.
- Jin, F., Bai, G.-H., Zhang, D.-D., Dong, Y.-H, Ma, L.-J., Bockus, W., and Dowell, F. 2014. Fusarium-damaged kernels and deoxynivalenol in Fusarium-infected U.S. winter wheat. *Phytopathology* 104:472-478. (<http://krex.kstate.edu/dspace/handle/2097/17838>)
- Peiris, K. H. S., Dong, Y., Bockus, W. W., and Dowell, F. E. 2014. Single-kernel near-infrared analysis for evaluating wheat samples for Fusarium head blight resistance. *Cereal Chemistry* 91:35-40. (<http://krex.kstate.edu/dspace/handle/2097/17254>)
- Salgado, J. D., Madden, L. V., and Paul, P. A. 2014. Efficacy and economics of integrating in-field and harvesting strategies to manage Fusarium head blight of wheat. *Plant Dis.* 98:1407-1421.
- Salgado, J. D., Madden, L. V., and Paul, P. A. 2015. Quantifying the effects of Fusarium head blight on grain yield and test weight in soft red winter wheat. *Phytopathology*: accepted (*First Look*).
- Shah, D. A., De Wolf, E. D., Paul, P. A., and Madden, L. V. 2014. Predicting Fusarium head blight epidemics with boosted regression trees. *Phytopathology* 104:702-714

Listings of recent FHB-related publications by USWBSI-associated principal investigators are invited. Listings should be sent to Don Lilleboe at dlilleboe@forumprinting.com

