



2021 Drought Conditions Minimize Fusarium Head Blight Impact Across the U.S.

By Dr. Amber Hoffstetter



Chris Sobieck of Douglas, ND, harvests his field of wheat after the crop experienced extreme drought conditions this season. (Chris Sobieck, Photo)

The 2021 wheat and barley season was one like no other in recent years. Hot and dry weather across most of the United States provided inadequate environmental conditions for the development of Fusarium head blight (FHB), caused by *Fusarium graminearum*. While the hot dry conditions also led to reduced yields for some states, other regions did receive rainfall but not at the appropriate times causing issues with pre-harvest sprouting and delaying fungicide applications and harvest. The [U.S. Wheat and Barley Scab Initiative \(USWBSI\)](#) reached out to state experts to gain their assessments on the 2021 FHB situation, their input is highlighted here by region.

Northeast Faced with Mixed Weather

(Malting Barley and Soft Winter Wheat)

In the Northeast region of the U.S., wheat and barley growing conditions were mixed. While areas of New England experienced moderate to severe drought and moderate to high yields of small grains, some areas received heavy rainfall during harvest causing issues with quality. In New York, the winter malting barley crop fared better than the spring malting barley crop and the soft winter wheat crop which both experienced issues with pre-harvest sprouting.

“Most of New England experienced dry and hot conditions throughout the early grain growing season,” said Heather Darby, extension agronomy specialist at the University of Vermont. “Mild winter temperatures led to excellent winter grain survival, and dry conditions in the spring of 2021 led to optimum planting dates for spring grains.” Many farmers reported planting small grains in mid-April.

However, things changed closer to harvest. “July was an extremely wet month for many states in New England with some areas receiving over 15 inches of precipitation and in some cases heavy winds that caused severe lodging. The wet conditions continued into harvest ending the season with lower quality grain than expected. Interestingly, other areas of New

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Heather Darby

England remained in moderate to severe drought conditions and reported moderate to high yields of small grains,” said Darby.

Fusarium graminearum infection rates really varied depending on location this season. “The levels of DON (deoxynivalenol; the mycotoxin that *F. graminearum* produces) from samples submitted to our testing lab have been very low from the Northeast,” Darby notes. “Of hundreds of samples evaluated at the University of Vermont’s commercial grain quality testing lab, roughly 22% of samples received had DON levels exceeding 1.0 ppm.”

For small grains in **New York**, 2021 was a tough growing season. Timely fall plantings of winter malting



Top Left: Moldy spring malting barley; Top Right: Sprout damaged spring malting barley; Bottom Left: Grain showing extensive fungal growth during micro-malting; Bottom Right: Molds growing from surface-sterilized spring barley grains on agar medium. (Daniel Sweeney and Jennifer Starr, Cornell University, Hannah Turner, Montana State University, photos)



barley generally yielded well, and harvest occurred before the rain came, notes Gary Bergstrom, professor of plant pathology at Cornell University. The winter malting barley crop had high quality, low pre-harvest sprout damage, and low DON levels. “Local maltsters were very pleased with the quality of this year’s local winter barley,” said Bergstrom.

By contrast, the spring malting barley crop was completely different. “Spring malting barley was nearly a total loss with sprout damage, moldy-appearing grain and, in some cases, DON contamination above limits for malting,” said Bergstrom. Bergstrom is conducting a survey of commercial barley crops for quality parameters, including fungal contamination, and examining additional mycotoxins, in hopes of providing more insight into the state’s malting barley growing season.

The state’s 2021 soft winter wheat crop was on target to be one of the best yielding, high quality crops on record. Many growers reported yields over 100 bu/acre, with excellent test weights (58-60 lbs.), and minimal DON contamination. Grain quality was ruined by pre-harvest sprouting damage, due to July rains that persisted through the harvest period. “Likely a quarter or more of potential loads were never trucked to mills because growers knew they had falling numbers well below 200,” said Bergstrom. Luckily, growers were able to avoid devastating economic losses due to the high prices for feed wheat, since the sprout damaged crop had little to no DON accumulation, and therefore, posed no risk to livestock health.

Mid-Atlantic States Saw Hot and Dry Spring Conditions

(Malting Barley and Soft Winter Wheat)



Malting barley emerges from boot during a dry spring at the USWBSI sponsored Integrated Management Trials in Lancaster, PA. *(Alyssa Collins, Penn State University, photo)*

Growing conditions in the Mid-Atlantic states were mostly hot and dry during the optimum time for FHB infection in small grains. This meant only a few small pockets received rainfall that resulted in issues with FHB and DON. Yields in the northern states were generally higher than those in the south where drought conditions reduced yields and test weights.

Conditions for FHB risk and disease development in **Pennsylvania** were highly variable this season. Grain yields in the commonwealth were overall, very good; but some issues with falling numbers were reported in many areas. “Central and

southern parts of Pennsylvania generally remained unscathed by FHB, apart from a few localized pockets of infection resulting in DON levels as high as 5 ppm,” said Alyssa Collins, associate professor at Pennsylvania State University and director of the Southeast Agricultural Research and Extension Center.



The USWBSI FHB Risk Tool's predicted risk was higher in the Northern and Western regions; however, the predicted risk did not always correlate with the actual FHB incidence and DON levels, said Collins. "The overwhelming majority of grain in these areas was very clean, and this may be reflective of the choice most farmers are making to apply fungicides at the appropriate times for FHB management." Over the last decade, efforts have been increased by extension professionals and allied agricultural industries to make the message about disease management known among growers.

Small grain crops in **Delaware** experienced a mild winter and received moderate rainfall in March keeping the fungal disease pressure quite low. Dry conditions prevailed in mid-April through May, the peak heading window. As a result, FHB risk remained low and very few cases of disease development were reported. "In my inoculated and misted plots, FHB incidence was 8% and no ratable FHB was observed in dryland plots," said Alyssa Koehler extension plant pathology specialist at the University of Delaware. "Scattered cases of Barley Yellow Dwarf Virus were noted, and we continue to observe varieties with fairly widespread physiological leaf spotting."

The dry conditions forced some growers to irrigate. Drought did limit the yield potential in some dryland fields. As grain reached maturity, high quality crops were observed throughout the region.

Maryland also experienced unusually dry conditions during the spring, especially during wheat flowering and barley heading. Some rain did fall towards the end of the growing season; but by then both crops were past the growth stage when typical infection occurs. "Overall FHB indices and DON content were not a major concern for small grain crops," said Nidhi Rawat, University of Maryland small grains pathologist. "The major focus of the general public in the state was the 17-year high population of *Cicadas* during springtime," added Rawat. While the insects did not pose a threat to the small grain crops, they did damage a significant percentage of the state's trees.

"There was one report of high FHB pressure in an irrigated field, but overall, the crop suffered more from drought stress than disease."

David Langston Jr.

Below average rainfall in April meant the risk of FHB in **Virginia** was low this year for small grain growers. Many regions saw little to no rain into May. "There was one report of high FHB pressure in an irrigated field, but overall, the wheat crop suffered more from drought stress than disease," said David Langston Jr., extension plant pathologist at Virginia Tech. "Many growers suffered low yields and test weights due to dry weather."



Southern Atlantic Met with Continued Dry Conditions

(Malting Barley and Soft Winter Wheat)

Farther south along the Atlantic, conditions remained dry for small grain crops. Hot dry weather during the key infection period meant few reports of FHB were received. Only a few cases where fields were at a medium risk for FHB were reported.

North Carolina experienced generally dry weather this year, and as a result, FHB risk was low “throughout the period of vulnerability for small grains,” says Christina Cowger, USDA-ARS plant pathologist located at North Carolina State University. There were “a few isolated pockets of medium risk” in the northeast corner of the state, however, they only appeared briefly. There are no reports of issues with FHB or mycotoxin contamination at grain intake points.

In **South Carolina**, similar weather patterns were observed. An abnormally dry spring resulted in low disease pressure for FHB. The wet winter conditions, followed by a dry April and May coupled with the lack of rain, resulted in yields being average to below average, despite the absence of FHB. “This weather pattern was unfortunate for growers as there was a 30% uptick in wheat acres from the 5-year average,” said Rick Boyles, Clemson University’s cereal breeder.

“Those acres that did receive rainfall or were irrigated to allow adequate grain fill should have resulted in the production of high-quality wheat without the threat of FHB and other fungal disease,” Boyles said. “Another abnormally dry spring in 2022 would be highly unexpected based on recent trends in high rainfall during the months of April and May.”

Wet and humid conditions in **Georgia** did not coincide with the flowering time for soft winter wheat, said Alfredo Martinez, University of Georgia small grains extension plant pathologist. Throughout the season, the USWBSI FHB Risk Tool predicted low risk. “An untimely frost in early April caused damage across the state, affecting early headed varieties, and possibly preventing early FHB infections.” Planted and harvested wheat acres were down and combined with unfavorable environmental conditions, the result was few samples reported with FHB this year.



University of Georgia (UGA)’s Scab nursery with mist irrigation in Plains, GA. Screening material includes UGA germplasm and SUNGRAINS germplasm. *(Mohamed Mergoum, University of Georgia, photo)*



Midwest Marked by Varied Circumstances

(Malting Barley & Soft Winter Wheat)

The 2021 Midwestern small grains crops were really a mixed bag and FHB risk varied across the Midwestern states. Some states had perfect weather conditions during heading and flowering that were conducive for FHB infection, though Missouri was the only state to report major issues related to FHB this season. Michigan experienced prolonged rain during harvest causing quality issues, though many states reported excellent wheat crops. Overall, FHB was generally not a concern for growers in the Midwest.

As predicted by the USWBSI FHB Risk Tool, the probability of FHB infection for small grains during the critical period remained low in **Michigan**. “Subsequently few issues with mycotoxins were reported post-harvest,” said Martin Chilvers, extension plant pathologist at Michigan State University. “However, we did have significant prolonged rainfall as the crop ripened which led to delays in harvest and some quality issues.”

“Statewide winter wheat disease pressure, in **Wisconsin**, was the lowest it’s been in several years,” said Damon Smith, extension plant pathologist at the University of Wisconsin. “The hot, dry weather during much of stem elongation, flag leaf emergence, heading, and anthesis stages, meant that infection was low or non-existent by the primary pathogens of wheat.” These conditions kept FHB at bay for growers in the state, and the disease was only observed by Smith on a “handful of heads” at several location visits this year.

Other diseases, such as Septoria leaf blotch and stripe rust, were also only found at a few locations at low levels. Powdery mildew, which thrives in cool, dry, and humid conditions, was the exception and could be found on some susceptible cultivars. “For the most part the powdery mildew pathogen was slowed, once daytime temperatures were consistently above 81°F,” said Smith.

“Extended grain-fill...coupled with adequate moisture and low disease intensity, resulted in one of the best wheat crops in recent years.”

Pierce Paul

In **Ohio**, cool weather conditions during anthesis led to low FHB and DON levels in most fields. This was consistent with predictions made by the USWBSI FHB Risk Tool. “Low FHB risk predictions did not prevent fungicides from being applied in several fields - Miravis[®] Ace or Prosaro[®] were the products of choice,” said Pierce Paul, extension plant pathologist at The Ohio State University. Most fields were harvested before it rained towards the end of the season, averting potential rain quality issues. “Extended grain-fill as a result of cool post-anthesis conditions, coupled with adequate moisture and low disease intensity, resulted in one of the best wheat crops in recent years,” said Paul. Overall, this year’s crop in Ohio had above average grain yields, decent test weights, and very good quality.



“Fusarium head blight was the major disease of wheat in **Indiana** in 2021,” said Darcy Telenko, extension plant pathologist with Purdue University. The forecasted FHB risk for the state remained low throughout early flowering (mid- to late- May). While FHB was found in many fields across the state, the disease pressure was lower than in recent years and “incidence and severity were highly dependent on variety and localized weather conditions,” said Telenko.



Hard red winter wheat versus soft red winter wheat yield trial in West Lafayette, IN. (Mohsen Mohammadi, Purdue University, photo)

University of **Illinois** small grains breeder, Jessica Rutkoski said, “This year in Illinois, Scab was generally not a problem.”

Some fields planted with susceptible varieties did report FHB outbreaks, but “many growers in Illinois are applying effective fungicides at flowering to help control the disease.”

Even with rain in some parts of **Kentucky** that coincided with flowering and grain development, high levels of DON were in general not an issue for Kentucky **crops** this season. “Wheat growers in Kentucky are doing a good job choosing varieties with improved levels of resistance to Scab and applying effective fungicides at the right timing,” said Carl Bradley, extension plant pathologist at the University of Kentucky. Bradley attributed these good production practices to reducing the impact of FHB in the state. While there were reports of sporadic fields with high DON levels, overall, the 2021 wheat yields were excellent.

The USWBSI FHB Risk Tool forecast moderate to high risk of FHB as a result of environmental conditions that were conducive to FHB development in the Western and Central regions of **Tennessee**, however very little FHB developed across the state. “The timely planting of wheat in the fall of 2020 and good growing conditions in the spring allowed most wheat to be just past bloom when the higher risk conditions occurred,” said Heather Kelly, extension plant pathologist with the University of Tennessee. “Furthermore, drier weather that finished out the season possibly helped to suppress FHB development as well as more tolerant FHB varieties being planted.”

Tennessee saw an increase in planted wheat acres this year, from 300,000 to 400,000 acres. In general, 75 to 80% of the planted acres make it to yield, while the rest is used as a cover crop; and this year was no exception. Increases in state yield this season, up 15 bushels per acre, compared to 2020, were a good indicator of the overall low disease pressure.

Cool weather and continuous rain during flowering resulted in FHB risk being high for most of the wheat growing region in **Missouri**. “Persistent rain resulted in many growers missing the window for fungicide applications entirely,” said Kaitlyn Bissonnette, extension plant pathologist at the

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University of Missouri. Growers using ground applicators had more difficulty making timely fungicide applications than those with aerial application capability.

As the winter wheat season progressed in Missouri, hot humid weather moved into the region and paved the way for other diseases including: Septoria leaf blight, stripe rust, leaf rust, tan spot, glume blotch, and Rhizoctonia root rot. “Following harvest, grain test weights were low in many areas and several grain elevators reported DON concentrations exceeding 5ppm,” said Bissonnette.

Southern States Adopted Practices Lowered Incidence

(Soft Winter Wheat)

Overall, FHB was not a problem in the Southern soft winter wheat region. The low levels of disease can be attributed to the adoption of varieties with moderate resistance and the increase in proactive fungicide applications.

“Several days of rain in southwest **Alabama**, immediately following flowering of early maturing varieties was conducive for Scab,” said Kira Bowen, Auburn University plant pathologist. The USWBSI FHB Risk Tool predicted high risk for the southwest part of the state in early April, however, commercial growers made only a few reports of FHB infections. Wheat in the rest of the state was at low risk throughout the critical infection period and very little, if any, FHB was reported by these growers, noted Bowen.

“Even in the wheat variety trials ... the levels of FHB observed were lower than years in the recent past.”

Tom Allen

The environment necessary to produce FHB and DON did not occur throughout the **Mississippi** wheat producing area this year. Though winter wheat acres were increased slightly, FHB related issues for producers remained low. “Even in the wheat variety trial plots, conducted by Mississippi State University across the state, the levels of FHB observed were lower than years in the recent past,” said Tom Allen, extension plant pathologist at Mississippi State University.

Arkansas’s winter wheat acreage increased substantially in the fall of 2020. This was mainly due to a rise in grain prices and good weather during the state’s optimal planting window, October. Coming out of winter, spring conditions were relatively wet, hindering the timely applications of top-dressed nitrogen for some producers, limiting yield potentials. “Fusarium head blight levels were generally low which can be partially attributed to the growing of varieties with moderate to good resistance,” said Jason Kelley, extension agronomist and Terry Spurlock, extension plant pathologist at the University of Arkansas. Additionally, more growers in the state are applying fungicides for FHB control, contributing to reduced cases, noted Travis Faske, extension plant pathologist at the University of Arkansas.

A few reports of susceptible planted varieties with substantial FHB incidence even in the presence of fungicide were received in Arkansas. High DON levels caused a few loads to be rejected and others to receive dockage fees for elevated levels. Prolonged rain at the beginning of June, caused sprouting damage, lowered test weights, and likely was the cause of increased



DON levels in the southern part of the state. Overall, the yields were slightly below normal in Arkansas.



Dr. Trey Price, Louisiana State University Agricultural Center, at a 2021 wheat field day.
(Stephen Harrison, Louisiana State University Agricultural Center, photo)

Louisiana's growing season presented many challenges this year. Wet conditions interfered with some grower's ability to plant and harvest. Despite the wet conditions, FHB incidences and severities were lower than last year. "This may be due in part to a cool spring, an increase in prophylactic fungicide applications, and varieties with better resistance to Scab," said Boyd Padgett, Louisiana State University Agricultural Center plant pathologist. Yields varied across the state and wet conditions contributed to low yields and test weights.

The soft red winter wheat region in northeast **Texas** experienced lower levels of FHB compared to previous years. "Scab was present but not widespread," said Amir Ibrahim, Texas

A&M University winter wheat breeder. This is probably due to the unfavorable weather conditions around flowering inhibiting infection by the fungus and many growers choosing to apply fungicides for stripe rust, which also offers some control for FHB. In the Central region of Texas, very little FHB was observed this season, said Tyler Mays, extension agent-IPM at Texas A&M University.

Northern Great Plains Experienced Extreme Drought

(Durum, Hard Winter Wheat, Hard Spring Wheat and Malting Barley)

Extreme drought conditions in the northern Great Plains prevented FHB from being an issue for most producers in the region. Lack of precipitation during heading and flowering meant FHB risk remained low during the developmental stages of hard winter wheat, hard spring wheat, malting barley, and some durum fields.

"**Minnesota** was too dry and too hot to allow FHB to even think about starting," said Jochum Wiersma, extension agronomist at the University of Minnesota. The weather got hotter and drier as the season progressed, with over half the state experiencing severe drought.

"Minnesota was too dry and too hot to allow FHB to even think about starting."

Jochum Wiersma

To the west, **North Dakota** growers received no relief. Relatively low humidity, higher than usual temperatures, and low amounts of precipitation in June resulted in a very low risk of FHB. For late-planted crops, these dry conditions continued into July, also reducing their risk of infection. "The only area of elevated Scab risk was for late-planted durum in a small pocket in



northwest North Dakota in mid-July,” said Andrew Friskop, extension plant pathologist at North Dakota State University. “Fungicide use this year was well below average, especially for small grain varieties that have moderate levels of resistance.” No reports from county extension agents and elevators concerning DON in spring wheat, durum, or barley were reported.



LeAnn Lux a graduate student at North Dakota State University, rates wheat plots in southwest, ND this year. (Andrew Friskop, North Dakota State University, photo)

This year’s drought also affected the **South Dakota** wheat crops. “The majority of the state was in a D2 or D3 category of the drought,” says Emmanuel Byamukama, extension plant pathologist at South Dakota State University. Due to the drought conditions, FHB was not an issue for most winter and spring wheat growers as very little disease developed. Moisture stress did however cause some growers to harvest their acres for hay rather than grain.

Montana’s small grains crops were also subjected to the extreme drought conditions this year. “Because of this it was far too dry for FHB disease development,” said Frankie Crutcher, extension plant pathologist at Montana State University. There are no reports in Montana regarding FHB observations/issues.

Great Plains Region Met with Isolated Occurrences

(Hard Winter Wheat)

For hard winter wheat growers in the Great Plains, FHB was more of an issue than those in the Northern Great Plains. Isolated occurrences were reported in Nebraska and Colorado, whereas Kansas, Oklahoma, and Texas all experienced more intense disease pressure in one or more regions.

Nebraska’s Scab prone regions are in the Southeast and South-central regions; however, FHB was only found at low levels in these areas. Stephen Wegulo, extension plant pathologist at the University of Nebraska, said he did receive one report of moderate to high FHB in a field located in southwest Nebraska, which was attributed to local rainfall coinciding with flowering time. “In general, the economic impact due to the disease or the associated mycotoxin, DON, was minimal.”

Overall, FHB was not observed in either wheat or barley in **Colorado**. “Cases of Scab typically occur at low levels in irrigated fields,” said Robyn Roberts, Colorado State University small grains pathologist, and this year was no exception. Roberts only received two samples that tested positive for Scab, both from western irrigated fields.



Areas of **Kansas** had above average or severe problems with FHB this season. “Disease surveys indicate that many areas of Eastern and Central Kansas had low to moderate levels of disease,” said Erick De Wolf, extension plant pathologist with Kansas State University. Growers in these regions plant resistant varieties and often make fungicide applications which likely contributed to disease suppression.

“...areas of West Central and Northwestern Kansas experienced severe problems with FHB in 2021,”

Erick De Wolf

Previously, FHB has not been a problem for western producers due to the dry conditions. This year the region received above average rainfall, coupled with extended periods of high humidity which created conditions conducive for FHB development during flowering. “As a result, some areas of West Central and Northwestern Kansas experienced severe problems with FHB in 2021,” said De Wolf.

Oklahoma State University small grains extension specialist Amanda de Oliveira Silva

said the variety trials at Afton, located in the northeastern part of the state, had high FHB incidence. Rotation with corn and moist environmental conditions contributes to disease development every year in this region of the state. “The biggest surprise this year was to find FHB at Kildare in North Central Oklahoma.” Levels of disease were so high, that determining the protein concentration using near-infrared transmittance spectroscopy was impossible.



Symptoms of FHB in the Texas A&M University misted Scab nursery at College Station, TX. (Amir Ibrahim, Texas A&M University, photo)

High levels of FHB, while not readily evident, were also found in the **Texas** hard winter wheat crop. The characteristic pink to salmon color that develops near the base of the affected glume(s) within 10 days after bleaching was noticeably absent, according to Ken Obasa, extension plant pathologist at Texas A&M University. *Fusarium* was recovered from all the grains tested for presence of the fungus in one instance. High DON levels caused some producers’ grains to be rejected by elevators in one of the counties in the Panhandle.



Northwest Region Experiences Hot & Dry Weather

(Malting Barley and Hard Spring Wheat)

Conditions in the Pacific Northwest tell the same story as seen in most other regions of the U.S., too hot and dry for *Fusarium graminearum* to infect the wheat and barley. Only a few cases were reported of high DON levels in malt barley. While conditions could have been problematic for growers with irrigated crops, high winds and lack of precipitation reduced disease development during heading and flowering.

While **Idaho** was significantly warmer than usual this season, FHB development was hindered by drought conditions. “In southern Idaho and areas of irrigated production in the Intermountain West, the warm conditions were very conducive to the development of FHB, but the dry winds and lack of thunderstorm activity during heading reduced disease development,” says Juliet Marshall, University of Idaho plant pathologist.

In the Magic Valley, a few instances of malt barley with either high or rejectable levels of DON were reported. Tested barley samples ranged from 1-2 ppm, but one sample of malt barley tested at 6 ppm DON. The Magic Valley area is prone to high FHB pressure because of the large acres of corn planted by dairy farmers that may serve as a source of inoculum. Molson Coors agronomists work closely with the state’s barley producers encouraging them to bury crop residues prior to planting, budget for fungicide use, and to plan for timely applications of fungicides.

FHB could routinely be found in eastern Idaho, near Ashton, and Marshall’s team collected isolates of the pathogen from this area. Warmer temperatures this year promoted infection, and DON levels in wheat after harvest above 5 ppm were reported. “In our screening nurseries in Kimberly and Aberdeen, disease development was lower than expected. Varieties that headed later, and then were rated later, did have more typical development of FHB.” Marshall attributed the ability to collect effective results from the screening nurseries to the ability to maintain high humidity using a mist-irrigation system.

“FHB risk in irrigated regions is increasing in Oregon....”

Christina Hagerty

Due to extreme drought conditions in **Oregon**, FHB risk was low in dryland production areas. “FHB risk in irrigated regions is increasing in Oregon due to increased corn production, specifically high-value hybrid corn contracts and increased commercial dairies,” said Christina Hagerty, **Oregon** State University cereal pathologist. OSU Extension is encouraging growers to incorporate a non-grass species into their crop rotations.



2021 Overall Challenging Conditions with Minimal FHB Incidence

Overall, the 2021 small grains season provided its own set of challenges to U.S. growers. While some fields did have FHB issues, most struggled through tough drought conditions that adversely impacted yields and test weights. Only a few regions of the U.S. received timely rainfall that sustained crops resulting in average to above average yields. Other regions were challenged with untimely precipitation promoting FHB, and/or contributing to harvest difficulties, including pre-harvest sprouting. Here's to hoping 2022 provides a different story for the United States' small grains producers. ■



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The USWBSI is a national multi-disciplinary and multi-institutional research consortium whose goal is to develop 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. The USWBSI's more than \$8.5 million annual budget comes from Federal funds appropriated through the USDA-ARS and is distributed to 150 research projects in more than 30 states.



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