PP-804 (Revised)

Plant Disease Management
NDSU Extension Service

Fusarium Head Blight (Scab) of Small Grains

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Figure 1. **FHB infected wheat with wheat head showing bleached spikelets.** (Photo by Marcia McMullen)

Fusarium head blight (FHB), or scab, is a fungal disease that can occur on all small-grain crops grown in North Dakota, but is seen most commonly on spring and winter wheat, durum and barley. FHB can cause significant yield losses and quality reductions. Yield losses in all crops occur from floret sterility; additional yield and quality losses can occur when shriveled, light test-weight kernels are produced as a result of infection. Quality reductions also may occur if fungal toxins (mycotoxins) are produced in infected seed. The toxins are unacceptable for certain end uses, so toxin-containing grain is downgraded at the market.

Symptoms

In **wheat and durum**, any part or all of the head may appear bleached (Figure 1). These white heads are very conspicuous in a susceptible variety (Figure 2). The partly white and partly green heads are diagnostic for the disease in wheat. The fungus also may infect the stem (peduncle) immediately below the head, causing a

Figure 2. Susceptible hard red spring wheat line with numerous FHB infected grain heads. (Photo by Shaobin Zhong)

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brown/purplish discoloration of the stem tissue. Additional indications of FHB infection are pink to salmon-orange spore masses of the fungus often seen on the infected spikelets and glumes during prolonged wet weather (Figure 3).

Many infected wheat and durum kernels are shriveled, lightweight and dull grayish or pinkish (Figure 4). These kernels sometimes are called "tomb-stones" because of their chalky, lifeless appearance. If infection occurs late in kernel development, Fusarium-infected kernels may be normal in size, but have a dull appearance or a pink discoloration. Infected kernels of durum often lose their amber translucence and appear chalky or opaque.

In **barley**, infected spikelets may show a bleached appearance or a browning or water-soaked appearance (Figure 5A, 5B). Severely infected barley kernels at harvest may show a pinkish discoloration (Figure 6). Although rare, salmon-orange spore masses of the fungus can be seen on the infected spikelet and glumes in barley during prolonged wet weather.

Figure 3. Salmon-orange spores of *Fusarium graminearum* visible on glumes of wheat. (Photo by Marcia McMullen)

Figure 4. Healthy durum kernels (left) and FHB infected durum kernels (right). Note chalky white to pink discoloration of infected kernels.
(Photo courtesy of Jim Miller)

Estimates of FHB levels in a field are based on counts of blighted heads or kernels. A colored visual scale to estimate severity of FHB in wheat is available from the NDSU Extension Service (publication PP-1095). Samples of entire diseased heads are helpful for confirmation of FHB. Grain suspected of containing scabby kernels also may be examined. Samples should be submitted to county Extension offices or the Plant Diagnostic Laboratory at North Dakota State University. The lab will process the samples for a nominal fee.

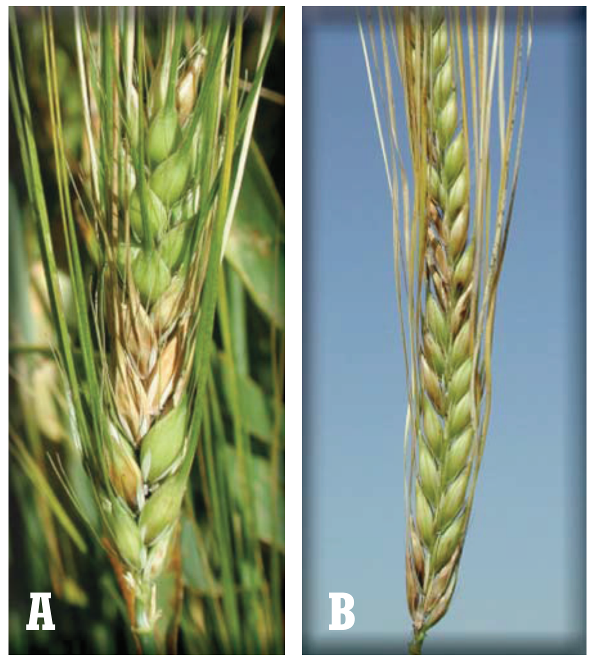


Figure 5A. FHB infected six-row barley.
Figure 5B. FHB infected 2-row barley.
(Photo 5A by Stephen Neate; Photo 5B courtesty of Yongliang Sun)

Figure 6. FHB infected barley kernels. Note pink discoloration caused by fungal infection and the blue-black structures which are the sexual stage spore-bearing bodies of the causal fungus.
(Photo courtesty of Paul Schwarz)

Causal Pathogens

FHB is caused by fungal species in the genus *Fusarium.* The most common species causing FHB is *Fusarium graminearum* (sexual stage – *Gibberella zeae*). This fungus is the same one that frequently is associated with stalk rot of corn. Another *Fusarium* species that causes FHB is *Fusarium culmorum*. Both *F. graminearum* and *F. culmorum* also may cause root rot of small grains. On barley, two other Fusarium species, *F. poae* and *F. avenaceum,* also may cause kernel blight.

Survival and Spread

The fungi persist and multiply on infected crop residues of small grains and corn (see disease cycle, Figure 7). During moist weather, spores of the fungi are windblown or splashed onto the heads of cereal crops. Spores can come from within a crop or can be blown from surrounding crops sometimes long distances away.

Wheat and durum crops are susceptible to infection from the flowering (pollination) period up to hard dough stage of kernel development. Spores of the causal fungus may land on the exposed anthers at flowering time and then grow into the kernels, glumes or other parts of the head. For spring barley, which flowers when the head is in the boot, infection is most common after the flowering period, once the head breaks through the leaf sheath. Infection in either crop may continue until close to grain maturity under favorable environmental conditions for the organism(s).

The most favorable conditions for infection are prolonged periods (48 to 72 hours) of high humidity and warm temperatures (75 to 85 degrees Fahrenheit). However, infection does occur at cooler temperatures when high humidity persists for longer than 72 hours. Early infections may produce air-borne spores, which are responsible for secondary spread of the disease, especially if the crop has uneven flowering due to late tillers.

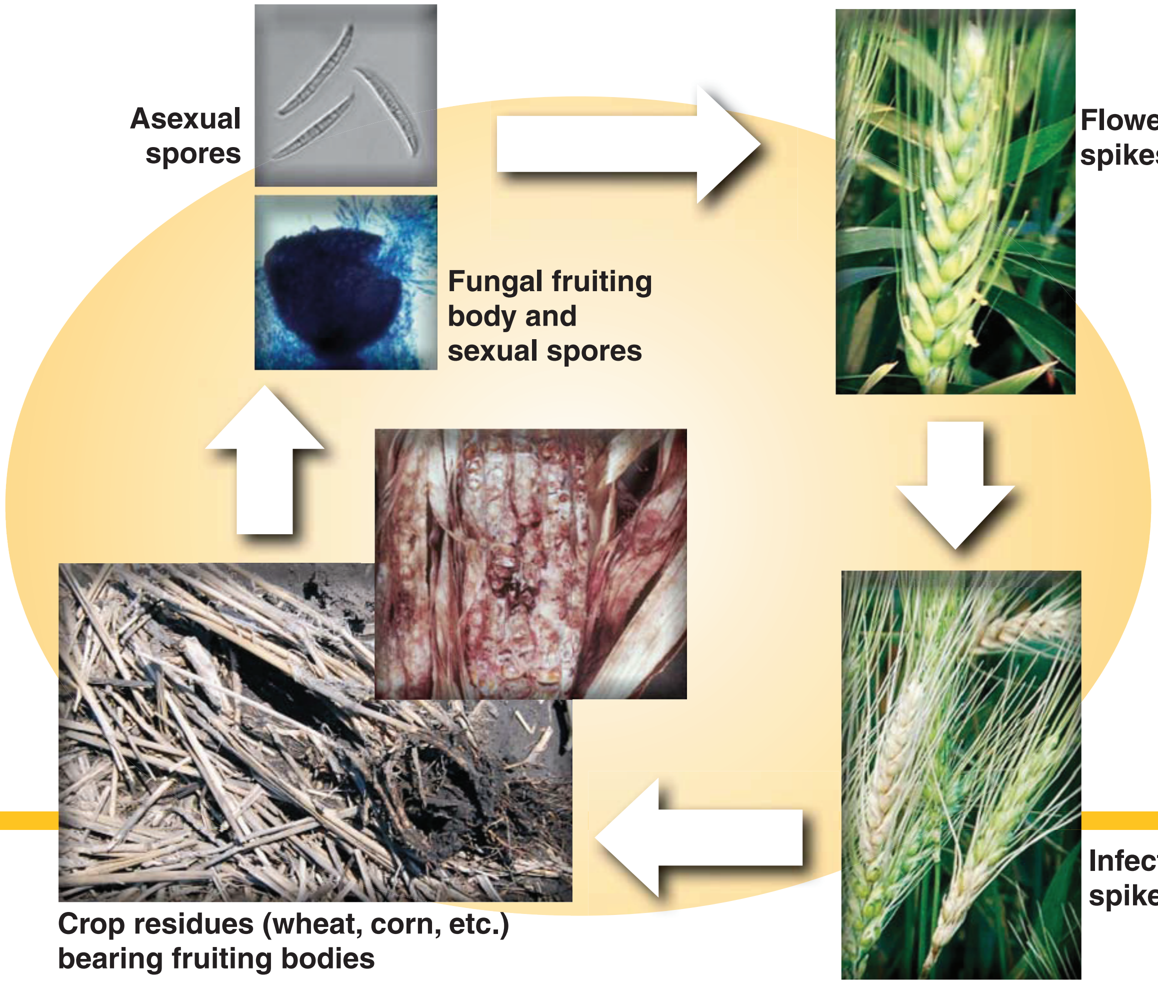


Figure 7. Fusarium head blight disease cycle.

(Life cycle composition by Shaobin Zhong; photos by NDSU Department of Plant Pathology)

Since FHB development depends on favorable environmental conditions from flowering (head emergence in barley) through kernel development, disease occurrence and severity varies from year to year. A combination of factors that may lead to the severest yield and quality losses are: abundant inoculum, prolonged or repeated periods of wetness and high humidity during flowering (head emergence in barley) through kernel development, and use of a very susceptible cultivar.

Management

FHB is best managed by integrating multiple management strategies. Use of a single strategy often fails when environment favors severe disease. Management strategies to reduce FHB should include a combination of as many of the following practices as possible:

Resistance

None of the available commercial cultivars is immune to *Fusarium* infection, but differences in reaction to FHB do occur. Two types of resistance, Type I and Type II, are widely recognized. Type I resistance reduces the number of initial infections and usually is measured by the number of infected spikelets following a spray inoculation. Type II resistance restricts spread of the fungus in infected tissue and is measured by the number of spikelets infected in a spike beyond an initial infection site (a single spikelet) inoculated near the center of the spike. Other types of resistance or tolerance also have been recognized in some wheat lines, based on the ability to resist kernel infection, to degrade mycotoxins (DON and others) or to maintain yield despite the presence of FHB (tolerance).

Improving FHB resistance is a high priority in wheat and barley breeding programs at NDSU and elsewhere in the region, and cultivars with various levels of resistance to FHB have been developed. Recently released spring wheat cultivars from NDSU, such as 'Alsen,' 'Steele-ND,' 'Glenn,' 'Howard' and 'Faller,' show much better resistance to FHB than those previously released, with incorporation of sources of resistance from Sumai 3 (a Chinese variety), *Triticum dicoccoides* (a wild tetraploid wheat) and/or native resistance germplasm. Several cultivars of private companies also have been released with improved FHB resistance.

Differences in resistance to FHB also occur among durum cultivars, but the level of FHB resistance in durum is less than in bread wheat.

Barley has natural Type II resistance to spread of the fungus in infected tissue. Barley breeding is targeted at developing Type I resistance and resistance to accumulation of DON. The University of Minnesota will soon release a cultivar that reduces FHB and DON by 50 percent on average, and North Dakota State University is prerelease testing lines with similar levels of resistance.

Producers in areas of high risk for FHB should select cultivars that have shown some level of resistance to FHB. The latest information on cultivar response to FHB is available in current NDSU variety trial publications and from county Extension offices.

Seed Treatment

Seed treatment and the use of high-quality seed will help reduce seedling blight due to infected seed but will not protect against subsequent head blight. If scabby grain is to be used as a seed source, it should be cleaned and conditioned thoroughly to remove the majority of scabby kernels and to improve test weight. A germination test should be run to indicate percent of germ and vigor of the seed. Seed treatment fungicides commonly used for small grains should be considered to improve stand and vigor of this seed.

Tillage

Tillage practices that bury residue from small grains or corn reduce the inoculum potential of the fungus because the fungus survives best on residue left on or above the soil surface. In minimum or no-till practices, effective spreading and distribution of chaff and other residue may allow faster decomposition of the chaff, reducing inoculum potential. Chopping or grinding corn residue to reduce the size of the remaining stalk pieces also may favor more rapid disintegration of infected tissue.

Crop rotation

Crop rotation is effective in reducing FHB levels. Crop rotation to a nonhost crop or planting of a small grain on last year's broad-leafed crop ground should be considered. The greatest risk of FHB infection is when small grains are planted on last year's FHB infected small-grain residue or on last year's corn residue. Species of *Fusarium* that cause FHB (and in particular *F. graminearum*) also attack corn, causing stalk, root and ear rot, and survive for several years in corn residue.

Planting date

Staggered planting of the small-grain crop or planting cultivars differing in days to maturity is advised; this reduces the risk of a producer's entire crop flowering or going through early grain fill during a period favorable for FHB infection.

Fungicide

A fungicide spray program may reduce FHB damage. Reductions in FHB severity of 50 percent to 60 percent can be achieved when fungicides are applied at early flowering for wheat and durum, and at early heading in barley. Triazole fungicides (fungicide resistance group 3) are recommended for FHB suppression because they are locally systemic and have been shown to reduce both FHB and DON. Federal registrations of several products in 2007 and 2008 provided wheat and barley producers additional products with very good efficacy against this disease. The table below lists products available as of 2008 for FHB suppression. The data is from the North Central Regional Committee (NCERA-184) of Small Grain Pathologists.

Application studies have shown that spray coverage and disease control with these fungicides is improved when the sprays are directed at an angle either both forward and backward toward the grain head, or with single nozzles directed toward the grain head, all at a 30-degree angle from the horizontal.

A multi-state scab forecasting model and a North Dakota forecasting model are available to help predict the risk of Fusarium head blight during the growing season. Use of these forecasting models helps in the decision to use or not to use fungicides. The web sites for these models are:

Multi-state model: www.wheatscab.psu.edu
North Dakota model: www.ag.ndsu.nodak.edu/cropdisease/

Harvest

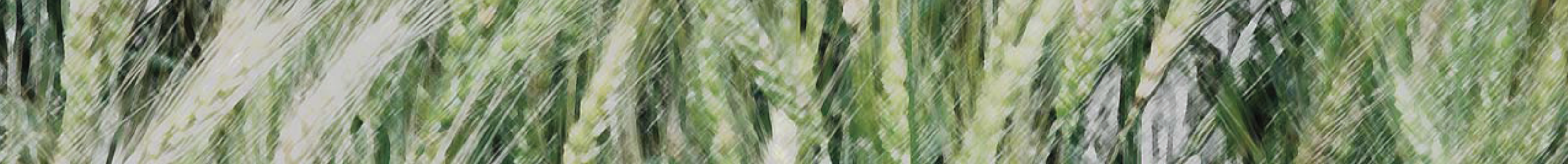
At harvest, the combine may be adjusted so that lightweight FHB kernels are removed along with the chaff. However, this will not remove all FHB kernels because some FHB infections occur late in the development of the kernel, and these infected kernels still may be fairly plump. Infected barley and oat kernels are not removed so easily in the combining process. Visible FHB damage is considered a part of total kernel damage by the Federal Grain Inspection Service and, if excessive, will lower the market grade. Severely affected grain may be graded

Fungicides available as of 2008 for FHB suppression.

Fungicide	Product names	Rate/A Fl oz/A	Head Scab Efficacy*	Preharvest Interval for grain
Metconazole	Caramba	10.0 – 17.0	G (VG)	30 days
Propiconazole	Tilt, PropiMax, others	4.0	P	40 days
Prothioconazole	Proline	5.0 – 5.7	G (VG)	30 days (32 for barley)
Prothioconazole + Tebuconazole	Prosaro	6.5	VG	30 days
Tebuconazole	Folicur, Orius, Monsoon, Embrace, Emboss, TebuStar, Tergol, others	4.0	F	30 days

*P = Poor; F = Fair; G = Good; VG = Very Good; (VG) rating when higher rate is used.

Product registration may change. Please check the current NDSU Extension publication PP-622, "North Dakota Field Crop Fungicide Guide," for updated information and more label restrictions on total amount of product that may be applied per season and for restrictions on use of treated crop for grazing, forage, and hay.



“feed” rather than “milling” for wheat, or rather than “malting” in the case of barley.

After harvest of wheat, gravity table grain separation may be very effective in removing light-weight, FHB-damaged kernels. The resultant product may have a high enough test weight to pay for the cost of the clean-out process.

Mycotoxin

FHB-infected grain may contain fungus-produced toxic substances called mycotoxins. The most common mycotoxin associated with FHB-infected grain in the northern Great Plains is deoxynivalenol or DON (vomitoxin), a mycotoxin that may cause vomiting and feed refusal in nonruminant animals, such as pigs. Presence of this toxin also may result in substantial price discounts at the market and even refusal of purchase if DON toxin levels are high. In the case of barley used by the malting and brewing industry, DON level requirements are very low, generally < 0.5 parts per million.

The presence of FHB-infected grain does not automatically mean mycotoxins are present. The occurrence, amount and kind of mycotoxins may depend on several factors, including environment, species of fungus present, severity of infection and the variety or kind of crop. FHB-infected grain may be tested for DON and other mycotoxins at properly equipped laboratories. In North Dakota, quantitative analysis for several mycotoxins, including DON, is provided by the Veterinary Science Diagnostic Laboratory, Van Es Hall, NDSU, Fargo, ND 58105, phone (701) 231-8307. A 0.5- to 1-pound representative sample of the harvested grain should be submitted. The lab will charge a testing fee.

Contact a veterinarian or feed specialist for further information on safe livestock feeding levels. The risk of human exposure to DON ingestion is minimal under the FDA guidelines (see adjacent table), but producers and elevator operators need to be aware that moldy grain can cause allergy and breathing problems. Producers and elevator operators should wear a good-quality dust mask when working around grain with high amounts of scab or other molds.

The Food and Drug Administration (FDA) has established the following advisory levels for DON in food and feed:

- 1 part per million (ppm) for finished grain products for human consumption
- No standard for raw grain going into milling process
- Cattle over 4 months old: 10 ppm (providing grain at that level doesn’t exceed 50 percent of diet)
- Poultry: 10 ppm (providing grain at that level doesn’t exceed 50 percent of diet)
- Swine: 5 ppm (not to exceed 20 percent of ration)
- All other animals: 5 ppm (providing grains don’t exceed 40 percent of diet)

This publication is based on the original publication PP-804, “Fusarium Head Blight (Scab) of Small Grains,” by Marcia P. McMullen and Robert W. Stack, Professor Emeritus, Department of Plant Pathology, NDSU.

For more information on this and other topics, see: www.ag.ndsu.edu

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