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report on
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SMUTS OF BARLEY

Smuts are among the most easily recognized and destructive diseases of barley worldwide. The spikelets of diseased plants are transformed into dark olive brown to black spore masses. Losses of 15 to 35 percent or more occur in individual fields in Illinois where untreated seed is planted (Figure 1). Losses for the entire state range from 0.2 to 10 percent, averaging 3 percent for covered smut and 2 percent for the two loose smuts.

Figure 1. Barley field of untreated seed.

The three barley smuts (covered, semi-loose, and loose) are caused by three different fungi. All three smuts can be controlled effectively by the same systemic fungicide seed treatments. Certain characteristics help distinguish between the three smuts before the barley crop matures. By threshing time, however, these characteristics have largely disappeared.

SYMPTOMS

Covered smut. This is caused by the fungus *Ustilago hordei* which attacks only barley, oats, rye, and a number of related grasses. Covered smut is more prevalent in the southern part of the state than elsewhere, but may be found in practically every field where untreated seed is sown. The smutted heads emerge from the boot (or occasionally through the sheath below the flag leaf) at about the same time or a little later than those of healthy plants. Compact, hard, dark brown to black masses of dusty smut spores (teliospores) replace the healthy kernels. These masses are covered with a thick, grayish white membrane that may remain more or less intact until the grain matures or is harvested. However, excessive or prolonged wind and rain may rupture the membrane, releasing millions of microscopic teliospores and leaving only the bare spike (rachis) at maturity. Covered smut usually causes stunting of infected plants, particularly at the top internodes.

DISEASE CYCLE

Some of the smut spores (teliospores) land on or under the hulls (glumes) of barley kernels in healthy heads. The teliospores on the surface of the seed usually remain dormant, while those deposited under the glumes may send infection hyphae beneath the hulls before or after threshing. The barley plant

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becomes infected between the time the seed germinates and the seedling emerges from the soil. Infection occurs over a temperature range of 57° to 77°F (14° to 25°C) with an optimum of 68° to 75°F (20° to 24°C).

Germinating teliospores develop a promycelium and four primary sporidia from which abundant secondary sporidia are produced (Figure 2, left). The sporidia are of two mating types and seedling infection occurs via direct penetration of the young shoot (coleoptile) by infection hyphae produced by the fusion of sporidia (basidiospores). The fungus continues to grow systemically within the plant tissues; and, at maturity, replaces the kernels with a dark mass of teliospores.

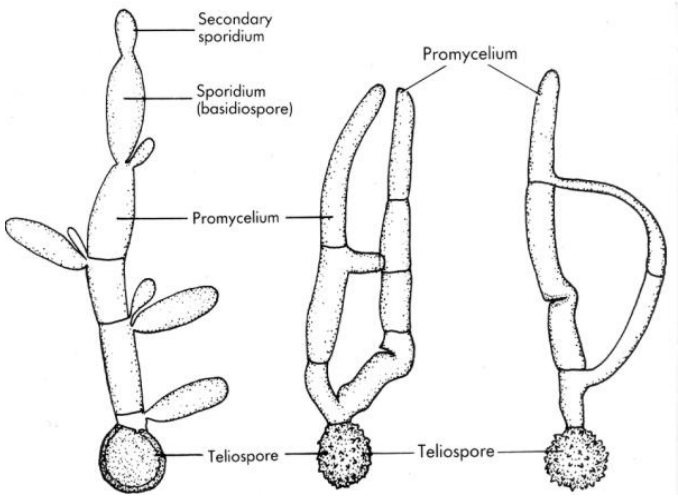

Figure 2. Germinating teliospores of the covered and loose smut fungi as they would appear under a high-power microscope. (Left) Ustilago hordei and (right) Ustilago tritici. (Drawing by Lenore Gray)

There is only one infection cycle per year. The amount of disease in the new barley crop depends on the percentage of infested kernels that were planted and on the temperature and moisture of the soil during germination. The highest percentages of smutted plants occur in acid or neutral soils when the soil temperatures during this period are between 50° and 70°F (10° to 21°C) and the soil moisture is low to moderate. This is probably the reason covered smut is more prevalent in winter barley than in spring barley. Soil type, soil compaction, depth of seeding, and the rate of seedling growth may also affect the development of covered smut. The causal fungus can be subdivided into a number of physiologic races based on their different abilities to attack a series of differential barley varieties.

Semiloose smut. This is caused by the fungus *Ustilago avenae* (synonym: *U. nigra*). Semiloose smut first becomes noticeable at heading time, when the dusty smutted heads appear. This disease is very difficult to distinguish from true or deep loose smut (Figure 3B-F) although the awns and glumes tend to develop to some extent in certain varieties. The two loose smuts often appear together in the same field. The teliospore masses of semiloose smut are dark chocolate brown to black, and vary in looseness. The membrane enclosing the spore mass is fragile–but often remains intact for a short period after the head emerges from the boot, giving it a partly covered appearance (Figure 3B). Semiloose smut can be distinguished positively from true loose smut only by observing the teliospores and their type of germination under a microscope. The teliospores of *Ustilago avenae* produce oblong sporidia on their germinating promycelia (like *U. hordei*) while the loose smut fungus (*Ustilago tritici*) does not (Figure 2). *Ustilago avenae* also produces secondary sporidia by yeastlike budding which is a useful diagnostic feature.

DISEASE CYCLE

Wind carries the smut spores to the flowers and young, developing seeds of healthy barley heads. The teliospores may lie dormant or germinate and form a subhull mycelium. Seedling barley plants are infected by the semiloose smut fungus in the same manner as is the covered smut fungus. As in covered smut, the amount of infection depends on the percentage of infested kernels that are sown and on the moisture and temperature of the soil during germination. Temperatures of 59° to 70°F (15° to 21°C). And

a relatively dry soil before the seedlings emerge are most favorable for infection. When such temperatures persist for 10 to 30 days after emergence, the percentages of semiloose smut are higher than when temperatures remain low. A number of distinct pathogenic strains or physiologic races of the smut fungus have been identified by their relations on a series of barley varieties. Several races are widespread in the united States.

The fungi causing barley covered smut and semiloose smut have been hybridized artificially. The results may partly explain how new types or races of smut arise.

True, or deep, loose smut. This is caused by the fungus *Ustilago tritici* (synonym: *U. nuda*), and is often the most common and detructive smut disease attacking barley. The smutted head usually emerges from the boot a day or two earlier than the heads of healthy plants. The medium- to dark-brown, powdery spore masses are enclosed within a fragile, silvery gray membrane that soon ruptures–releasing the pale yellow-brown smut spores which are lighter in color on one side. By harvest, an erect and naked spike is all that remains of a smutted head.

Figure 3. Semiloose smut. A, healthy head of barley; B, newly emerged head of semiloose smut; C-F, four older heads of semiloose smut in various stages of disintegration (USDA photo).

DISEASE CYCLE

Some of the dustlike teliospores–which are quickly scattered by air currents, rain, insects, or other agents–lodge in the open flowers of healthy barley heads. Infection probably never occurs after the fertilized ovary has attained a third of its mature size. If cloudy, cool weather (61° to 72°F or 15° to 22°C) with frequent light showers and dews prevails during the flowering period, the spores germinate. Their long, delicate, infection hyphae (Figure 2, right) enter the young ovary of the flower and grow deeply into the germ or embryo of the developing seed, but do not kill it (Figure 4). As the grain matures, the loose smut fungus becomes dormant until the following growing season. When the infected barley seed germinates, the fungus grows systemically within the new plant. As the barley plant approaches heading, the mycelium penetrates the head tissues and converts them to masses of teliospores. Germinating the teliospores produce a four-celled promycelium that, in turn, forms branches. The branches elongate, fuse, and rebranch to form mycelium. No sporidia are produced (Figure 2, right). Plants grown from infected seed are more susceptible to winter-killing, especially under severe conditions, than are healthy plants. The loose smut fungus survives between crop cycles as dormant mycelium in the embryo and endosperm of diseased seed (Figure 4).

Figure 4. Barley embryo infected with the true or deep loose smut fungus (left) and healthy embryo (right). Embryos are about 1/16 inch long (courtesy Dept. of Plant Pathology, Univ. of Minnesota)

The percentage of true loose smut infection in a crop of barley depends on how many of the seeds were infected. This, in turn, is determined by (1) the percentage of infection in the field during the previous season, (3) the weather at flowering time, and (3) the barley variety. A warm soil when seedlings emerge seems to be more conducive to loose smut than a cold soil. A heavy infection in the field will often mean a fairy heavy infection in the next crop. However, even fields with a light infection sometimes produce seed with a high percentage of smut. Cool, damp weather at flowering time is necessary for heavy infection.

1. Sow certified, smut-free barley seed of resistant varieties recommended for your area by University of Illinois Extension Agronomists and your nearest Extension adviser. None of the recommended barley varieties are completely resistant to all the physiologic races of the three smut fungi. Refer to the Illinois Agricultural Pest Management Handbook for the reactions of barley varieties to smut diseases. This publication is revised annually and should be available at your nearest Extension office.

2. Treat all barley seed with a systemic fungicide or fungicide mixture. A properly applied fungicide treatment controls all three smut fungi.