U. S. Wheat & Barley Scab Initiative

Fusarium Focus

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1993-2003: Through Hell and High Water

Minnesota grain producer describes how FHB has affected his cropping system in the last decade

Richard Magnusson's farm might be described as a microcosm of grain farms in northwest Minnesota, indicative of the weather and disease challenges and subsequent production changes that have taken place over the past decade.

Magnusson, like other grain farmers in northwest Minnesota, was broadsided by Fusarium head blight (FHB, commonly called scab, or "tombstone" in Canada) in 1993. His 3,000 acres of wheat early that growing season 10 years ago appeared to have excellent yield potential. However, weather conditions conducive to the formation of scab at grain heading resulted in a severe epidemic of the fungal disease, the likes of which grain farmers, plant pathologists and agronomists in North America had never seen before.

"The straw looked like it had 70-bushel yield potential, but virtually nothing was coming into the hopper of the combine," he says. "We couldn't figure out what was going on."

The little wheat that Magnusson attempted to harvest that year yielded less than five bushels per acre. He ended up burning most of his standing wheat—about 3,000 acres— to get rid of the scabby residue and prepare for the following growing season. The scabby crop had little market value anyway, with more than 50% kernel damage and over 10 parts per million vomitoxin (deoxynivalenol or DON, which is a "mycotoxin" or contaminating byproduct of FHB that makes wheat unsuitable for milling and barley unsuitable for malting).

Like a number of other crop producers in northwest Minnesota and other parts of the U.S., Richard Magnusson of Roseau, MN has been battling adverse weather conditions over the past decade. In 1993, Magnusson and other farmers in the Northern Plains burned scab-infected wheat and barley crops, since it was not worth the investment to harvest the severely scabby grain that held little to no market value. In 2002, Magnusson lost his crops again, this time to a deluge of rain early in the growing season.

What barley Magnusson harvested that year yielded somewhat better than the wheat, but with DON levels at 10 ppm or higher, none of it sold for malting. He ended up selling the barley he harvested in 1993 as feed the following summer.

In 1994, Magnusson's wheat and barley crops were again affected by FHB, although the fungal disease wasn't as widespread or severe throughout the Northern Plains as in 1993. As well, the marketing system had a better handle on selling the damaged grain. Still, there were production losses. Federal crop insurance and disaster payments helped, but not enough to fully cover farm and family living expenses.

The effects of FHB and DON on Magnusson's farm have been variable in subsequent growing seasons. It was severe again in 1997. FHB didn't affect Magnusson's wheat and barley fields in 2002—over a foot of rain on June 11 wiped out his growing season entirely.

Almost every year since 1993, the

Continued on Next Page

Magnusson • *from page 1*

presence of DON has prevented some of Magnusson's barley from making malting. The price of malting barley in 2003 promises to be the highest in years, yet this year will be the first that Richard Magnusson will not grow malting barley on his farm. "Contracts call for zero DON, and we're not confident we can achieve that," he says. Other barley producers feel the same way: Despite attractive prices, USDA's prospective plantings report on March 31 indicated that Minnesota producers intend to plant 14% less barley than last year. "It seems that the bar keeps changing as to what level of DON the elevators will accept," says Magnusson.

Increased Production Costs

FHB prompted major changes to Magnusson's cropping system, and that of other producers. In 1993, about half of his wheat and barley was grown on acreage that was wheat and barley the year before. Now, Magnusson has done away with continuous cropping and includes more broadleaves in his crop rotation to help manage FHB.

Norm, Gus, Vance, and Grandin were the spring wheat varieties Magnusson grew in 1993—all were susceptible to FHB. Now, Magnusson grows spring wheat varieties that are less susceptible to the disease. In 2003, Magnusson's experience with fungicides was limited to experimental test strips, primarily to suppress leaf diseases, not FHB. Now, not only does Magnusson use fungicides to suppress both leaf diseases and FHB, but is well-versed on application practices to improve treatment success. "We look at fungicide applications now the same way we do herbicides," he says. "It's become regular practice."

Magnusson has fungicide for suppressing FHB applied mostly aerially. "The key is getting it on in a timely manner," he says.

Still, even the most effective fungicide on the market won't eliminate DON entirely. That's why Magnusson, like many other crop producers in areas where FHB has been a problem, have given up on growing barley for malting. And although spring wheat varieties available today are more tolerant of FHB, no variety can yet be described as resistant.

Thus, despite the advancements in research and knowledge in managing FHB over the past 10 years, the disease remains an Achilles Heel to many wheat and barley growers, including Magnusson. He estimates that his production costs have risen 20% because of FHB. In an age when grain growers across the world compete for marketshare to be least cost producers, that's a huge disadvantage.

There have been larger economic repercussions as well, from the effects of FHB, adverse weather, and lower farm prices. "There were five implement dealers in Roseau 10 years ago, and now there's one," Magnusson says. "Land comes up for rent, and there's little demand for it. We've probably lost about one third of the total farms in our county since 1993, and about 25% of farmable land is in CRP."

He also points out that without small grains in a cropping system, the disease pendulum can swing the other way, creating problems such as Sclerotinia (white mold) in broadleaf crops. "We need better fungicides, better varieties that are more resistant to scab, and more accurate and repeatable methods for testing DON at the farm and country elevator level," he says. ■

Roseau, Minn. farmer Richard Magnusson explained how FHB has affected his farm at the U.S. Wheat and Barley Scab Initiative's national forum held last December near Cincinnati. At the forum, crop scientists from around the world along with leaders of the U.S. wheat and barley industry discussed progress and challenges in researching solutions for the grain disease. The fungus has plagued wheat and barley production in many areas of the United States since the early 1990s, resulting in economic losses estimated in the billions.

Variety Development Update

CIMMYT New Barley Screening Cooperator

Conlon, a two-row malting barley adapted for the Northern Plains, is often affected less by DON than other leading six-row malting barley varieties. However, it isn't preferred by all U.S. brewers, according to Jerry Franckowiak, two-row barley breeder at North Dakota State University. With the help of marker-assisted selection, progress is being made in developing varieties with better resistance, although there is no quick, easy solution to the FHB problem in barley. He points out that strategies for control of FHB in malting barley didn't even exist prior to the 1993 FHB epidemic.

Since then, FHB screening nurseries were established in North Dakota and Minnesota, to test barley lines for FHB resistance. Cooperative nurseries were established in eastern China, where natural inoculum and favorable weather often cause high levels of FHB. In 2002, the cooperative regional FHB screen nursery was expanded to include a testing site in Manitoba and renamed the Northern American Barley Scab Evaluation Nursery. An agreement to have the International Maize and Wheat Improvement Center (CIMMYT) barley program in Mexico as a screening cooperator is in place for 2003, and discussions are underway to include Uruguay as well. Expanded cooperation on FHB testing should help breeders to better understand and address obstacles (such as the role of plant height and

Continued on Next Page

Scabby barley kernels compared to healthy barley kernels

One Last Look...

Several crop scientists squeeze in a few extra moments to review research findings at the conclusion of the poster session at the 2002 National Fusarium Head Blight Forum, held last year near Cincinnati.

The annual forum highlights research being conducted under the U.S. Wheat and Barley Scab Initiative, organized in 1997 to find multiple solutions for controlling FHB in wheat and barley. The national research initiative in the 2002 federal fiscal year involved over 100 research projects, carried out in 25 states at 23 land grant universities, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and the U.S. Department of Agriculture's Agricultural Research Service, which funds the Initiative.

At the research forum, scientists reported research results and advancements in variety development and uniform screening nurseries; epidemiology (how scab develops, spreads) and disease management; food safety, toxicology, and utilization; biotechnology; chemical and biological control; and germplasm introduction and evaluation.

A full report of research conducted under the U.S. Wheat and Barley Scab Initiative and discussed at the Forum is posted on the Internet at www.scabusa.org. Click on the "Forums" link for research reported at the 2002 Forum and proceedings/research reports conducted under the Initiative since 1998. ■

2003 National FHB Forum

December 13-15
Holiday Inn Select
Bloomington, MN
See more information and online registration after July 1 at
www.scabusa.org

maturity adaptation genes) in developing better FHB tolerance in malting barley, says Franckowiak.

FHB Progress East of the Mississippi

Michigan State University wheat breeder Rick Ward says it was the 1996 FHB epidemic in the central U.S. that served as the impetus for an increased research focus on the disease. Because of FHB, virtually all white wheat produced in Michigan that year was feed quality, and millers were forced to buy white wheat from the Pacific Northwest. "The wheat millers virtually spent more to ship the wheat than to buy it," says Ward.

In the late 1990s, most wheat breeding programs east of the Mississippi River had little research focus on FHB. Now, Ward says that virtually all programs do, cooperating in a uniform FHB nursery to weed out susceptible lines and identify wheat lines that are more tolerant. Most are using marker-assisted selection, are collaborating with the USDA-ARS Genotyping Center at Kansas State University, and some breeding programs have already released varieties with improved FHB tolerance.

Breeding Technique Helping SRW FHB Tolerance

Virginia Tech wheat breeder Carl Griffey reports that two newly released varieties from the Virginia Tech Small Grains Program, McCormick and Tribute, possess significantly improved FHB tolerance. More experimental lines in greenhouse and field tests also show promise. Progress in transferring type II (spread of FHB on the wheat head) resistance into soft red winter wheat genotypes has been accelerated by using a "wheat x maize" hybridization technique that has proven to be efficient for haploid production in wheat. The doubled haploid system is proving to be a more efficient, less time-consuming method of developing lines with better wheat scab resistance.

Hermann Buerstmayr, group leader, Laboratory for General Plant Breeding, the Institute for Agrobiotechnology, Austria, was a guest speaker at the 2002 National FHB Forum. Buerstmayr discussed FHB evaluation methods employed by the Institute www.ifa-tulln.ac.at) which, among its programs, conducts joint research on FHB cooperatively with crop scientists in Iran. Buerstmayr said that the concern with FHB in Europe is focused more on mycotoxin contamination than crop yield loss.

New U of M Variety "Oklee" Moderately Resistant to FHB

The University of Minnesota has released a new spring wheat variety, "Oklee," tested as MN95002, which has high grain yield, test weight, and grain protein and is moderately resistant to FHB, similar to the variety 2375. It is one of the earliest maturing varieties ever released by the U of M, according to wheat breeder Jim Anderson,. Oklee seed will be grown mostly by seed producers this year, with seed more widely available in 2004.

Diversified Germplasm, Research Methods Needed

Crop scientists involved with FHB research say that in the quest for increased FHB tolerance, there cannot be tradeoffs in other characteristics, such as end-use quality and rust tolerance. Crop scientists involved with the Initiative are seeking to evaluate a diverse array of germplasm from around the world to find sources with different types of FHB resistance.

There is a need to evaluate germplasm for other types of FHB resistance. "There is a risk of relying on a single source of resistance over a wide area," says Greg Shaner, plant pathologist at Purdue. "Types 1 (resistance to infection) and 2 (spread in the head) resistance are reasonably well-defined and testable by spray and point inoculation. Types 3 (DON accumulation), 4 (kernel infection), and 5 (yield tolerance) need re-evaluation and refinement." Combining different types of resistance will require marker-assisted selection, he says.■

Another Section 18 Season for Folicur; Uniform Fungicide Trials Generate Supporting Data

Folicur will receive Section 18 emergency label registration for another growing season, allowing wheat and barley growers in states that apply for the label to use the fungicide for FHB suppression.

Jim Bloomberg, with Bayer CropScience, the maker of Folicur, says the company is working with the Environmental Protection Agency to resolve questions EPA has about the tebuconazole product before it receives full Section 3 registration.

Folicur and another experimental Bayer fungicide (JAU 6476, tested under the code AMS 21619) have had the most consistent efficacy against FHB in uniform fungicide and biological control trials conducted under the U.S. Wheat and Barley Scab Initiative, according to plant pathologists Marcia McMullen, North Dakota State University, and Eugene Milus, University of Arkansas. Milus is current coordinator of this research area of the Initiative, and McMullen before that.

Uniform trials established under the Initiative were first conducted in 1998, evaluating five uniform fungicide treatments on three classes of wheat and spring barley in seven states. The number of cooperating states has since doubled, and methods for applying treatments and recording results have steadily improved. New treatments are tested for at least two years. The first biological control agents (BCAs) for FHB suppression were included in the uniform trials beginning in 2001.

During its first five years, the uniform fungicide and biocontrol trials have evaluated 10 fungicides provided by six crop protection companies and BCAs from EMBRAPA (Brazil), Cornell, USDA, and Ohio State University. Reductions in FHB field severity across locations have averaged about 50%, and have been as high as 78% with the best fungicide treatment. Most of the tested treatments have been eliminated from further consideration because of poor efficacy, tendency to increase DON levels, and/or termination of the product by the crop protection company.

Data generated in the uniform trials have been instrumental for justifying Section 18 registrations for Folicur in several states, and likely will be important for any future registrations, say McMullen and Milus. They point out that the uniform trials put in place through the Initiative has successfully established common protocols across the U.S. for evaluating fungicides and BCAs over multiple environments and grain classes. They say that the collaborative network helps in the sharing of data and evaluations and in generating research improvements and conclusions. ■

Fungicide Application Technology Workshop Held

Networking and communication is a key component of the USWBSI. Thus, an application technology workshop, organized by the USWBSI's Networking and Facilitation Office and its Chemical and Biological Control Committee, was held February 18-20 in Minneapolis, MN. Participants included agricultural engineers, plant pathologists, and Louis Arnold, a wheat and barley grower from North Dakota who articulated a grower's perspective on fungicide applications for managing head blight.

Previous work has shown that typical application techniques deposit only a small portion of the spray volume on heads of wheat and barley and that efficacy against head blight was proportional to the amount of fungicide deposited on heads. The goal of the workshop was to foster synergy among agricultural engineers and plant pathologists that would lead to the development of techniques that deposited higher proportions of spray volume on heads and more effective control of head blight.

Researchers interested in ground application technology agreed to evaluate several variables using commercial and experimental sprayers in large replicated field plots at several locations. Research on aerial application should benefit from the involvement of the USDA-ARS Aerial Application Team from College Station, Texas (http://apmru.usda.gov). The Team has state-of-the-art equipment for applying and measuring the deposition of pesticides and will conduct field experiments in Texas during 2003 and then move its equipment and personnel to an area prone to head blight epidemics during 2004. Ground and aerial application research will include fluorescent dyes to determine the deposition on heads of wheat and barley so that useful data can be obtained even in the absence of disease. – *Eugene Milus, Department of Plant Pathology, University of Arkansas* ■

Low Proposed DON Tolerances in Europe May Make Scab International Issue

Across Europe, FHB (scab) has increasingly become a problem, with outbreaks reported in Germany, France, Belgium, and the Netherlands. Especially in Germany there are many concerns about it. This past year the central and northern parts of the country had a lot of problems with the disease, and recently I had the "good fortune" of participating in a seminar on FHB in Germany.

Unlike in Minnesota and North Dakota, it seems that FHB in Germany is affecting winter wheat production but not winter barley, spring barley or spring wheat production. It appears that these other crops escape infection. This is interesting because these crops flower at least partially during the same period.

Within the European Union (EU), tolerances for DON (vomitoxin) have been discussed for the past 18 months or so. The limits as they are currently proposed are very stringent and much lower than the recommended levels the USDA and FDA maintain, which is one part per million for finished flour. Here, instead of talking about concentrations in parts per million (ppm) they talk about parts per *billion* (ppb). At the EU level, the proposed maximum limit in the raw grain intended for food is not to exceed 500 ppb (or 0.5 ppm).

In addition, it is proposed not to allow blending of different lots of grain if any of the individual lots exceed the 0.5 ppm limit. Individual member countries within the EU can opt to even further lower the limits, and some researchers in Germany feel that German policymakers might actually decide to do so, largely out of food safety concerns and consumer protection motives. Target limits are also being proposed for the feed industry. However, as one researcher commented, there is only two letters difference in the spelling of "food" and "feed," and he worried that the same limits imposed for food could be imposed on the feed industry.

The most common crop rotation in the central part of Germany has changed in the past ten years to the inclusion of winter wheat followed by corn for silage. In addition, reduced till and no-till are also implemented. As many growers in the Northern Plains already know, this is a recipe for a disaster.

German crop breeders realize this too, and have responded by selecting taller wheat types with better FHB tolerance. Why taller wheat types? One thought is that a taller spike may catch more wind and dry up a bit faster, although one wouldn't want to bet the farm on this. They fully acknowledge that breeding taller varieties may result in more problems with lodging, especially given Germany's intensive production system.

Selecting for tall types looks like an escape mechanism rather than true genetic resistance to the disease like breeders in the U.S. are developing with Chinese spring wheat lines. Breeders in Europe have made some crosses with the same Chinese sources of resistance, but most of the material didn't make it through the first rounds of selection. They all were very reluctant to spend much time and energy in working the Chinese sources of resistance into a European background. Why the reluctance? Because they know it's a long-term proposition, as evident by how long and how difficult it is taking breeders in the U.S. to incorporate Chinese sources of FHB resistance.

Jochum Wiersma, U of M small grains specialist

It is apparent, at least from my observations, that FHB is an international issue, and it bears watching by the wheat and barley industry on the North American side of the pond. The low European tolerances for DON that are being proposed could especially become a concern for the North American grain trade, as these limits might also be applied to grain that is imported from the U.S. and Canada. – *By Jochum Wiersma, currently on leave as small grains specialist at the University of Minnesota, and living in his native Netherlands.* ■

Transgenic Wheat with PIN Protein May Protect Against FHB

Research at Montana State University indicates that a protein naturally found in wheat that is involved in determining kernel texture and softness may provide protection against Fusarium and other fungal diseases in wheat and barley.

The wheat puroindoline proteins (PINA and PINB) are endosperm-specific. Transgenic plants developed in research conducted cooperatively by John Sherwood, Mike Giroux, and Shirley Gerhardt of MSU's Department of Plant Sciences and Plant Pathology has distributed these proteins through the plants. While this distribution hasn't had any effect on reducing take-all, it does seem to give plant roots increased resistance to diseases such as root rot. It also appears to increase resistance to FHB.

The growth of both *F. graminearum* and *F. culmorum* was suppressed in *in vitro* bioassays. Control and transgenic HiLine wheat varieties with the pinB gene were inoculated with *F. culmorum* in both field (summer 2001) and greenhouse (2001-02) studies. The plants were analyzed for scab by visual inspection of the heads. The majority of control plants had between 40-70% infected spikelets/head. Pin-B-transgenic lines showed a large increase in plants with only 0-20% infected spikelets/head, a decrease in both the moderately and severely infected heads, and a decrease of the percentage of FHB, when compared to the control. Experiments with *F. graminearum* generated similar results.

The MSU researchers are just beginning their transformation efforts using barley (using the two-row variety Harrington), to see if the PIN proteins have an effect in reducing FHB, as well as DON levels. The MSU research is supported in part by the USWBSI.■

FHB News Briefs

USWBSI Committee Leaders

Paul Murphy, North Carolina State University, is the new chair of the Variety Development & Uniform Nursery Research Area Committee, replacing Herb Ohm, Purdue, whose term on the committee ended in 2002. Mohamed Mergoum, North Dakota State University, is a new member serving on this committee.

Also, Michael Pate, Midstate Mills, Inc., North Carolina, is a new member of the USWBSI's Executive Committee. He replaces Rick Seimer, Seimer Milling, Illinois, whose term ended in 2002.

Other new members have been elected to serve on the Initiative Steering Committee as well. Their terms began Jan 1, 2003. On the USWBSI web site, www.scabusa.org, click on the link "USWBSI Committees" for the entire list of all Executive Committee, Steering Committee, and Research Committee members.

"The wheat and barley industry owes gratitude to those who have dedicated their time to serve on these committees, which are the wheels that drive this research initiative," says Rick Ward, co-chair of the USWBSI.

Dakota Growers Pasta Launches Durum Breeding Program

Dakota Growers Pasta Company has launched its own durum breeding program headed by James Quick, who will serve as a consulting durum breeder for the company.

Quick retires as head of the Colorado State University Soil and Crop Sciences Department on June 30, 2003. His experience in plant breeding and genetics spans about 40 years, including 12 from 1969 to 1981 as a durum breeder at North Dakota State University, where he developed 10 durum wheat varieties, including the first semi-dwarf and the first strong gluten cultivars developed for the major durum region of the U.S.

Quick

For several years, DGP has already been working with Quick and Western Plant Breeders to conduct field trials, including research on FHB resistance, which has been causing durum quality problems.

DGP will be the first pasta maker to develop its own durum varieties. Having its own breeding program will allow DGP to develop specialized durum to fill niche or identity-preserved markets, says Brad Miller, the company's research agronomist.

Miller, who serves on the USWBSI's steering committee, says the creation of its own private durum breeding program does not mean that Dakota Growers Pasta isn't satisfied with public durum breeding efforts.

Continued on Next Page

"Breeding is a numbers game. With more breeders working on a problem such as scab, and with more crosses being made with more diverse genetic material, the better the chances that a scab resistant variety will be found. We will also be able to respond more quickly to fill niche or IP markets."

Organized in 1991 as a cooperative of durum wheat growers, Dakota Growers Pasta is the third largest producer of dry pasta products in North America, and is the leading supplier of retail store brand pasta and a leader in the foodservice and ingredient pasta markets.

CAST Report on Mycotoxins Available

The Council for Agricultural Science and Technology (CAST) has released a scientific task force report, "*Mycotoxins: Risks in Plant, Animal, and Human Systems*."

A collaborative effort by 38 international scientists, it covers mycotoxin-producing fungi; mycotoxin control in crops, foods, and feeds; mycotoxin-caused disease in humans and animals; mycotoxin testing, control, and international regulation; economics; and research and policy recommendations. It is available at www.cast-science.org.

KSU Fusarium Workshop June 22-27

Kansas State University will host a Fusarium Lab Workshop June 22-27 in Manhattan, Kans. Workshop topics will include lab strain ID, VCG Analysis, mating types and crosses, species concepts, and molecular identification. More info online: www.oznet.ksu.edu/plantpath/events/fusarium/. Or for more details contact John Leslie, 785-532-1363, jfl@plantpath.ksu.edu

Database of FHB Researchers Online

A database of crop scientists involved with FHB research, as well as other wheat and barley industry contacts with an interest in FHB research, can be found online at www.scabusa.org. Click on the database link at the top of the home page of the USWBSI, or type the URL, www.scabusa.org/db/contacts.cfm into your web browser. Search for contacts by name, institution, or organizational unit.

New Plant Pathologist at University of Minnesota

Char Hollingsworth is a new University of Minnesota extension plant pathologist, based at the Northwest Research and Outreach Center, Crookston, MN. She may be contacted at (218) 281-8627, email holli030@umn.edu.

Hollingsworth

Fusarium graminearum: Genomics, Sequencing Info Online

Frances Trail, with the department of botany and plant pathology at Michigan State University, has Fusarium graminearum genomics and gene sequencing data posted online at www.msu.edu/~trail/index1.htm or www.scabusa. org/research_epid.html. Given scarce funding nationally for fungal genomics research, Trail says the USWBSI has been instrumental for enabling sequencing research on Fusarium, which ultimately will help in controlling it. ■

U.S. Wheat and Barley Scab Initiative Fusarium Focus

This newsletter is made possible by the U.S. Wheat and Barley Scab Initiative administered by the USDA-ARS. For more information about the Initiative, or to submit news items for consideration in this quarterly publication, contact Sue Canty, U.S. Wheat & Barley Scab Initiative, Networking & Facilitation Office, 380 Plant & Soil Sciences Building, East Lansing, MI 48824-1325 Phone: (517) 355-2236 FAX: (517) 353-3955 E-mail: scabusa@msu.edu.

This newsletter contains an update on only a sampling of research funded by the USWBSI. For more information on scab research in the U.S., and projects funded by the USWBSI, see the Initiative's website, www.scabusa.org.

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