

Corn Smuts

S. K. Mohan, P. B. Hamm, G. H. Clough, and L. J. du Toit

Corn smuts are widely distributed throughout the world. The incidence of corn smuts in the Pacific Northwest (PNW) varies by location and is usually low. Nonetheless, these diseases occasionally cause significant economic losses when susceptible cultivars are grown under conditions favorable for disease development. Smut diseases of corn are, in general, more destructive to sweet corn than to field corn.

The term **smut** is derived from the powdery, dark brown to black, soot-like mass of spores produced in galls. These galls can form on various plant parts.

Three types of smut infect corn—**common smut**, caused by *Ustilago maydis* (= *Ustilago zaeae*); **head smut**, caused by *Sphacelotheca reiliana*; and **false smut**, caused by *Ustilaginoidea virens*. False smut is not a concern in the PNW, so this publication deals only with common and head smuts.

Common smut

Common smut is caused by the fungal pathogen *U. maydis* and is also known as boil smut or blister smut (Figure 1). Common smut occurs throughout PNW corn production areas, although it is less common in western Oregon and western Washington than east of the Cascade Mountains.

Infection in commercial plantings may result in considerable damage and yield loss in some older sweet corn cultivars, but yield loss in some of the newer, less susceptible cultivars is rarely significant. Sweet corn grown in home gardens sometimes suffers substantial losses.

In addition to reducing yield, common smut can cause significant losses to the processing industry by adversely affecting product quality. Ears may be shorter, smaller in diameter, and weigh less, while kernel depth can be reduced. This disease is also suspected to be associated with a “leaky kernel” symptom, in which darkening of the kernel is evident after the kernels are blanched during processing (Figure 2, page 2).

Ear characteristics can be affected regardless of the location of the galls. When three sweet corn cultivars were compared in the Columbia Basin (central Washington and north-central Oregon), galls on the lower stalk, upper stalk, and tassel reduced fresh weight and diameter of husked ears. Galls on the upper stalk also reduced ear length. Galls on the base of the plant reduced only fresh weight of the ear. As gall size increased up to 4.1 inches in diameter, ear fresh weight and diameter decreased. The presence



Photo by S. Krishna Mohan, © Oregon State University

Figure 1. Common smut galls on an ear of sweet corn. Each gall represents a single kernel infected by the common smut fungus.

S. Krishna Mohan,
University of Idaho;
Philip B. Hamm and
George H. Clough, both
of Hermiston Agricultural
Research and Extension
Center, Oregon State
University; and Lindsey J.
du Toit, Washington State
University.

of galls larger than 4.1 inches in diameter reduced ear length. Kernel depth was not affected by size or location of galls.

Galls are not the only quality issue related to common smut infection. In highly susceptible cultivars such as ‘Jubilee’, the smut fungus has been found growing on ears of corn without producing galls (Figure 3). Discolored areas on the inner ear leaf sometimes were associated with fungal growth on the kernels, which was verified as *U. maydis* by isolations. Damage to individual kernels was difficult to detect visually at harvest, but became obvious when the ears or kernels were blanched (Figure 2). Ears with such symptoms are culled during processing.

In field or grain corn, cultivars vary in susceptibility, and severe outbreaks can reduce yield. Corn silage or grain contaminated with smut is not toxic to livestock (unlike corn contaminated with ergot or mycotoxin-producing fungi such as *Aspergillus* and some *Fusarium* species).

Symptoms of common smut

Common smut symptoms may appear on any above-ground part of the plant, such as the stalks (Figure 4, page 3), ears (Figure 1, page 1), leaves (Figure 5, page 3), or tassels (Figure 6, page 4). Generally, infection does not result in plant mortality, unless plants are infected at a very early growth stage (Figure 7, page 4).

Infected tissues grow into galls, sometimes as large as 5 inches in diameter. Common smut galls are initially firm to spongy and are covered with a glistening, greenish-white to silvery-white membrane (Figures 1 and 4–7). As the gall ages, the interior turns dark, and the membrane eventually ruptures to expose a mass of powdery, dry, black, sooty fungal spores (teliospores). Galls on leaves are usually small, hard, and dry, and often do not rupture.

Common smut disease cycle

The black, resting teliospores fall or are blown by wind from galls to the soil. The spores are readily wind dispersed, but can also be deposited on ears in great numbers as galls release spores during harvest (Figure 8, page 5). Teliospores overwinter in the soil, where they can survive for several years.

The following spring, spores may be spread by surface irrigation, drainage water, farm machinery, insects, or wind. If spores are deposited on young, actively dividing corn tissue, or on recently wounded corn tissue, the teliospores germinate and form sporidia. Teliospores can also germinate in the soil to produce sporidia, which are then spread by wind or splashing water.



Photo by Philip B. Hamm, © Oregon State University

Figure 2. Individual kernels believed to be infected with a strain of one mating type of the common smut fungus, *Ustilago maydis*. Discoloration is visible following blanching of the ear, a condition known as “leaky kernels.”



Photo by Philip B. Hamm, © Oregon State University

Figure 3. Growth of the common smut fungus (white to off-white fungal growth between the kernels) on what otherwise seems to be a healthy ear. No galls formed, presumably due to the presence of only a single mating type of the fungus. *Ustilago maydis* was isolated from these kernels onto agar media.

Germinating sporidia of two different, compatible mating types of the fungus can infect the same area (kernel, leaf, stalk, etc.) of the corn plant. The hyphae from the germinating sporidia of the two mating types fuse, exchange genetic material, and form what is called a dikaryon (an organism in which each cell has two nuclei). Growth by only one of the two mating types of the fungus is thought to cause the “leaky kernel” symptom (Figure 2).

The dikaryon grows into the plant tissue through stomata, wounds, or even intact cell walls. Infected cells and adjacent cells are stimulated to enlarge and multiply rapidly, transforming the tissue into a visible gall within a few days to a few weeks after infection.

Susceptible cultivars

Table 1 (page 7) lists 21 cultivars of sweet corn tested for at least 3 years in the Columbia Basin for susceptibility to common smut. Although available corn cultivars in the seed market change constantly, this list may help growers select a cultivar that is less susceptible to common smut. Two widely popular cultivars, ‘Jubilee’ and ‘Supersweet Jubilee,’ are highly susceptible.

The common smut fungus can also infect field or grain corn. One cultivar trial in the Columbia Basin showed marked differences in susceptibility among field corn hybrids. Hybrids with high levels of smut incidence may produce clouds of teliospores during combining/harvesting operations (Figure 9, page 5). Information on common smut resistance or susceptibility of grain corn cultivars grown in the PNW is not available, as new cultivars are released frequently without being tested for susceptibility to common smut.

Environmental factors

One of the primary factors predisposing corn ears to infection by the common smut fungus is environmental stress during the period of pollen release and silk emergence. Corn silks are susceptible to infection by *U. maydis* only prior to pollination. After pollination, the silks rapidly develop an abscission zone at the point of attachment to the kernel, which prevents the common smut fungus from growing into the ovary and immature kernel.

Therefore, environmental conditions that interfere with optimum “nicking” of pollen release with silk emergence (e.g., heat stress or drought stress) increase the length of time between silk emergence and pollination and, consequently, the duration when silks are susceptible to infection. Since environmental conditions vary year to year, even cultivars that are considered moderately resistant to common smut during a “normal” year can develop severe outbreaks if plants are stressed during this vulnerable period. This factor also can be affected by planting date.

Moisture is needed for sporidia to germinate and the fungus to penetrate host tissue. Hence rainfall, irrigation, or humid conditions are assumed to be critical during this



Photo by S. Krishna Mohan, © Oregon State University

Figure 4. Gall formation caused by the common smut fungus infecting the base of a corn stalk.



Photo by Philip B. Hamm, © Oregon State University

Figure 5. Common smut galls on corn leaves.

phase of the disease, although infection of corn silks may be an exception to moisture requirements. After infection, disease and gall development is favored by dry, warm weather (optimum temperatures between 80 and 95°F).

Soils with high levels of nitrogen (N) also tend to favor infection, probably as a result of promoting rapid growth of soft, susceptible host tissue. Injury caused by hail, blowing sand, cultivation, spraying, or detasseling can increase the potential for infection.

Edible common smut

Young common smut galls on immature corn ears are considered an edible delicacy if harvested about a week before regular sweet corn ear harvest for fresh markets. In Mexico, freshly harvested smut galls are known as “huitlacoche,” and in the U.S. they are popularly referred to as “maize mushrooms” or “Mexican truffles.” Recently, U.S. demand for sweet corn ears with these large smut galls has increased.

Management of common smut

Recent information generated by research in the Columbia Basin has focused on evaluating several aspects of this disease in sweet corn, including management strategies. During 12 years of trials and field observations, sweet corn planted before May 11 always had less infection than did corn crops planted after June 9. Common smut galls in earlier planted corn generally were distributed throughout the plants, whereas later-planted sweet corn had a greater incidence of infection on the lower stalk and tassel than on the base or upper stalk.

As expected, given year-to-year variation in environmental conditions, the percentage of plants infected was not the same each year. A trend toward reduced incidence of the disease over this period of study was noted in research plots, likely from lower inoculum levels due to more widespread planting of less-susceptible cultivars (Figure 10, page 5). A similar trend has been seen by local corn processors.

The following management strategies are recommended:

- When possible, grow corn where common smut has not previously occurred or has not occurred for several years.
- Plant less-susceptible cultivars, if possible (see Table 1, page 7).
- In the Columbia Basin, plant early (before mid-May).
- Avoid mechanical injury to plants during cultivation, or any other practice that may wound plants. In seed production fields, avoid detasseling during wet weather.
- Provide balanced fertilization. Excessive N tends to increase the incidence and severity of common smut.



Photo by Philip B. Hamm, © Oregon State University

Figure 6. Common smut galls on a corn tassel.



Photo by Philip B. Hamm, © Oregon State University

Figure 7. Common smut infection can kill young corn plants.

- In home gardens, remove and dispose of smut galls in trash or, secondarily, by burying the galls in compost piles. Complete composting is required before the galls mature and disperse teliospores. This practice will minimize soil contamination.
- Seed treatment with fungicides is not effective, due to the localized nature of infection in corn plants. In corn, infection by *U. maydis* does not occur below the soil surface and is never systemic, unlike head smut.
- Foliar application of fungicides does not reduce the incidence of common smut infections.

Head smut

There are two races of the head smut fungus (*Sphacelotheca reiliana*): one attacks corn only, and the other is limited to sorghum and Sudan grass. Head smut has been a destructive disease of corn in several regions of the world. It has occurred sporadically in the U.S., mainly in the intermountain and southwestern regions. During the 1960s, head smut was severe in the Treasure Valley of Idaho, but its prevalence was reduced as growers started planting more resistant cultivars, producing corn in noninfested fields, and using effective fungicide seed treatments.

In recent years, the disease seems to be increasing again in some areas of the U.S., principally on sweet corn and popcorn. The incidence of head smut has been associated with N deficiency. For example, the disease may be more severe in areas of fields where accidental “skips” occurred during N application.

Symptoms of head smut

Head smut galls typically develop only on ears and tassels. Smutted ears are usually rounded or pear-shaped and do not produce silks. The galls are initially covered with a thin membrane that ruptures to expose dry, powdery, dark brown to black masses of teliospores. A characteristic symptom of head smut, which distinguishes this disease from common smut, is the presence of fine, thread-like strands within the galls (Figure 11, page 6). These strands are remnants of the vascular tissue of the corn plant.

Tassel infection may be confined to individual spikelets, resulting in shoot-like growth, or the entire tassel may be transformed into a leafy structure interspersed with smutted spikelets (Figure 12, page 6). If the tassel is infected, all ears on that plant



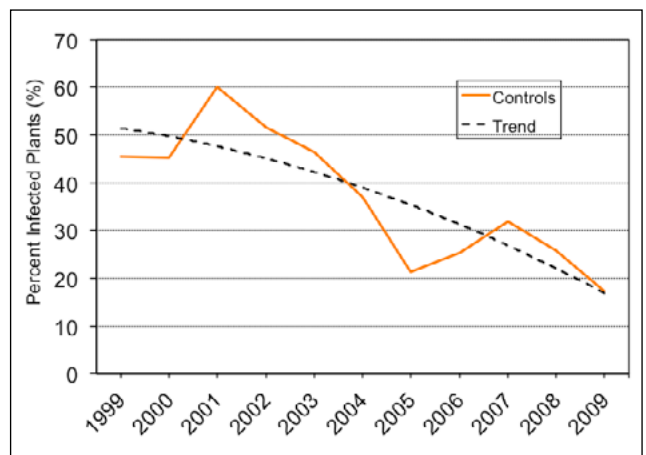
Photo by Philip B. Hamm, © Oregon State University

Figure 8. Mature spores released from common smut galls during harvest can contaminate the space between kernels and are difficult to remove during washing and processing.



Photo by Philip B. Hamm, © Oregon State University

Figure 9. Spores of common smut released into the air (“dirt” cloud behind the combine) during harvest of a grain corn crop infected with *Ustilago maydis*.



Graph by George Clough and Philip B. Hamm, © Oregon State University

Figure 10. Incidence of common smut in sweet corn trials near Hermiston, OR, 1999–2009.

will be smutted or aborted, with small, leaf-like structures replacing the ears.

Infected plants are usually severely stunted and barren, and may show excessive tillering.

Head smut disease cycle

Resting spores of the fungus from smutted corn ears and tassels are dispersed by wind and rain. They can overwinter in contaminated soil for at least 4 years. These spores germinate and serve as the main source of inoculum. Spores may also contaminate the surface of corn seed, but this source of inoculum is not considered significant.

Acidic soils seem to favor germination of the resting spores. After resting spores germinate and conditions are favorable, they produce infective spores (sporidia). Favorable conditions for sporidia production include moderate to low soil moisture and warm temperatures (optimum of 70 to 80°F).

The fungus usually infects seedlings before they reach the four- to six-leaf growth stage. After infection, the head smut fungus grows systemically (internally) in the plant, eventually invading the developing floral parts (tassel and ears) and transforming part or all of these tissues into smut galls.

Management of head smut

- Plant less-susceptible cultivars, where available. The cultivars ‘Jubilee’, ‘Bonanza’, ‘Sugar Daddy’, and ‘Platinum Lady’ are susceptible to head smut.
- Practice a 2- to 3-year rotation to nonhost crops. Although crop rotation will not eliminate the fungus from contaminated soil, rotation can reduce disease incidence.
- Consider use of the systemic fungicide carboxin as a seed treatment. Carboxin can be very effective at preventing or limiting infection of corn plants. Consult the agricultural Extension agent in your county for current information. Always read and follow the fungicide label directions.

Use pesticides safely!

- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Read the pesticide label—even if you’ve used the pesticide before. Follow closely the instructions on the label (and any other directions you have).
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

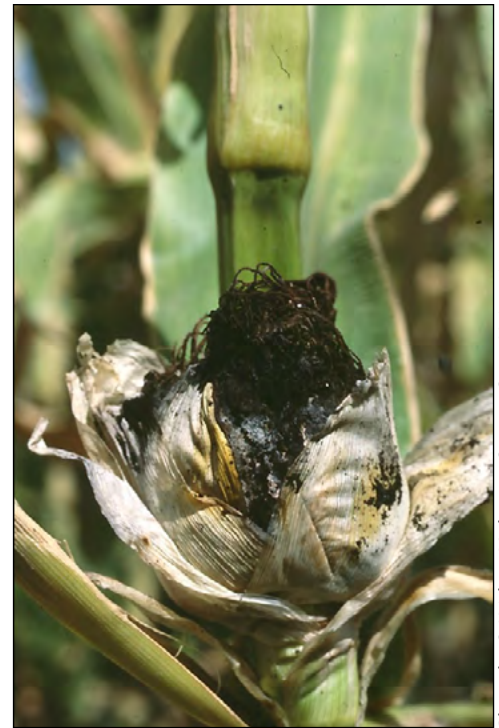


Photo by S. Krishna Mohan, © Oregon State University

Figure 11. Head smut symptoms on a sweet corn ear. Note the fine, thread-like strands inside the gall.



Photo by S. Krishna Mohan, © Oregon State University

Figure 12. A corn tassel infected with head smut. Note the leafy structures interspersed with smutted spikelets.

Table 1. Susceptibility of sweet corn cultivars to common smut based on the incidence of infected plants (% of plants with ears infected) under field conditions at Hermiston, OR, 1999–2010.

Cultivar ^a	% ears infected	No. of years tested	Seed source
<i>Most susceptible</i>			
1861	16.1	3	Rogers
2684	12.5	3	Rogers
Jubilee	11.4	12	Rogers
Challenger	11.0	3	Seminis
Supersweet Jubilee	8.5	12	Rogers
Summer Sweet 8100	7.3	5	Abbott & Cobb
Summer Sweet 500	7.0	10	Abbott & Cobb
ACX429	7.0	3	Abbott & Cobb
Crisp n Sweet 710	6.4	11	Crookham
Krispy King	6.2	12	Rogers
<i>Least susceptible</i>			
Conquest	0.6	3	Crookham
Marvel	0.7	11	Crookham
Sockeye	0.9	7	Harris Moran
GH2547	0.9	7	Syngenta
Eliminator	0.9	3	Crookham
GH6462	0.9	6	Syngenta
Intrigue	1.0	3	Crookham
Fortitude	1.0	4	Crookham
Tamarack	1.0	3	Crookham
GSS1477	1.1	5	Syngenta
ACX232	1.1	5	Abbott & Cobb

^aCultivars listed represent a subset of 40 cultivars evaluated for at least 3 years during 12 years of field trials.

Trade-name products and services are mentioned as illustrations only. This does not mean that the participating Extension Services endorse these products and services or that they intend to discriminate against products and services not mentioned.

© 2013 Oregon State University.

Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the Oregon State University Extension Service, Washington State University Extension, University of Idaho Extension, and the U.S. Department of Agriculture cooperating.

The three participating Extension services offer educational programs, activities, and materials without discrimination based on age, color, disability, gender identity or expression, genetic information, marital status, national origin, race, religion, sex, sexual orientation, or veteran's status. The Oregon State University Extension Service, Washington State University Extension, and University of Idaho Extension are Equal Opportunity Employers.

Published July 2013.