



Fusarium Focus

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Spring 2013

FHB Scab Alert Site Improved for 2013

FUSARIUM HEAD BLIGHT Prediction Center

US Commentary last update 2013-03-08 Erick DeWolf.

Welcome to the Fusarium Head Blight Prediction Center; 2013. The Fusarium prediction tools were completely redesigned to improve access to the risk maps for Fusarium head blight and interpretation of information provided. We hope you will take a few minutes to explore the new features of the site. A brief user guide is available to help you learn about the new features available for 2013.

1. Choose a State
State: United States

2. Choose a Model
Wheat: Spring Winter

3. Weather Forecast Mode
Forecast (hrs): 0 24 48 72

Assessment Date: 03/11/2013

3/3 3/4 3/5 3/6 3/7 3/8 3/9

Advanced: Save Model and Location
Name: Save As New
Saved Locs:

Legend

Blight Risk	High	Medium	Low
No Data	■	■	■

Weather Stations

- FAA
- AgrNet
- Inactive (for model)

Subscribers to the U.S. Wheat & Barley Scab Initiative's FHB Alert System will find several improvements in 2013 — all designed to make the web-based tool more useful and to enhance ease of navigation. Erick De Wolf, Kansas State University extension plant pathologist and one of the system's coordinators, says the following changes are in place for this season:

- Improved navigation features for the risk map offer more flexibility.
- Additional geographic information

is now available, as map layers, to help users better identify their location.

- There is better graphical representation of information at specific weather stations.
- Improved integration of risk map tools and supporting information.
- A user guide has been added to help address common questions.
- Special version of the tool for use on mobile devices.

"These new features should improve access to the information, as well as user

interaction with the prediction models," De Wolf says.

(Along with the new features noted above, the site also has a completely new "look" for 2013, as shown at left.)

The purpose of the FHB Alert System is to give growers, crop consultants and others better advanced notice of potential outbreaks and the risk of scab in their area, thus aiding the timely treatment of at-risk fields with fungicides. The system is tied in with the Fusarium Head Blight Risk Assessment Tool hosted by USWBSI, Pennsylvania State University, Kansas State University and Ohio State University.

The FHB risk assessment tool — found at <http://www.wheatscab.psu.edu/riskTool.htm> — is where alerts originate.

Prediction model data are supplemented by commentary from university extension plant pathologists and other crop specialists in participating states. The commentaries provide timely, localized interpretation of crop-impacting factors that may not be considered by the scab prediction model.

De Wolf says the site had more than 8,500 unique visitors between March and September 2012. Those visitors accessed the information more than 20,000 times. A survey of 342 site users indicated that nearly two-thirds (62%) were either farmers or farm advisors. More than 68% of respondents applied the information directly on their farm or used it to make recommendations about disease management to others. Of the survey respondents, 96% ranked the information as being of high or moderate value for their farming operation or business.

To sign up for 2013 scab alerts, go to http://scabusa.org/fhb_alert.php.



— 2012 FHB Forum —

Attendance 180 at 2012 FHB Forum

About 180 scientists, growers and wheat and barley industry representatives gathered on December 4-6 for the 2012 National Fusarium Head Blight Forum. The 15th FHB Forum took place at the Wyndham Orlando Resort in Orlando, Fla.

The event featured stakeholder and scientific invited speaker presentations, along with focused group discussions and various social venues for attendee interaction. Numerous research posters were on display as well, with primary authors present to discuss the projects and their findings.

Organized and hosted by the U.S. Wheat & Barley Initiative (USWBSI), the 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 USWBSI Steering Committee met following the Forum adjournment.

The following pages contain photos and narrative of excerpted highlights from the 2012 Forum. Full Forum proceedings are on USWBSI's website: www.scabus.org.



Above: Attendees at the 2012 FHB Forum represented a variety of scientific disciplines and commercial entities, from USDA and university research and extension personnel, to grain growers and agribusiness. Included in this photo is USWBSI co-chair and University of Kentucky wheat breeder Dave Van Sanford (lower left).

Below: Focused group discussions allowed those directly involved in the various USWBSI research areas and coordinated projects to come together, discuss their progress and challenges and chart action plans for future work. Pictured here is the FHB Management session, led by Erick De Wolf of Kansas State University.



Mark Your Calendar!

**2013
National Fusarium
Head Blight Forum**

December 3-5

**Hyatt Regency Milwaukee
Milwaukee, Wisc.**



— 2012 FHB Forum —

John Weinand, a farmer from Hazen, N.D., and member of the North Dakota Grain Growers Association Board of Directors, provided the keynote address at the 2012 National Fusarium Head Blight Forum. The title of his talk — “Fishing vs. Scab?” — underscored the mindset of many farmers who deal with scab, *i.e.*, the less time and effort we need to expend on the disease, the more time we have for other business and personal endeavors . . . like fishing!

Weinand, who farms in the west central part of North Dakota, traced his scab experience back to 1998. It was a favorable season for small grains, with good moisture bringing along bountiful crops. But a serious scab infection resulted in barley with 12 ppm DON and spring wheat that was basically a “train wreck” in yield and quality.

Farmers have much better tools now to battle this disease: varieties with at least partial resistance, better fungicide options — and, in general, much more information on how to



manage scab through an integrated approach. But, Weinand emphasized, while battles have been won, the war has not. “On my own farm, we practice a diverse rotation, [based on] information you people have provided,” he told the Forum audience, seldom including cereals in that rotation more than two years out of five.

“We’re also now in the habit of

spraying all our cereals with at least one or two applications of fungicide to maintain grain quality and yield.”

But, Weinand continued, “I would like to get back to fishing” rather than spending a good share of the late spring and early summer scouting for scab and figuring out its management. “With winter wheat, barley and sometimes durum in our cropping mix, much of my time is spent scouting for proper timing of fungicide applications.”

The growers’ ultimate wish list, Weinand affirmed, has at its center the development of wheat and barley cultivars with continually improving resistance to scab. “I for one would be more than happy to pay for seed that would protect my bottom line without having to spend more time scouting or worrying about the effects of Fusarium,” he said.

“The research and information you folks are providing is wonderful, and all the growers very much appreciate that work. Let’s build upon the progress already made.” ♦

Paul Schwarz, professor of malting barley quality at North Dakota State University, updated Forum attendees on quality assurance issues for testing of deoxynivalenol (DON).

The U.S. Wheat & Barley Scab Initiative currently funds four DON diagnostic labs. One is located at Virginia Tech, one at the University of Minnesota, and the remaining two — one for wheat, the other for barley — at North Dakota State University. Together, these labs test more than 50,000 samples each year.

DON testing quality assurance and control is critical, Schwarz pointed out, because wheat and barley researchers rely on it in the design of their experiments, the interpretation of data — and for an understanding of limitations. Program administrators likewise need a mechanism for over-



sight in this area of considerable investment. Lab managers are responsible for ensuring that proper procedures are being followed, methods are

adequate, and that instrumentation is performing properly.

Analysis of DON involves four basic phases, Schwarz explained: (1) sample grinding and extraction; (2) cleanup of samples (and derivatization); (3) chromatography (*i.e.*, separation and detection); and (4) quantitation. He then outlined what is involved in each of these phases.

Intra-lab checks occur on a regular basis to ensure that results are consistent over time; “too large a deviation from the means suggests that analyses be repeated and source(s) of error be identified,” Schwarz noted. (Each of the four USWBSI labs runs between 500 to 1,000 checks per year.) Inter-lab checks, provided by an outside laboratory, provide a comparison between the four DON labs but are not used as a measure of accuracy. ♦



— 2012 FHB Forum —

Chris Bowley had everyone's attention before he even started speaking to the 2012 National Fusarium Head Blight Forum audience. He gained it with the title of his presentation: "Can We Effectively Control Scab and DON Levels in Large Scale Commercial Farming?"

Bowley is president of Wheat Tech, Inc., an independent crop consulting firm based in southwest Kentucky. Wheat Tech consultants work with about 235 growers in Kentucky, western Tennessee and the Boothill area of southeastern Missouri. As of 2012, they were consulting on about 160,000 acres of wheat, 80,000 of soybeans and another 50,000 corn acres — beginning with field and variety selection and continuing through the season, including disease scouting and application of fungicides.

Wheat Tech conducts extensive wheat variety testing. "Varieties are a useful tool" in scab management, Bowley concurred. "But in a bad scab year, in our environment," their effec-



tiveness is limited.

The vast majority of wheat in the region served by Wheat Tech follows corn in the rotation. That presents a formidable challenge in and of itself when it comes to controlling scab. Adding to that challenge is the fact that virtually all those acres are

under no-till systems. Planting no-till wheat into corn stalks is a serious impediment to scab management, Bowley pointed out. Another hindrance is uneven nitrogen levels in some wheat fields due to poor application and/or poor use of N by the preceding corn crop — which then contributes to uneven wheat heading.

One big difference between small research plots and the commercial world, Bowley observed, is the difficulty of managing fungicide application timing in farmers' fields. The large acreages and the competing needs of different crops can result in less-than-optimum timing.

So what was Bowley's summary answer to the intriguing question in his presentation title?

If scab infection is light to moderate, the answer is a qualified "yes," scab and DON can be effectively controlled in the region's commercial fields. But in moderate to severe scab years like 2009 and 2010, the answer is still "no." ♦



Left: The traditional poster sessions once again were a popular venue at the National FHB Forum. There were 79 posters available for attendees to review at various times during the 2012 Forum, with most authors also present for questions and discussion. There were 18 posters under the Gene Discovery and Engineering Resistance research area; six under Pathogen Biology and Genetics; 14 under FHB Management; 37 under Variety Development and Host Resistance; two posters under Food Safety, Toxicology and Utilization; and two more in the "Other" category.



— 2012 FHB Forum —

Marcia McMullen, recently retired extension plant pathologist with North Dakota State University, provided a historical overview of the Fusarium Head Blight (often referred to as “scab”) experience in the Upper Midwest region during the past two decades — along with a prescription for future management needs.

Regional newspaper headlines in the summer of 1993 — ones like “A blight on the land” and “Wheat scab shocks Valley” and “Vomitoxin rears its ugly head” — aptly reflected the devastating impact of that year’s scab epidemic in western Minnesota, eastern North Dakota and South Dakota. McMullen said the epidemic and the response of those affected produced several important lessons:

- A huge crisis occurring on a region’s (or locale’s) most important crops definitely increases interest among producers to find answers and to utilize best management options.
- An immediate response to such a crisis is necessary.
- A strong research-extension infrastructure enables an effective response.
- All impacted communities must be brought together.
- There must be shared planning and extensive sharing of results.

A regional forum involving affected parties in Minnesota, North Dakota, South Dakota and Manitoba was held annually from 1993 to 1996. The forums attracted not only university, USDA and private scientists, but also growers, commodity groups, the crop protection industry, seed labs, millers, elevators, FGIS and FDA. Those forums were invaluable for sharing research results, identifying future research needs and developing research funding options.

Meanwhile, the Upper Midwest region’s research and extension community quickly geared up to screen for improved scab tolerance or resistance, to evaluate and register effective fungicide options — and to provide as much information as possible to producers on how



to best deal with this disease.

By 1997 it was apparent that the scab threat went well beyond one geographic area or a single grain class, McMullen pointed out. Another severe outbreak in the Upper Midwest, along with serious outbreaks in soft red winter wheat districts, underscored the need for a national effort in scab control. That awareness resulted in the formation of the U.S. Wheat & Barley Scab Initiative (USWBSI).

Focusing again on the spring grain region, McMullen listed several important success stories since that onerous season in 1993. There has been, she noted:

- Continued variety improvement, sharing of nursery results and germplasm.

How do you gain and retain wheat and barley growers' attention in years when scab is minimal or absent?

- Good grower adoption of new varieties with improved scab resistance.
- Broad grower adoption of the most effective fungicides to treat scab and of recommended application techniques.
- Adoption of the U.S. scab forecasting model.
- Development of Minnesota, North Dakota and South Dakota forecasting web interfaces.
- Availability and use of ScabSmart and the USWBSI-sponsored scab alerts.

A 2010 survey of Minnesota and North Dakota wheat producers revealed that 81% of respondents grew scab-resistant varieties that year; 76% used what they deemed a good scab-hindering rotation; and 68% sprayed a recommended fungicide for scab control. Most utilized an integrated approach combining the above steps.

Looking ahead, McMullen advocated several important steps to ensure maximum progress in the battle against this disease:

- Best management strategies for each grain class should continue to be refined and communicated.
- It’s critical that messages regarding varietal response, fungicide use, etc., be clear and consistent when providing recommendations to growers. (Also helpful would be a streamlining of the ways the various states make available varietal response information, i.e., better “apples-to-apples” comparisons.)
- Examine new ways to get the information out to growers, crop consultants and other users, such as YouTube videos and social media outlets.
- Seek ways of sustaining interest and success in the absence of crisis. (How do you gain and retain growers’ attention in years when scab is minimal or absent?)
- Continue focusing on the long term, not allowing weather, crop prices or acreage fluctuations to drive research and information dissemination.
- Form alliances with other entities that address multiple producer concerns, not just Fusarium Head Blight. ♦



— 2012 FHB Forum —

USDA-ARS plant pathologist **Christina Cowger** chose to address a challenging question for her presentation to the 2012 FHB Forum, namely: How extensively have the nation's wheat producers, to date, adopted scab management tools provided by the public and private research community?

During the past two decades, researchers have developed and disseminated a variety of recommendations for management of scab in wheat. The three primary ones are: (1) increase your acreage of moderately resistant varieties whenever feasible; (2) monitor scab risk leading up to heading and flowering; and (3) when warranted, make a timely application of an effective fungicide. "Use of these techniques has been demonstrated to significantly reduce kernel abortion, kernel damage and mycotoxin contamination," Cowger said.

So, are U.S. wheat growers following this advice? "From anecdotal evidence, it appears that wheat grower adoption of these techniques is uneven," reported the North Carolina-based USDA pathologist. To gain more insight, she looked at two sets of data: (1) subscriptions to the U.S. Wheat & Barley Scab Initiative (USWBSI)-sponsored scab alert system, and (2) 2011 wheat acreage, by variety.

As of June 2012, a total of 937 individuals had signed up to be notified of scab alerts via either email or text message. North Dakota, at 250, had the



most participation, followed by Ohio at 143 and Minnesota with 97. Those numbers encompassed all occupations, not just farmers. In fact, in several states, farmers constituted a minority of users (though it should be pointed out that many farmers leave risk monitoring to paid crop consultants). Even in the highest-participation states, "it's not a very high rate of subscription" when compared against the overall potential number of subscribers, Cowger stated.

The 2011 acreage-by-variety evaluation looked at ratings of commonly planted wheat varieties in 21 states covered by the USWBSI scab risk forecasts. These states have significant wheat

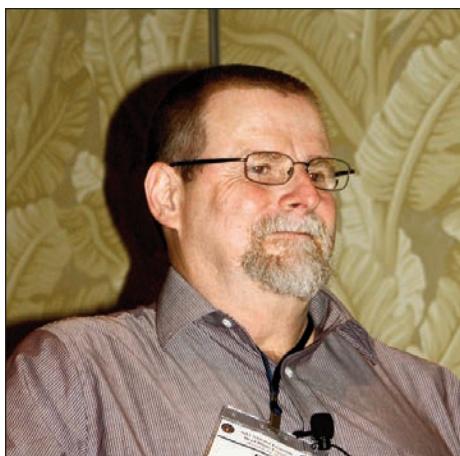
acreage and are subject to scab epidemics. In five states that produce hard wheat and durum, their annual variety survey allowed an estimation of percentages of acreage planted to specific varieties; thus, scab resistance ratings could be applied and extrapolated on an acreage basis. Planting of moderately resistant varieties ranged from 0 to 62%.

By way of contrast, out of 16 scab-vulnerable states that primarily grow soft wheat, only one had published a recent survey of wheat variety acreage that allowed estimation of percentages of moderately resistant, moderately susceptible and susceptible cultivars. That obviously made the task of measuring scab-resistant cultivar usage nearly impossible.

Cowger had two "take-home" messages from her examination of grower usage of scab management information:

- "Yes, we need better solutions. But we also need better adoption of the solutions we do have. And that requires us to assess the extent of adoption and understand barriers to adoption that may exist." To that end, she noted, the USWBSI is teaming up with USDA's National Agricultural Statistics Service (NASS) to conduct a 17-state survey of wheat and barley growers.

- "We need to share success stories of those who have helped growers adopt a scab management strategy that operates year-in and year-out."



Left: Bill Lasker, wheat breeder with Pioneer Hi-Bred International at Windfall, Ind., spoke to the impact of the private breeding effort on resistance to Fusarium Head Blight in soft wheat.

*Right: Frances Trail, professor of plant biology at Michigan State University, discussed the impact of the *Fusarium graminearum* genome sequence on the quest for control of FHB.*



— 2012 FHB Forum —

University of Minnesota wheat breeder **Jim Anderson** presented an overview of breeding for scab resistance in spring wheat. Along with some history, he outlined the steps and timeline in the breeding process.

Wheat breeding priorities fall under three main categories, Anderson explained. The first — agronomic characteristics — encompasses traits like yield, test weight, lodging resistance, shattering, kernel color and preharvest sprouting resistance. The second category — diseases — covers resistance to Fusarium Head Blight (scab), leaf rust, stem rust, leaf spotting (tan spot and the Sertorius), bacterial leaf streak and barley yellow dwarf virus. The third focus category is bread-making quality characteristics, including percent protein, mixing properties, loaf volume, flour water absorption, kernel hardness, milling yield and percent flour ash.

Zeroing in on Fusarium Head Blight, Anderson observed that while scab has been on the “radar screen” of Upper Midwest scientists and farmers for several decades, interest and concern about the disease was sporadic and unsustained until the severe outbreak of 1993. Epidemics of scab have been a fairly regular occurrence since then in varying areas due to higher rainfall/humidity near flowering time and increased amounts of residue on the soil surface due to changes in tillage practices.

The “modern-era” scab-resistant germplasm development timeline began with the late 1980s establishment of a



screening nursery in which crosses were made with the moderately resistant Chinese-origin source, Sumai 3. Major epidemics during 1993-97 proved devastating to breeding germplasm, prompting a massive effort to identify resistance sources within the U.S., as well as from China, South America and Europe.

The 1996 season brought the release of “BacUp,” which possessed moderate resistance to scab but was very poor agronomically. “Alsen,” released by North Dakota State University in 2000, was a moderately resistant spring wheat variety that became widely grown in the region.

Today, Upper Midwest producers have a number of moderately resistant spring wheat varieties available to them

— in fact, more than half of the available cultivars in the region fall into the “moderately resistant” category. *Fhb1*, a major QTL for scab resistance, is present in the majority of these cultivars, Anderson pointed out. And growers are planting them. As of 2011, more than 50% of Upper Midwest wheat acreage was seeded to cultivars with a moderately resistant rating; in Minnesota, the percentage was closer to 70.

“Despite these genetic gains and improved fungicides, even the most resistant materials available today can incur damage when environmental conditions are conducive for an epidemic,” Anderson noted.

Breeders have identified DNA markers for many QTL using biparental mapping populations, “and a few are being routinely used in marker-assisted selection (MAS),” Anderson added. “The *Fhb1* QTL was present in cultivars grown on 40% of the region’s wheat acreage in 2011.” Phenotypic assessments for scab resistance are still necessary, however, “because there are likely to be numerous genes with minor effects, which need to be combined with the major QTLs in order to obtain the desired level of resistance.”

Genomic selection is occurring as well, speeding up the scab resistance screening and selection process. Being able to identify and discard susceptible lines prior to entry into the yield trial phase “eliminates a major bottleneck in our breeding program,” Anderson explained. ♦



Left: Kemal Kazan of CSIRO Plant Industry, Inc., Queensland, Australia, updated Forum attendees on new insights revealed by comparative genomics into the evolution of Fusarium pathogenesis in wheat. He also spoke on genetic and genomic approaches for managing Fusarium pathogens causing head blight and crown rot.

Right: David Miller, Carleton University, Ottawa, Ont., gave an overview of DON: past, present and future. His presentation is posted on the USWBSI’s website.



Forum Talks on Website

The following invited speaker presentations from the 2012 National FHB Forum can be accessed on the U.S. Wheat & Barley Scab Initiative website (www.scabusa.org). Proceedings of the 2012 Forum also are available there.

- *Can We Effectively Control Scab and DON Levels in Large Scale Commercial Farming? / Chris Bowley, Wheat Tech, Russellville, Ky.*
- *Known Knowns and Known Unknowns: Assessing Adoption of Scab Management Tools / Christina Cowger, USDA-ARS, Raleigh, N.C.*
- *FHB Management: Progress and Potential Knowledge Gaps / Erick De Wolf, Kansas State University*
 - *FHB Management in Spring Grains Lessons Learned, Successes, Future Needs / Marcia McMullen, North Dakota State University*
 - *Deoxynivalenol – Past, Present, Future / David Miller, Carleton University, Ottawa, Ontario, Canada*
 - *Quality Assurance Issues for DON Testing / Paul Schwarz, North Dakota State University*



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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- Overview of Breeding for FHB Resistance in Wheat — Where We've Come From and Where We Are / Jim Anderson, University of Minnesota
- Impact of Private Wheat Breeding on Fusarium Head Blight Resistance - North America / Bill Lasker, Pioneer Hi-Bred International, Windfall, Ind.
- Genotype-by-Sequencing: Breaking the Bottleneck / Robert Brueggeman, North Dakota State University
- Genetic Analysis of Fusarium Head Blight Resistance in Tunisian-Derived Durum Wheat Populations / Shahryar Kianian, North Dakota State University
- Regulation of Mycotoxin Production and Kinome Analysis in Fusarium Graminearum / Jin-Rong Xu on Behalf of Chenfang Wang, Northwest A&F University, Yang Ling, Shanxi, China
- New Insights into the Evolution of Fusarium Pathogenesis in Wheat / Kemal Kazan, CSIRO Plant Industry, Brisbane, Queensland, Australia
- Developing Fusarium Head Blight Resistant Wheat / Gary Muehlbauer, University of Minnesota
- Genetic and Genomic Approaches for Managing Fusarium Pathogens / Kemal Kazan, CSIRO Plant Industry, Brisbane, Queensland, Australia
- Lipid Transfer Proteins Confer Resistance to Trichothecenes / John McLaughlin and Amer Bin-Umer, Rutgers University

Recent Scab-Related Publications

- Bockus, W. W., Zhang, G., Fritz, A., Davis, M., Baenziger, P., and Berzonsky, W. 2013. Reaction of Kansas, Nebraska, and South Dakota winter wheat accessions to Fusarium head blight (FHB), 2012. (online) Plant Disease Management Reports 7:CF019. DOI:10.1094/PDMR07. The American Phytopathological Society, St. Paul, MN.
 - Cowger, C., and Arellano, C. Posted 19 Dec 2012. Fusarium graminearum infection and deoxynivalenol concentrations during development of wheat spikes. *Phytopathology*, <http://dx.doi.org/10.1094/PHYTO-03-12-0054-R>.
 - Crane, J.M., D.M. Gibson, R.H. Vaughan and G.C. Bergstrom. 2013. Iturin levels on wheat spikes linked to biological control of Fusarium head blight by *Bacillus amyloliquefaciens*. *Phytopathology* 103:146-155.
- Listings of recent FHB-related publications by USWBSI-associated principal investigators are invited. Listings should be sent to Don Lilleboe at dlilleboe@forumprinting.com

Impact of the Release of 'Everest' on Vulnerability of the Kansas Wheat Crop to FHB

By William W. Bockus and Allan K. Fritz,
Kansas State University

Fusarium head blight (FHB) is an important disease of wheat throughout the world. Although FHB is episodic in Kansas, it can cause serious losses when it occurs. The most recent outbreaks of the disease in Kansas occurred in 2008, 2009 and 2010.

Most of the disease problems occur in the eastern portion of the state where rains and high humidity during flowering are more common. Those environmental conditions result in infections of the head by the causal fungus. Although fungicides applied to the heads at this time can help manage the disease, deployment of resistant cultivars is also an important control method.

In 2009 Kansas State University released the first winter wheat cultivar adapted to Kansas that was specifically developed with improved levels of resistance to FHB. Partial funding for development of Everest came from the USDA via the U.S. Wheat & Barley Scab Initiative.

Everest is rated a 4 in KSU Extension publications where 1 is highly resistant to FHB and 9 is highly susceptible. For comparison, most recent popular cultivars are rated in the 7 to 9 range.

Everest has been popular with wheat producers and has now become the most-planted cultivar in Kansas for the 2013 harvest season. As Everest has gained popularity, it has had a noticeable impact on the vulnerability of the Kansas wheat crop to FHB. This has been especially true in the eastern portion of the state where Everest is particularly popular. Prior to the release of Everest, the average ratings for the entire state and the eastern third of the state were always above 7 and approached 8 in some years, indicating high susceptibility.

However, with the adoption of Everest, the ratings have declined so that the rating for 2013 is now below 6.5. For the eastern third of the state, where FHB is more prevalent, the rating has dropped even more dramatically so that the 2013 rating is approaching 5. Thus, the adoption of Everest has significantly reduced the overall vulnerability of the Kansas wheat crop to outbreaks of FHB.

