U. S. WHEAT & BARLEY SCAB INITIATIVE

Fusarium Focus

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2001 FHB Forum:

International Cooperation Proving Helpful to Grain Scab Research

Esmond, N.D. farmer Louis Arnold was the opening speaker at the 2001 U.S. Wheat and Barley Scab Initiative Forum, attended by close to 200 crop scientists from around the world and leaders of the U.S. wheat and barley industry. Arnold said at the Cincinnati forum that scab is a key factor in eroding small grain acreage in the Northern Plains. He said it needs to be brought under control, "or we may have an industry, like barley, become extinct."

The worldwide problem of Fusarium head blight (FHB) in small grains is depending on worldwide cooperation among crop scientists to find solutions.

Close to 200 crop scientists from around the world and leaders of the U.S. wheat and barley industry met in Cincinnati Dec. 8-10 in a national forum to discuss advancements in the research of FHB, commonly called scab. The fungal disease 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.

A byproduct of FHB, called deoxynivalenol or DON, can make wheat unsuitable for milling, and barley unsuitable for malting. FHB was common and severe in parts of North Dakota in 2001, resulting in field severity as high as 80 percent. The disease caused wheat marketing problems in Michigan, and affected grain in other states as well.

Louis Arnold, an Esmond, N.D. farmer, opened the Cincinnati forum by explaining how FHB is a key factor in the erosion of small grain acreage in the Northern Plains. "On my farm, we used to grow 2,500 acres of wheat, and now that is down to about 1,500 acres. We used to grow 600 acres of barley, now we only have about 10 acres. Other crops can be grown, but our geographic location is best suited for barley and wheat. If we don't grow these crops, who will?" FHB needs to be brought under control, he said, "or we may have an industry, like barley, become extinct."

A concerted national research initiative to find multiple solutions for controlling FHB in wheat and barley got underway in 1997. The $5 million national research initiative in the 2001 federal fiscal

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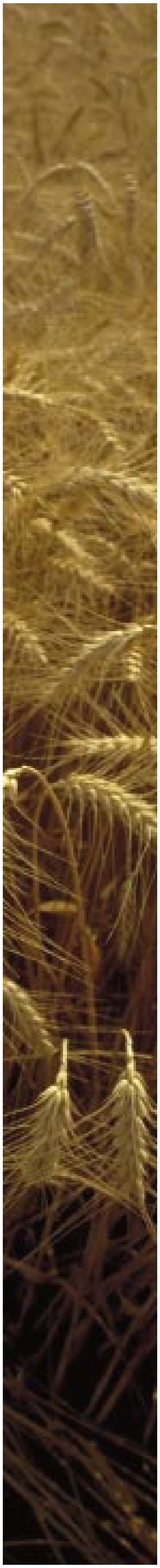
The poster sessions at the 2001 Fusarium head blight forum in Cincinnati enabled crop scientists to display and discuss their progress and results of FHB research. The USWBSI Steering and Executive Committees have approved the location and tentative dates for the 2002 Forum, to be held for one more year at the Cincinnati Airport Holiday Inn. The tentative dates for the Forum are Saturday, December 7, beginning at 1 p.m. and concluding at noon on Monday, December 9, 2002.



Cooperation • *from page 1*

year involved 83 scientists working on 109 projects, carried out in 25 states at 22 land grant universities, the International Maize and Wheat Improvement Center (CIMMYT) and the U.S. Department of Agriculture's Agricultural Research Service, which funds the Initiative.

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

U.S. wheat and barley breeders are crossing FHB-tolerant small grain cultivars from China with domestic wheat and barley lines to develop new varieties that are resistant to scab. Field tests indicate progress is being made. For example, in North Dakota field tests where durum lines are screened under intense FHB pressure, the disease severity of some new FHB-tolerant durum lines is less than 10 percent, compared to susceptible varieties, which had FHB severity closer to 60 percent.

"Breeders have been working to develop lines with better scab resistance for the past four to five years, and now we're at the point where they're becoming available to producers," said Tom Anderson, a Barnesville, Minn., farmer and Initiative co-chair. "For the first time we're starting to see more scab-tolerant varieties such as the spring wheat variety Alsen from NDSU, and there will be others within the next year or two. This is a direct result of the efforts of this research initiative."

Still, it takes time to develop, analyze, and increase a new variety that not only has better scab resistance, but acceptable agronomic, yield, and end-use quality characteristics. North Dakota State University durum breeder Elias Elias likens the variety development process to building a car: An engineer can build a new and better engine, but the car isn't complete and ready to drive until all of the automobile's features are assembled.

Wheat and barley breeders in the U.S. not only share germplasm from promising lines with each other, but also with crop scientists from other countries. One example is the collaboration that the U.S. Wheat and Barley Scab Initiative has established with CIMMYT. A major crop research center headquartered in Mexico, CIMMYT is the originator of high-yielding wheats that helped stave off widespread starvation for millions of people in the mid 1960s. Working with CIMMYT is allowing access to germplasm potentially resistant to scab from around the world that might not otherwise be possible, said Rick Ward, Michigan State University wheat breeder and co-chair of the Initiative.

Twelve countries were represented at the Cincinnati FHB Forum: Australia, Brazil, Canada, Czech Republic, Germany, Hungary, Japan, Mexico, Romania, Belgium, Uruguay, and the U.S. A number of crop scientists from other countries presented FHB reports and updates on FHB research. For example, researchers in Brazil have found that FHB is capable of causing damage in soybeans. They even suggest a name—fusarium pod blight—to describe the disease in soybeans.

A comprehensive report of research conducted under the U.S. Wheat and Barley Scab Initiative and discussed at the Forum in Cincinnati is available in the 2001 National Fusarium Head Blight Forum Proceedings on the Internet at: www.scabusa.org. Click on the link, "annual forums." ■

Carson New CDL Research Leader

Martin Carson recently accepted the position of research leader at the USDA-ARS Cereal Disease Laboratory in St. Paul. He replaces Kurt Leonard, who retired. Carson joined the CDL February 11, 2002. Most recently, Carson was supervisory research plant pathologist in the USDA-ARS Plant Science Research Unit at North Carolina State University. In addition to administrating and coordinating CDL research activities, he will carry out his own research projects, including FHB. The CDL has major research programs on FHB and cereal rust diseases. More information about CDL research may be found on the web: www.cdl.umn.edu. ■

Characterizing and Developing FHB Resistance in Barley

It is widely agreed that deployment of resistant cultivars is a key means by which to reduce and minimize the effects of FHB. However, finding and analyzing potential sources of resistance might be compared to finding a needle in a haystack.

For example, over the past five years, barley researchers in the Northern Plains have evaluated over 10,000 barley lines or accessions for resistance to FHB, but less than 30 have exhibited a useful level of resistance for breeding, according to University of Minnesota plant pathologist Brian Steffenson. Additional evaluations have been made on these 30 accessions in St. Paul in 2001, and only 10 consistently exhibited moderate FHB and deoxynivalenol (DON) levels (see table on next page).

Barley breeders can only accommodate three to five resistance sources in their FHB program, he says, and to effectively identify and exploit the very best sources of FHB resistance for breeding, controlled greenhouse evaluations are being made on the 10 barley accessions selected for resistance in the field. These selected accessions will be analyzed for resistance type (i.e. resistance to initial infection and to spread), pathogen growth and DON accumulation.

Pyramiding genes from the most resistant accessions will facilitate development of malting barley cultivars that yield well and accumulate low DON levels under FHB epidemics, says Steffenson.

The U.S. Wheat and Barley Scab Initiative has supported traditional breeding efforts and research to map the positions of genes that provide resistance to FHB, says Kevin Smith, U of M barley breeder.

A relatively new type of marker, simple sequence repeat (SSR) markers, is being used to enhance barley genetic mapping efforts. These markers are well suited for application in a breeding program, and in the past year, approximately 52 SSR markers have been added to maps devel-

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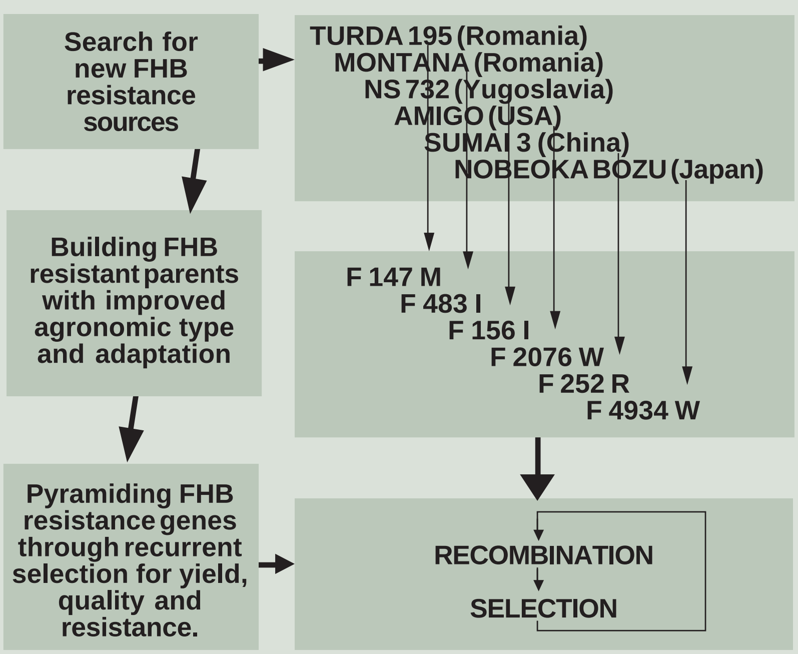
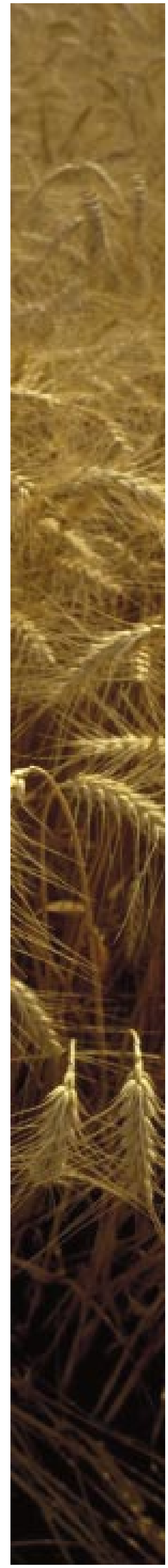
Progress in Breeding for FHB Resistance in Romanian Wheat

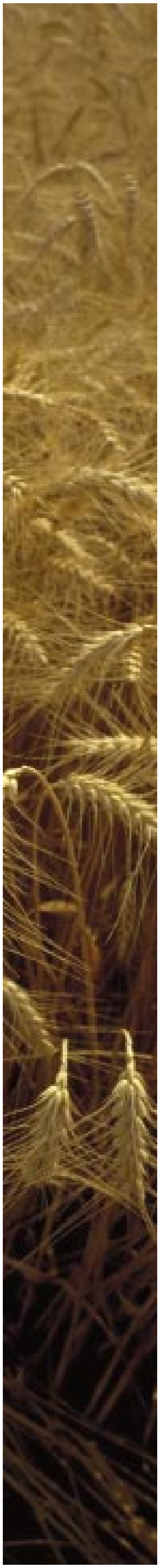
Marianna Ittu, a highly regarded crop scientist from Romania, was a keynote speaker at the 2001 Cincinnati Forum, and discussed her strategies in breeding winter wheat for scab resistance, as well as developing more reliable methods of screening FHB. The primary steps and sources of resistance used by Ittu are summarized in the following diagram. After the Forum, Ittu traveled to the University of Missouri, where she and U of MO. wheat breeder Anne McKendry shared and compared information on their wheat breeding techniques. ■

Marianna Ittu

Breeding Wheat Resistance to FHB in Romania
Main Steps and Sources of Resistance Identified







Progress In The Biotech Research Area For FHB Resistance

Projects funded under the Biotechnology Research Area of the U.S. Wheat and Barley Scab Initiative cover three main areas of research: 1) transformation, 2) gene discovery, and 3) gene mapping.

Transformation

Transformation of wheat, barley and durum is underway in a number of labs, and preliminary results from greenhouse and field testing for FHB and DON are beginning to show the effects of these genes.

Research conducted by Subbaratnam Muthukrishnan's group at Kansas State Univ. primarily focuses on identifying pathogen-related (PR) proteins from Sumai-3 and incorporating them into wheat germplasm by genetic engineering. Twenty-six independent transgenic lines with single or combinations of genes encoding PR–proteins were generated and screened for the presence and expression of the transgenes. Four of these lines showed stable high-level expression, and were screened for resistance against FHB. One line with a chitinase/glucanase combination was identified which showed 40-50% increased resistance when compared with the parental line (Bobwhite) and the resistant check (MN99112). A field trial is planned this spring with appropriate checks for this line.

Gary Muehlbauer's group at the Univ. of Minnesota has been developing novel wheat and barley germplasm for FHB resistance via genetic engineering. Through collaborations with Ann Blechl (USDA-ARS, Albany, CA) and Richard Zeyen (Univ. of MN), they obtained a large set of plant transformation plasmids carrying a promoter driving antifungal protein gene expression. They developed transgenic wheat plants which have been planted in the greenhouse and will be screened for FHB resistance.

Researchers at the Univ. of Nebraska also are testing transformed wheat. Their lead candidate transgenes continue to perform well in greenhouse FHB tests, and they are increasing seed to test these lines in the field using a mist inoculation system. The transgenic event does not

FHB severity (%) and DON concentration (ppm) of the 10 most resistant six-rowed barley accessions identified in the field at St. Paul, 2001.

	Field 2001 St. Paul	
Accession	**FHB**	**DON**
CIho 9114	4.5	11.6
CIho 11526	6.0	—[2]
CIho 6613	2.9	9.2
CIho 4530	2.8	16.0
CIho 4095	2.9	12.2
Chevron[1]	3.4	3.6
Stander[1]	5.3	35.6
CIho 4196[1]	4.4	12.8
CIho 9699	9.8	17.2
PI 328642	9.9	10.0
PI 370919	5.4	3.7
PI 371317	2.3	7.4
PI 565567	0.7	6.0
Chevron[1]	3.4	3.6
Stander[1]	5.3	35.6
CIho 4196[1]	4.4	12.8

[1]Chevron (CIho 1111) and Stander (PI 564743) are resistant and susceptible six-rowed controls, respectively. CIho 4196 is the resistant two-rowed control.

[2]Not tested.

Barley • *from page 3*

oped in the lab, Smith says.

"It is clear from our research on resistance to FHB in barley that multiple genes from multiple sources of resistance will be necessary to attain levels of resistance that are needed to make barley production profitable," says Smith. "To reach that goal, we intend to map with DNA markers as many genes as we can identify and use these markers to accumulate these genes in superior malting barley lines."

This past year, a new mapping population has been constructed consisting of 243 lines. "We have begun to screen markers that will be placed on this map and will begin field evaluations of the population in the summer of 2002. This overall effort to improve molecular marker tools should help us to enhance our traditional breeding effort by combining multiple resistance genes to provide higher levels of FHB resistance in barley," says Smith. ■

provide the level of resistance that is found in Alsen (formerly ND2710), but may be a complementary resistance mechanism that can enhance the resistance found in Alsen from Sumai 3. This transgenic line has been crossed to Alsen (to see if the level of resistance in Alsen can be enhanced), to Wheaton (to see how the transgene might enhance resistance in a very susceptible line), and to winter wheat lines to begin putting their lead transgenes in commercial backgrounds. As programmed cell death may be involved in many diseases and also in stress tolerance, they also will be testing these lines to determine if they have other disease or stress tolerances.

A collaborative project between North Dakota State University and USDA-ARS in Fargo, ND, has been inserting putative toxin resistance genes into barley. Lines expressing *Tri101*, which acetylates DON to a less toxic form, and *PDR5*, which transports DON out of cells, were tested in the field in 2001. Preliminary data indicate that some lines with each gene showed decreased FHB levels, but only lines with PDR5 had reduced DON concentrations. The same lines are now being tested in the greenhouse, and the best lines from all the disease tests will be evaluated in replicated field trials this summer. Additional transgenic barley lines carrying combinations of these genes plus various antifungal genes are under development.

Additional transformation research for FHB resistance is underway in barley at Ron Skadsen's USDA-ARS laboratory in Madison, WI, and at Peggy Lemaux's lab at UC Berkeley in collaboration with Phil Bregitzer (ARS, Aberdeen, ID). Additional wheat and durum transformation projects are being led by Ann Blechl (ARS, Albany, CA).

Gene Discovery Research

Gene discovery research is underway in several laboratories with the goals of providing additional genes for transformation and better understanding of the mechanisms of resistance to FHB.

The primary objective of FHB research at the USDA-ARS Mycotoxin Research Unit in Peoria, IL, is to identify and isolate genes that are promising candidates for providing wheat and barley increased resistance to *Fusarium*. A secondary objective is to develop a model plant transformation system for the rapid screening of toxin resistance genes.

Since toxins are virulence factors in wheat head blight, they hypothesize that an increase in resistance to these toxins will provide the plant greater resistance to FHB. Sources of toxin resistance genes include microorganisms which themselves produce a toxin, as well as plant material that shows a limited amount of toxin resistance. They have inserted genes from the semi-resistant wheat cultivar, Frontana, after it had been exposed to DON, into yeast that are sensitive to toxin. After plating the transformed yeast onto toxin-containing media, they selected yeast transformants carrying toxin resistant genes, sequenced the genes and compared them to existing sequences in GenBank. Collaborative studies with Gary Muehlbauer are underway to determine the method of providing the toxin resistance. Perhaps the overexpression of these genes in wheat will someday provide the plant with increased resistance to fungal invasion.

Due to the lengthy process of transforming wheat and barley and then testing for expression of the gene of interest, they also are developing *Chlamydomonas*, a single-celled plant, as a model plant transformation system. They propose to transform this plant with the *Fusarium* toxin-resistance gene, *Tri101*, and measure the transformant's ability to resist the harmful effects of toxin. A successful transformation system such as this one will

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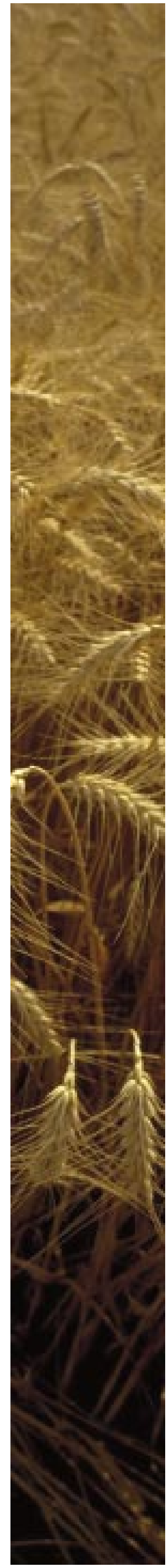

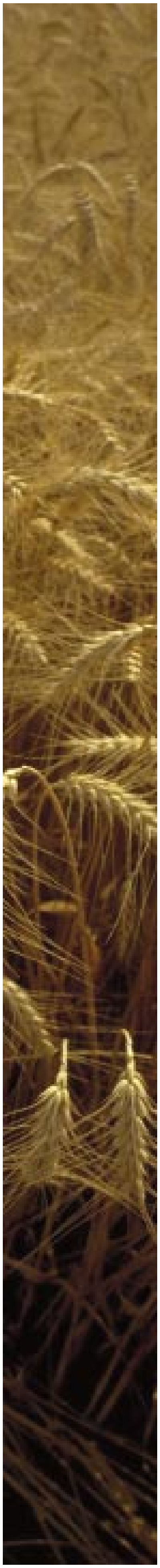

Biotech • *from page 5*

allow rapid screening of hundreds of toxin resistance genes in a model plant system.

Muehlbauer's group also has established a genomics approach to identify mechanisms and essential genes for FHB resistance in wheat and barley. They developed a cDNA library from Sumai 3 wheat spikes spray-inoculated with *F. graminearum* and are having Dr. Olin Anderson's laboratory (USDA-ARS, Albany, CA) sequence 10,000 expressed sequence tags (ESTs) from this library. To date, approximately 5,000 ESTs have been generated by Dr. Anderson's laboratory (http://wheat.pw.usda.gov/NSF/).

They also collaborated with Tim Close (Univ. of California-Riverside) to develop a barley library from the cultivar Morex, spray inoculated with *F. graminearum.* Rod Wing (Clemson University) has sequenced 5,000 ESTs from this library. They used the 5,000 wheat and 5,000 barley sequences to investigate gene expression in wheat and barley after inoculation with *F. graminearum*. The EST sequences they are generating, along with an effort to catalog all of these sequences, will provide a rich resource for identifying molecular mechanisms and essential genes for FHB resistance. In addition, this information will be used for obtaining novel genes for their genetic engineering work to enhance FHB resistance in wheat and barley.

Other related work in Muehlbauer's lab involves studying the interaction between wheat and the pathogen. This work was a collaboration with Carroll Vance, Bill Bushnell and David Somers, also at the Univ. of MN. They found that the fungus infects through multiple pathways, indicating that the fungus can interact with wheat flowers in a variety of ways. In addition, wheat induces a large set of defense response genes in response to infection.

In a companion set of experiments, they examined the genetic responses in uninfected portions of the plant. That is, do infected cells alert uninfected cells to signal a threat from the fungus? They found that, indeed, this does occur. They also examined the effect of benzothiadiazole (BTH) on gene expression and FHB resistance. BTH has been shown to induce a set of genes that are associated with conferring resistance to a variety of pathogens. They found that BTH does induce these same genes in wheat spikes, but that FHB resistance was not conferred.

Guihua Bai's lab at Oklahoma State University also is conducting a genome-wide analysis of gene expression in response to infection by *F. graminearum* to discover novel genes for FHB resistance, and provide insight into further understanding of genetic mechanisms of wheat resistance to FHB.

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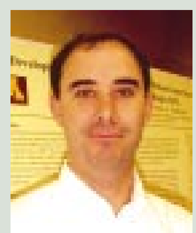
New Wheat Geneticist Focusing on FHB Research Effort

David Garvin joined the USDA's Agricultural Research Service in St. Paul as wheat geneticist last fall. He replaced Bob Busch, who retired in June 2000. Busch had been USDA-ARS wheat geneticist and U of M wheat breeder since 1978. Jim Anderson assumed the reins of the U of M's wheat breeding program in 1999.

As a wheat geneticist, Garvin is focusing his efforts on studying the type, number and location of genes that code for desirable and undesirable genes that exist within the plant. This information can then assist the wheat breeder in developing new varieties that possess desirable characteristics, and omit undesirable ones. Having two scientists focusing on these objectives, rather than one, will result in broader coverage of research issues in wheat improvement, he says.



David Garvin

Working in cooperation with other crop scientists, Garvin's research will focus in large part on genetic and molecular aspects of FHB resistance in wheat. "In addition to characterizing existing FHB resistance genes, we are also interested in the possibility that there may be genes in wheat that suppress the action of known FHB resistance genes. If so, this may provide new avenues for enhancing FHB resistance in wheat that complement ongoing research by others," he says.■

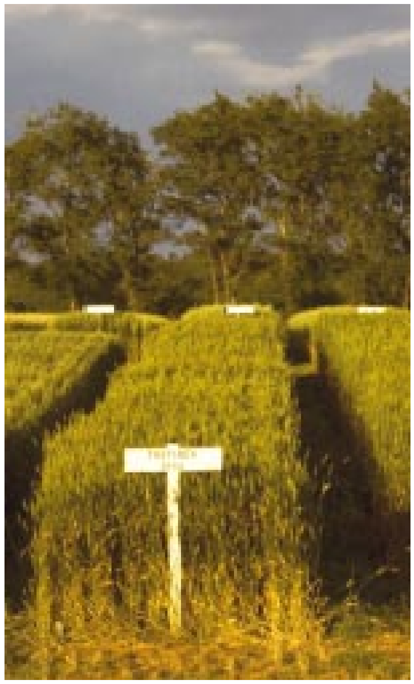
A Snapshot of Wheat Research From Across the Nation

Close to 50 wheat research projects are outlined in the proceedings booklet of the 5th annual National Wheat Industry Research Forum, held earlier this year and sponsored by the National Association of Wheat Growers and the Wheat Industry Resource Committee. The proceedings may be obtained through the NAWG office, ph. 202-547-7800, and may also be posted on the Internet at www.wheatworld.org.

Following are summaries of some of the research findings as they relate to FHB research. Crop scientists working on FHB research or other wheat-related projects are encouraged to submit reports for the proceedings or participate in the forum in the future. Russ Karow, Oregon State University, was coordinator of the 2001 NWIR Forum. Proceedings were coordinated by Ron Madl and Susan Kelly, Wheat Research Center, Kansas State University.

Consortium Aims for Marker-Assisted Selection Research, Outreach

A national wheat Marker Assisted Selection (MAS) consortium has been established involving 12 wheat breeding and research programs across the U.S. The consortium's objectives are to: 1) Enhance market demand of U.S. wheat classes through end-use quality improvements; 2) Reduce pesticide use in wheat production through improved host plant resistance; 3) Strengthen MAS as a cultivar improvement tool by enhancing current DNA markers; and 4)



Enhance public awareness of the potential of biotechnology for providing a stable and safe food supply.

Molecular markers are particularly useful for incorporating genes that are highly affected by the environment, genes for resistance to diseases that cannot be easily screened for, and to accumulate multiple genes for resistance to specific pathogens and pests within the same cultivar, a process called gene stacking or pyramiding.

The research consortium is using available molecular markers to transfer 24 genes for resistance to rusts, virus, and insect pests, and 17 gene variants related to bread, pasta, and noodle quality into 328 adapted varieties or breeding lines belonging to all major market classes of U.S. wheat.

Recent progress in the area of wheat genomics has been cited as the beginning of a new "Green Revolution," but these discoveries need to be implemented in new cultivars to realize that potential.

Adding FHB Resistance without Losing Stem Rust Protection

The only real solution to solving Fusarium head blight in wheat appears to be in breeding varieties that are resistant. Fortunately, sources of resistance to FHB are available, but some sources of good resistance to FHB are in wheats susceptible to wheat stem rust, a disease threat potentially as werious as FHB. The widespread use, in several major spring wheat breeding programs, of germplasm resistant to FHB but highly susceptible to stem rust raises the risk that a stem rust susceptible wheat might become widely planted, invoking the specter of a future major rust epidemic.

To gauge this risk, researchers in the North Dakota State University Departments of Plant Pathology (Bob Stack, Dennis Tobias) and Plant Sciences (Richard Frohberg, James D. Miller) tested 14 FHB resistance source lines for reaction to 14 pathotypes of wheat stem rust. Breeding lines included ones from China, Japan, Brazil, Mexico, and Hungary. NDSU included past and present prevalent stem rust pathotypes and several potentially threatening ones.

This stem rust test was done after previous results showed that one source line of FHB resistance, "Sumai 3," was highly susceptible to many races of stem rust. Seedlings of each breeding line were tested for stem rust

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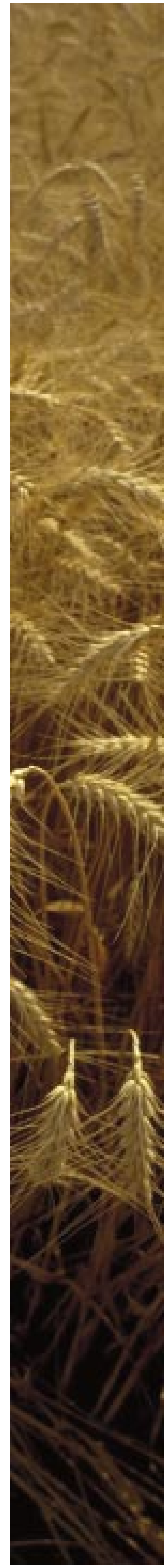


Stem Rust • *from page 7*

reaction using standard methods of inoculation and scoring for infection type. Resistant checks and a universal rust-susceptible check were always included. Most of the FHB source lines were of an intermediate type: susceptible to some stem rust cultures and resistant to others.

Four lines were resistant to all 14 stem rust cultures in the test; three of these lines were from China (W9207, Ning 7840, and Busch CG-29) and one was from Brazil (BR19). The strain of Sumai 3 that has been widely used for FHB resistance breeding in the spring wheat region was susceptible to 13 of the stem rust cultures and showed a mixture of resistant and susceptible reactions to the 14th rust culture.

Wheat breeders need to be aware that lines derived from exotic FHB resistant parent sources should be thoroughly screened for stem rust reaction prior to release. Growers ready to buy seed of new FHB-resistant wheats should carefully check whether the line has been fully tested for stem rust resistance.

These results indicate that there is no biological or genetic reason why wheat cannot be resistant to both FHB and stem rust. Adequate testing by originators and appropriate caution by growers should avoid any future problems.

Pre-harvest Grain Sampling for Early DON Detection

Deoxynivalenol (DON) contamination of grain because of Fusarium head blight (scab, FHB) is uneven from field to field and within a field. Widespread epidemics of FHB occurred in Michigan in 1996, 2000 and 2001. The 1996 epidemic was severe, and no Michigan wheat (soft white) was used to process into products for human consumption. Although the 2000 FHB epidemic appeared to be mild, wheat processors (General Mills, Kelloggs, Jiffy Mix) indicated that 50% of the wheat they normally use from Michigan had to be imported because of high DON levels.

The high levels of DON were not consistent with scouting which indicated a low incidence and severity of FHB. In 2001, DON levels were lower than predicted from the incidence and severity of the FHB in the field, but still presented problems to processors because of the variability of DON in the delivered grain. Therefore, an important aspect of DON management is early detection and quantification.

The poor correlation between FHB incidence and DON levels in Michigan wheat in 2000 and 2001 suggested a need to develop in-field sampling protocols to reliably estimate DON prior to harvest. Previous studies analyzing wheat collected immediately after harvest by using commercial probes to sample grain in trucks showed that increasing the number of probe samples increased the accuracy of the estimate of DON.

A minimum of four individual probe samples per truck was recommended to accurately estimate truck levels of DON. However, estimating DON levels pre-harvest has several advantages in light of: 1) most processors of white winter wheat have lowered the levels of DON they will accept in fresh grain from 3 ppm to 1.5 ppm and below, and 2) the length of time required to collect probe samples from trucks and analyze the grain after harvest. In-field sampling of wheat prior to harvest to determine levels of DON could gain wide acceptance.

Based on our preliminary studies, in-field sampling and testing of grain from pre-harvest wheat could provide information on DON levels that is useful to growers, elevators and millers. ■

– Patrick Hart, Department of Plant Pathology and the Center for Integrated Plant Systems, Michigan State University; Oliver Schabenberger, Department of Statistics, Virginia Tech University.

Investigating How FHB Infects the Heads of Wheat and Barley Plants

W.R. Bushnell, ARS-USDA Cereal Disease Laboratory, St. Paul, along with Sharon Lewandowski, junior scientist, University of Minnesota, have conducted research to evaluate possible pathways of entry by *Fusarium graminearum* into heads of barley and wheat. Past work in our laboratory and elsewhere indicates that the outer surfaces of individual florets in wheat and barley spikes have thick-walled epidermal cells. The FHB fungus cannot penetrate these armored epidermal cells. If, however, the fungus can gain entry into the interior of florets, which is lined with thin-walled epidermal cells, it can readily penetrate and invade interior tissues.

Therefore, Bushnell is trying to find out how the fungus gains access to the floret interior. The principal postulated pathways of entry into florets are: 1) stomatal openings on the exterior surfaces of florets; 2) crevices between the lemma and palea, the two overlapping structures that enclose the floret; and 3) the mouth at the apex of the floret.

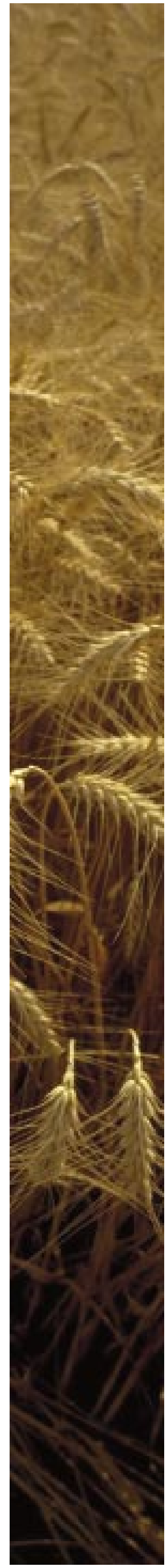
In 2001, Bushnell evaluated each of these pathways. Results suggest that stomates are not a major pathway of entry, at least not the stomates on the lemma and palea of the barley floret. Busnell and Lewandowski confirmed that the lemma-palea crevice as a pathway of entry and highlighted the importance of the palea as a site of initial colonization. Further, that the mouth at the floret apex provides an avenue for fungal growth into the interior of the floret. Overall, the results demonstrate the ability of the FHB pathogen to colonize floret surfaces under field conditions. Preliminary results also suggest that the fungus may be obtaining nutrients from floret surfaces which promote fungal growth.

In 2002, Bushnell will follow up investigation of floret invasion with both laboratory and field experiments to confirm these results. Bushnell will investigate fungal penetration of thin-walled epidermal cells in the floret interior. This research was done in conjunction with an investigation (funded by the U.S. Wheat and Barley Scab Initiative) of the effects of DON in the development of FHB, and the physiological response of a wheat or barley plant to infection.

In related research, Bushnell and University of Minnesota junior scientist, Tina Seland, found that DON induces rapid and complete loss of chlorophyll and carotenoid pigments in detached barley leaf segments. This bleaching response is light dependent and not closely associated with leaf cell death. In addition, at low concentrations, DON induced reddish-brown pigmentation in leaf segments. These results indicate that some of the bleaching and browning in spikes typical of FHB may be a direct effect of DON. ■

Fungal Pathways into Florets

Pathway	Conclusion
Direct penetration of exterior epidermal cells	Fungus cannot penetrate thick-walled epidermal cells.
Penetration of stomates	Has minor role, except possibly for the wheat glume.
Floret mouth	A major pathway for infection.
Anthers	Caught anthers help the fungus enter via the floret mouth.
Crevice between palea and lemma	A major pathway for basal one-third of barley florets.

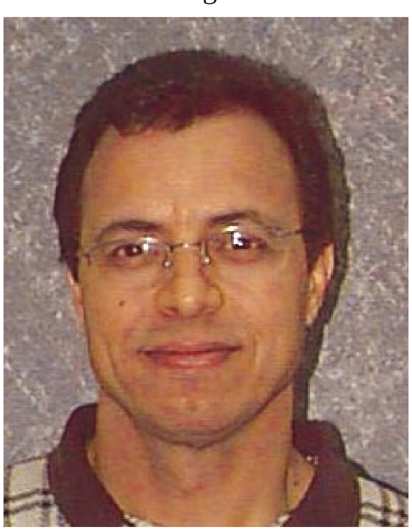


"Interact With Growers and Listen To What They Have To Say"

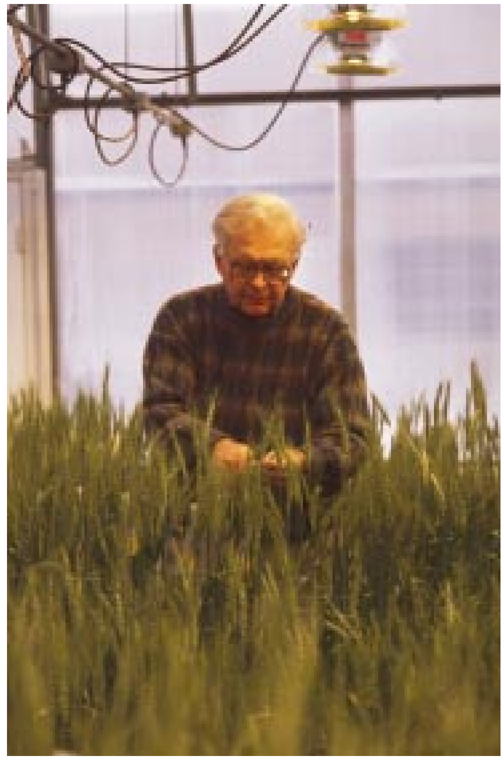
That mantra has guided North Dakota State University spring wheat breeder Richard Frohberg for over 36 years. Frohberg retires in February, 2002. Over his career, he developed 21 hard red spring wheat cultivars and 1 hard white spring wheat cultivar.

Frohberg sums up the biggest challenge he faced during his career in three words: "Fusarium Head Blight." He says that FHB or scab "has been a real challenge because of its urgency." He talks about the millions in losses in the spring wheat economy due to scab, and how it has even played a factor in some families getting out of farming, and affecting whether some young people will get into farming. As a coup de grâce to his breeding effort directed against FHB, Frohberg developed the cultivar Alsen, released in 2000, which is the first cultivar released by NDSU with FHB tolerance.

He believes there are two imminent challenges to the future of wheat breeding. The first is



Mohamed Mergoum



Richard Frohberg

the emergence of patenting breeding material and processes that has evolved with the introduction of biotechnology. Even aside from public acceptance of biotechnology, Frohberg believes that patent protection issues will continue to be a real challenge for public breeding programs. A second challenge for wheat breeding, he says, is the emergence of molecular marker selection for wheat traits and developing efficient strategies for implementing them in breeding programs.

Frohberg is also concerned about an erosion of appropriated funding for wheat breeding research. This has created a necessity to rely on grant funding, which has very specific objectives that need to be followed. "The success of a good, productive breeding program should not be based on grant writing," he says, adding that a person can be a good wheat breeder and not necessarily a good grant proposal writer.

His advice to new wheat breeders, which he has already shared with his replacement, Dr. Mohamed Mergoum, is something he learned from producers at the beginning of his career. "Interact with growers and listen to what they have to say," he says.

Mergoum, originally from Morocco, started his position as NDSU's new hard red spring wheat breeder in late January, 2002. He received his Master's Degree at the University of Minnesota, under now retired barley breeder Dr. Don Rasmusson. Mergoum received his Doctorate from Colorado State University. Since 1982, Mergoum has held various positions in Mexico and Morocco as bread wheat, triticale, and durum breeder. He was recently Senior Scientist for winter wheat breeding with the International Maize and Wheat Improvement Center (CIMMYT) based at a CIMMYT research site in Turkey. ■

– By David Boehm

For more information about the U.S. Wheat & Barley Scab Initiative, visit www.scabusa.org

SDSU Introduces FHB Forecasting Model

South Dakota State University will have a Fusarium head blight forecasting model in place in the 2002 growing season to help producers fight the crop disease.

SDSU extension plant pathologist Marty Draper says the forecasting model will rely on weather information gathered partly with the help of cooperators working with SDSU. The model will use such factors as precipitation, temperature extremes and the period of leaf wetness or residue wetness to come up with a risk assessment for the area. Draper says that initially, SDSU plans to gather information in two to five areas in S.D. He says it's not certain yet whether the model will rely on data from spore traps.

Producers who catch FHB in time can partially suppress it by use of the fungicide Folicur, which can reduce the extent of the disease by up to 60% while also decreasing leaf disease. That can mean an additional five to 15 bushels an acre in those fields, Draper says.

The South Dakota Department of Agriculture, along with other Northern Plains states, is again requesting special label authorization from the Environmental Protection Agency to allow use of Folicur in small grains for the coming season. Draper says EPA is expected to grant that request.

Draper says producers will have to apply the information from the forecasting model to their particular situation. The risk will be different for fields that are in flower than for fields that are not flowering, for example, and fields with heavy residue from corn or wheat also carry higher risk.

Counting the costs of the fungicide and application costs, farmers can spend about $14 an acre battling FHB, says Draper. "This will not make a

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Gene Mapping

Molecular marker work includes the development of new simple sequence repeat (SSR) markers for wheat and using the SSR and other markers to locate genes associated with FHB resistance.

In addition to the gene discovery research, Guihua Bai's laboratory is working to develop molecular markers that can be directly used for breeding programs. Large-scale field screening for FHB resistance in wheat is difficult because environments significantly affect performance of the resistance genes. Marker-assisted selection (MAS) may provide a powerful alternative for evaluation of FHB resistance in the laboratory.

For efficient use in a breeding program, marker analysis should be inexpensive, technically simple and not require complicated instruments. Recently, Bai's lab developed such a marker called a sequence-tagged site (STS). The presence of this marker can increase FHB resistance at least 50%, and application of this marker will possibly make MAS in conventional breeding programs routine, and speed up the breeding process to enhance FHB resistance in wheat.

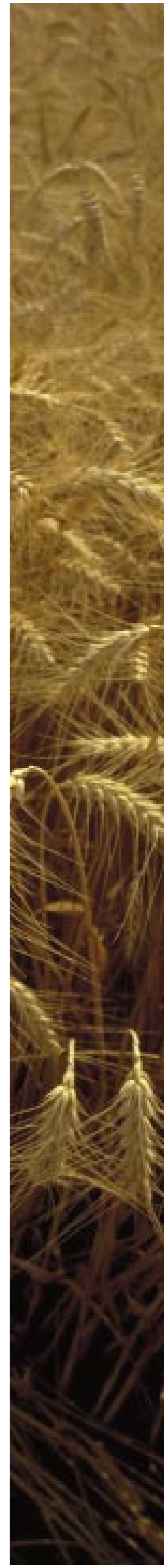
Bai also is examining molecular markers to characterize the genetic relationships among the FHB resistant wheat cultivars from different countries to provide useful information for avoiding unnecessary duplication and improve breeding efficiency. Test results indicate that U.S. cultivars are more closely related to cultivars from Europe and Argentina than cultivars from Asia; therefore, integrating FHB resistance from Chinese sources may increase the genetic diversity of U.S. wheat cultivars.

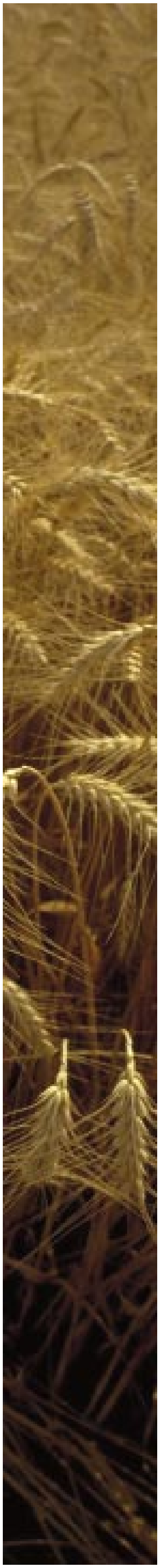
Kevin Smith's group at the Univ. of MN has also been examining SSR marker diversity among different barley FHB resistance sources (a summary of which is included elsewhere in this newsletter).

Steve Baenziger's group (Univ. Nebraska) has found that the molecular marker development work (specifically the creation of wheat microsatellites) is providing a very useful set of tools for the wheat community as a whole, not just for FHB resistance. Indeed, many aspects of FHB biotechnology research are providing tools and insights that are forming the framework for future wheat and barley improvement.

Numerous other mapping projecs are underway, and several other breeding programs are testing molecular markers in wheat and barley to increase the efficiency of selecting resistant lines. ■

–By Lynn Dahleen, USDA-ARS, Fargo, N.D., chair of the Initiative biotechnology research area. A more detailed version of this report can be found online at www.scabusa. com under the link, "Fusarium Focus." Additional information on these and other projects relating to biotechnology research funded by the USWBSI can be found in the 2001 National Fusarium Head Blight Forum Proceedings and elsewhere on the web site.





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decision for growers," says Draper. "What we hope this will do is help producers understand the risk and give them more information to make a decision."

South Dakota producers lost less than 1% of their crop to FHB this past growing season, says Draper, although some individual fields had damage of up to 50%. In some recent years the losses statewide have been greater than 5%.

UW Madison to Host Mycotoxin Short Course April 10

The Food Research Institute (FRI) at the University of Wisconsin is presenting a one day "Fungi and Mycotoxin Short Course" in Madison on April 10, 2002. Information and the registration form can be found on the Internet at:
http://www.wisc.edu/fri/
For more information, contact Ronald Weiss at the FRI,
Ph: 608-263-6826, email:
rweiss1@facstaff.wisc.edu ■

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. *Fusarium Focus* is compiled by Prairie Ag Communications, 2607 Wheat Drive, Red Lake Falls, MN 56750.

Histology Of Fusarium Head Blight Research

A listing of selected past research conducted on how FHB infects wheat and barley can be found online at www.scabusa.com under the link, "Fusarium Focus." The list was compiled by Bill Bushnell and referenced during his presentation, "What is Known About Infection Pathways in FHB?" at the 2001 FHB Forum. ■

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