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CORN SMUTS

Corn smuts occur throughout the world. Common corn smut, caused by the fungus *Ustilago zeae* (synonym *U. maydis*), and head smut, caused by the fungus *Sporisorium holci-sorghi* (synonyms *Sphacelotheca reiliana, Sorosporium reilianum* and *Sporisorium reilianum*), are spectacular in appearance and easily distinguished. Common smut occurs worldwide wherever corn (maize) is grown, by presence of large conspicuous galls or replacement of grain kernels with smut sori. The quality of the remaining yield is often reduced by the presence of black smut spores on the surface of healthy kernels.

Figure 1. Infection of common corn smut on the ear. Smut galls are covered by the silvery white membrane.

COMMON SMUT

Common smut is well known to all Illinois growers. The fungus attacks only corn–field corn (dent and flint), Indian or ornamental corn, popcorn, and sweet corn–and the closely related teosinte (*Zea mays* subsp. *mexicana*) but is most destructive to sweet corn. The smut is most prevalent on young, actively growing plants that have been injured by detasseling in seed fields, hail, blowing soil or and particles, insects, "buggy-whipping", and by cultivation or spraying equipment. Corn smut differs from other cereal smuts in that any part of the plant above ground may be attacked, from the seedling stage to maturity.

Losses from common smut are highly variable and rather difficult to measure, ranging from a trace up to 10 percent or more in localized areas. In rare cases, the loss in a particular field of sweet corn may approach 100 percent. With resistant varieties and hybrids, annual losses seldom exceed 1 percent in large areas. The number, size, and location of the smut galls or "boils" on a plant affect the yield loss. The reduction in yield is greatest when large galls are located on or above the ear. Plants with galls on the lower stalks may be barren or may produce several small ears. Such plants often appear reddish in the fall, resembling those heavily infested with aphids earlier in the season. Leaf galls and galls resulting from detasseling are usually small and generally cause little damage. The heaviest smut infection generally occurs when rainfall is light during the early stages of growth and temperatures are between 79° and 93°F (26° and 34°C).

Vigorous plants are most susceptible, but may escape the more serious effects of smut because of their

rapid growth. Corn growing in soil particularly high in nitrogen and organic matter (for example, barnyard manure) frequently shows more smut than corn growing in soil with well-balanced fertility. Dry weather, during which corn growth is slowed, and, abnormally cool, wet weather that retards growth of young corn plants are both conducive to infection. Early infection may stunt or kill young seedlings, although such an occurrence is rare.

Smut galls are **not** poisonous to animals except as they increase the dust content of dry fodder. In fact, immature smut galls are considered a delicacy in some South American countries.

Figure 2. Common smut on a corn tassel and stalk. The galls are rupturing, exposing millions of black, powdery smut spores.

Symptoms

Common corn smut is easily recognized and is probably the best known disease on corn. All actively growing or embryonic corn tissue is susceptible. Galls are commonly found on the tassels, husks, ears and kernels, stalks, leaves, axillary buds and, rarely, on the aerial roots. As the smut galls enlarge, they are covered by a glistening, greenish to silvery-white membrane. Later, the inner tissue darkens as a result of spore formation (Figure 1). Mature galls may reach 6 inches (15 centimeters) in diameter and are filled with millions of microscopic, dark, olive brown to black, greasy to powdery spores–except for the small, hard, pea-sized galls that form on the leaves. The spores (teliospores, sometimes called chlamydospores) are released when the whitish outer membrane of the gall ruptures at maturity (Figure 2).

Disease Cycle

The diploid (2N) teliospores, which are very resistant to freezing and drying, may survive in the soil or corp debris for several years. During spring and summer, when the temperature is between 50° and 95° F (10° to 35° C) and moisture is present, the black, globose or subglobose, spiny teliospores which are 8 to 12 μm in diameter, germinate to form a 4-celled basidium (promycelium) that produces from 4 to a large number of oval, haploid (N) sporidia or basidiospores, which are of two sexes, (+) and (-) (Figure 3). The sporidia are blown about by air currents or are splashed by water to young, developing tissues of corn plants. Infection occurs when the + and - sporidia germinate to form fine hyphae that penetrate into corn tissue through stomata, wounds, or directly through cell walls. The hyphae of two compatible sporidia fuse. The resulting hypha enlarges in diameter, becomes binucleate and dikaryotic (N+B), and stimulates an increase in size and number of cells in the corn plant forming a gall. Infection may also occur from hyphae arising directly from germinating teliospores. Ears of corn are infected by hyphae growing through the silks much like pollen grains.

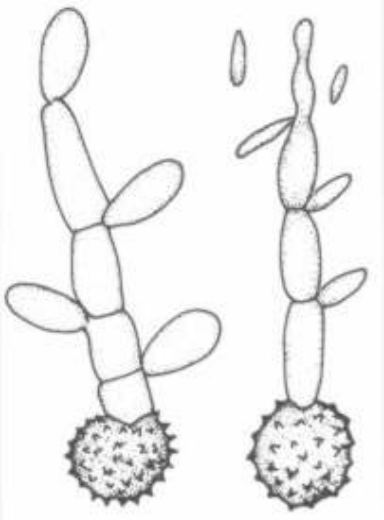

Figure 3. Germinated teliospores of the common smut fungus (Ustilago zeae) with a 4-celled basidium bearing 4 sporidia (drawing by L. Gray).

The smut mycelium in a gall grows between the corn cells until just before the teliospores are formed. The enlarged corn cells are then invaded, collapse and die. The smut

fungus feeds on the cell contents for its further growth and the gall then consists primarily of dikaryotic mycelium and the remains of corn cells. Most of the smut cells develop into teliospores which absorb and utilize the contents of other mycelial cells. Only the membrane covering the smut gall is unaffected by the fungus.

The interval between infection and the formation of mature galls varies from one to several weeks under favorable conditions. Spores formed in the first smut galls may germinate and infect the same or other corn plants, although most spores fall to the ground or remain in corn debris. Galls form and spores are disseminated more or less continuously through the summer growing period.

When animals eat "smutty" stalks, leaves, and ears, the spores may remain alive when passing through the alimentary canal and can be carried in the manure. When infested manure is spread on crop land, sporidia produced by the germinating teliospores may be blown or washed to the surface of a corn plant, germinate, and cause infection. Smut spores are killed by the acids in silage.

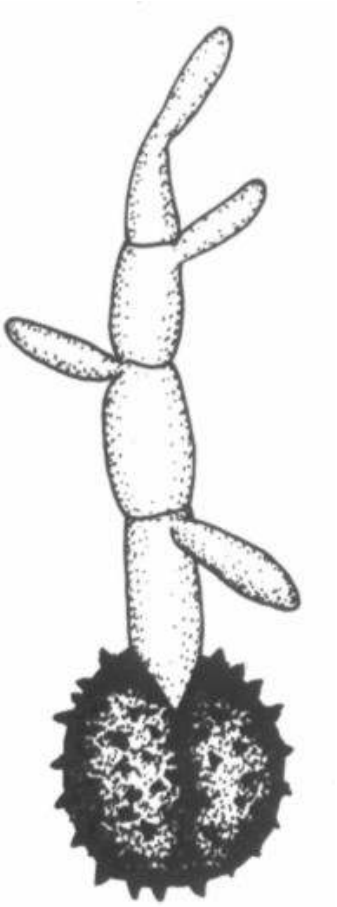

Figure 4. Germinated teliospore of the head smut fungus (Sporisorium holci-sorghi) with a 4-celled basidium bearing 4 sporidia (drawing by L. Gray).

Control

1. **Corn hybrids differ in apparent resistance**. Choosing the best adapted, resistant hybrids and varieties available is the best means of controlling common smut. Such hybrids possess generalized or field resistance to the corn-smut fungus. The difference in apparent resistance between corn lines is often based on the protection given by the sheath and husks. Corn breeders generally avoid using very smut-susceptible inbreds and their hybrids or varieties.

2. **Maintain well-balanced soil fertility based on a soil test**.

3. **Avoid mechanical injuries to plants** during cultivation and spraying.

4. **Protect corn against insects** (such as corn earworms and European corn borers) by timely applications of insecticides recommended by University of Illinois Extension Entomologists. This often decreases the incidence of common smut in sweet corn.

5. In home gardens, **cut out and destroy the galls before the smut "boils" rupture and the teliosporses are released.**

The following practices are both effective in Illinois for controlling common smut: fungicide seed treatment, crop rotation, and plowing down smut-infested debris

HEAD SMUT

head smut occurs sporadically in the United States and in drier soils in many countries where corn is

grown. The disease has not yet been reported in Illinois. However, Illinois growers should be familiar with this disease and its symptoms because it is present in other corn-growing states in the Midwest. It is more common in drier soils of California, Idaho, New Mexico, Oklahoma, Oregon, Texas, Utah, and Washington. However, it also has been reported in Minnesota, Nebraska, Indiana, Iowa, Kansas, Ohio, and New York. Yield losses result from the replacement of the ear with large smut sori. Replacement of the tassel with sori can seriously affect the efficiency of pollination. Resistant hybrids are known and most field corn is highly tolerant. *Sporisorium holci-sorghi* does not exclusively infect corn. Sorghums, teosinte, pitscalegrass, and Sudangrass also are hosts of the fungus. Pathogenic specialization occurs in the head smut fungus with one group limited to corn and another to grain sorghums, sorgo, forage-sorghum hybrids, and some Sudangrass varieties. A hybrid of *S. holci-sorghi* has been identified that infects both corn and sorghums.

Figure 5. Corn ear destroyed by head smut. Note the tangled mass of threadlike strands (remnants of the vascular system).

Symptoms

Head smut is not evident until the tassels and ears appear. It is characterized by the presence of sori on the the tassels, ears, or rarely, the leaves. A sorus (plural sori) is a compact mass of dark brown to black spores (teliospores) covered with a thin grayish white membrane which soon ruptures to release a powdery mass of spores which are quickly scattered by air currents and rain. A tangled mass of threadlike strands, vestiges of the vascular system of the corn inflorescence, ramify through the sori and are characteristic of infection by the fungus (Figure 4). The presence of the vascular strands, surrounded by the mass of black-brown spores, distinguishes head smut from common smut. Infected tassels are completely or partially covered by a sorus (Figure 5) and normally do not produce pollen. The individual florets are replaced entirely by teliospores without the formation of a gall that is characteristic of common smut.

Figure 6. Corn tassel partially covered by a sorus of head smut.

Figure 7. Proliferation of leaf-like and husklike structures (phyllody) of a corn ear affected by head smut.

Disease Cycle

The head smut fungus overwinters as teliospores in the soil and occasionally on the seed. Survival is better in dry than in moist soils. The microscopic diploid (2N) teliospores are reddish brown to black, globose to subglobose, abundantly and conspicuously spiny, and 9 to 14 μm in diameter. Teliospores may germinate in either one of two ways: directly in soil by producing a long dikaryotic (N+N) infection hypha or indirectly by forming a basidium on which lateral sporidia (basidiospores) are borne (Figure 8). The 1-celled sporidia are haploid (N), hyaline, subglosose, and 7 to 15 µm in diameter. Sporidia of opposite mating types (+ and -) exist in approximately equal numbers. Seedling infection occurs when sporidia of opposite mating types fuse,

forming a dikaryotic (N+N) germ tube or infection hypha. The parasitic mycelium develops systemically, invading the meristematic tissue of seedlings and later the undifferentiated ear and tassel tissues. Part or all of these tissues develop into smut sori in which teliospores are produced. Teliospores from smutted tassels and ears overwinter in soil and can survive for 3 or more years. High soil moisture and winter soil temperatures above 32°F (0°C) lead to decreased survival. Although the teliospores may be seedborne, this is not an important source of inoculum. Teliospores also may be introduced into a field by contaminated harvesting, planting, or cultivation equipment, which transport spores from a diseased to a disease-free field. The infection level is related to low soil moisture (15% to 25% W/w) are optimal for seedling infection. Temperature is more important than soil moisture for infection. Head smut is more prevalent in clay loam soils than in sandy loam or silt loam soils and is accentuated by nitrogen deficiency.

Figure 8. Stripes in corn leaves filled with teliospores of the head smut fungus.

Control

1. **Plant resistant varieties and hybrids**; most commercial hybrids in the United States are highly tolerant.

2. **Rotate corn with other crops**. Isolates of the fungus that infect corn usually do not infect sorghums and vice versa. Other crops, such as soybeans, small grains, and forage cropsa re not susceptible.

3. Fungicides applied to soil at or before planting may be useful in reducing inoculum in seed production fields.

4. Application of a protective fungicide seed treatment (e.g., captan) is only partially effective while a systemic fungicide, such as carboxin (Vitavax), is reported to give good protection.

5. **Maintain balanced fertility** based on a soil test.

6. Where feasible, **promptly remove and burn smutted tassels and ears** before the spores are scattered.