rusts of importance on grasses that can thus be controlled to any practical degree. Elimination of the alternate host has another advantage: It is on that host that hybridization between strains of rust takes place, often with the result of new and more virulent strains capable of attacking varieties of grasses and cereals that previously were resistant.

The development or selection of grasses resistant to rust has lagged behind such projects in the cereals. Strains have been noted in timothy, orchardgrass, crested wheatgrass, blue bunchgrass, big bluegrass, and others that are resistant to their particular rusts. It is usually true, however, that those resistant strains are valid only in restricted regions and are not generally resistant to the various and numerous races or strains of rusts in all localities. The individual State colleges can best give advice on such local problems.

The fact remains that genetic resistance does exist in strains of most of our forage grasses and can be used in breeding work when necessary or desirable.

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Smuts That Parasitize Grasses

George W. Fischer

Nearly 140 different species of smuts attack approximately 300 species of grasses in the United States.

The common name smut derives from words meaning to besmirch or smudge and refers to the presence of sooty, dirty, black, or brownish masses on the affected plants.

All the smuts are plant parasites. Most of them occur on grasses and cereals. As with the rusts, the average person is much more familiar with the destruction wrought by smuts on cereals than on grasses. Familiar examples of destructive cereal smuts are bunt or stinking smut of wheat, oat smuts, barley smuts, sorghum smut, and boil smut on corn. In everyday practice, the name smut is used to designate the disease as well as the fungus responsible for the disease, although the latter is more correctly spoken of as the smut fungus.

The smut fungi have much less complicated life histories than do the rust fungi and generally are easier to control. The familiar dusty black smut masses are made up mostly of millions of tiny cells or groups of cells—spores, which serve the same purpose to the smut fungi as seeds do to the seed-bearing plants, namely, for reproduction and dissemination.

Some smuts destroy the flowering structure. Others are restricted only to certain parts of it. Some are confined almost exclusively to the stems of grasses. Others produce galls or
tumorlike structures in various parts of their host plants.

As with the rust fungi, many smut fungi exhibit a remarkable degree of specialization not only to certain species of plants but also to certain varieties or strains within those host species. Likewise, there are often strains or races of the smut fungi to contend with. The common stinking smut, for example, has nearly 30 known strains or races, each capable of attacking different varieties of wheat and different strains or varieties of wheatgrasses and related grasses.

The smut fungi are not entirely obligate parasites as are the rust fungi. In fact, some smuts can easily complete their entire life cycle on an artificial medium if it contains the nutrients essential for growth. Some smuts apparently persist indefinitely in the soil or in old manure piles. They are fully capable, however, of attacking their host plants when the plants are available under the requisite conditions for infection.

The smut fungi have a more adverse effect directly (and perhaps indirectly) on their hosts than do the rust fungi. The smuts that attack all or parts of the flowering structures generally destroy the seeds entirely. The leaf smuts and the stem smuts, while only occasionally involving the flowering structures, do nevertheless generally suppress these structures and likewise result in a more or less complete loss of seed on affected plants. The smuts that attack the vegetative structures (that is, the leaf smuts and stem smuts) have a decidedly weakening effect on their host plants and make them more susceptible to other sinister factors in their environment.

Many of the grass smuts are seedborne. The wind carries millions of smut spores, which become lodged in or on the developing seeds of healthy plants. When the seeds germinate, the smut spores also germinate and infect the young seedlings. Then the plants that arise from the seedlings are smutted.

Some of the smut fungi are not limited to seedling infection. Apparently they can infect any succulent or rapidly growing part of their host plants and thereby make them smutty in time. The time between infection and the appearance of smut varies rather widely. In the stripe smut of grasses, for example, seedlings often show smut within 6 weeks of the time the smut-contaminated seed is planted. Other smuts are not evident until their hosts head out. One of the stem smuts, to be described later, requires 2 to 4 years after infection before smut actually appears.

Spores of the smut fungi generally are much more durable than are those of the rust fungi. It is hard to maintain viability of rust spores for more than a year; usually it is much less than that. In the case of the smut fungi, it is unusual for viability to be maintained for less than a year. For most smuts viability is maintained for two to several years, especially if humidity is low. Some smuts have been known to retain at least some viability for 25 years.

The cultivation of grasses seems to have much to do with the development of smut in them: Often cultivation practices, including harvesting and threshing, disperse the smut and contribute toward an increase in the amount of smut in succeeding crops. Any of the grass smuts therefore is a potential threat to the welfare of its grass host if the grass comes under cultivation.

Some of the grass smuts are the same as those that are destructive parasites of our cereal crops.

**Seed smuts** or bunt (*Tilletia* species) are terms used here to designate the smuts of grasses in which the normal seeds are replaced by smut "balls." The balls retain somewhat the shape of the normal seed and are even encased by the seed wall; actually, though, the inside of the seed is a solid mass of spores.

About 25 of these grass seed smuts
occur in the United States. Several have actual or potential importance in cultivated grasses. One of the potentially most important is the one that on wheat is commonly called stinking smut or bunt. Three species of fungi are involved in it, including what is commonly known as dwarf smut. These smuts are well known on wheat because of the very extensive losses they have caused for a long time the world over. Besides wheat, tall oatgrass and several of the wheatgrasses are known to be susceptible, including crested wheatgrass, slender wheatgrass, and intermediate wheatgrass. Care has to be taken to keep those grasses from falling prey to the cereal smuts.

The dwarf bunt is soil-borne. It has thus far presented a knotty problem of control except when resistant varieties are used. The other two species, being mostly seed-borne, may be controlled by seed treatment and the use of resistant varieties.

Some of the bentgrasses are susceptible to another of the seed smuts, especially on the east and west coasts where considerable smut infestation is sometimes encountered in harvested seed crops. The life history of this smut is not known.

Various other groups of grasses, for example the bromes, fescues, wildryes, hairgrasses, velvetgrass, and others, are prey to similar seed smuts.

**Head smut** (species of *Sorosporium*, *Sphacelotheca*, and *Ustilago*) applies loosely to a variety of rather conspicuous smuts that occupy all or part of the flowering structures but do not replace the seeds themselves as do the seed smuts I mentioned. By virtue of prevalence, severity, wide distribution, and their very numbers, this group of smuts probably comprises the most economically important group of the several here discussed. Familiar examples are loose smut of wheat and barley, loose smut of oats, covered smut of barley and oats, and kernel smut and loose smut of sorghum. Many similar types of smuts occur on many of the grasses, but only a few pose an economic problem, probably because grasses have been cultivated only to a limited extent.

One of the most common of the head smuts of grasses is caused by *Ustilago bulbata*. It complicates the cultivation and production of several of our best forage grasses. More than 60 species of grasses have been reported as hosts to it, among them wheatgrasses, bromes, fescues, wildryes, and barley grasses. In 1946 it was thought that head smut in mountain brome, one of our most valuable forage grasses, was under control through the release of a new variety, Bromar, which was developed jointly by the Department of Agriculture and the Washington Agricultural Experiment Station. In repeated tests the new strain had remained resistant to the various races of the head smut fungus. In 1950, however, an entirely new and very virulent strain of head smut made its appearance and caused some very badly smutted fields of Bromar mountain brome. There are 12 known races or strains of the head smut fungus, each of which is specialized to different species of the wheatgrasses, bromes, wildryes, and barley grasses. None of the cereals is susceptible to it.

Several dozen other head smuts of grasses constitute a potential problem among economically important forage or range grasses. Practically nothing is known concerning the life history and methods of controlling most of them.

**Leaf smuts** are of two types: The spot or blister smuts (*Entyloma* species) and the stripe smuts (*Urocystis* and *Ustilago* species).

The spot or blister smuts appear as flat or slightly raised, blackish, round or oval spots in the leaves. Although rather widely distributed, they seldom cause great losses. Once in a while spot smut develops in a bluegrass lawn to such an extent as to cause premature yellowing and death of the leaves. With the stripe smuts, however, it is quite a different matter.
The stripe smuts are evident in the leaves as black stripes, which contain the smut spores. The spores are shed and dispersed into the wind. Afterwards the affected leaves take on a shredded and curled appearance and soon wither. Affected plants quite frequently are dwarfed and contorted and produce abnormal, sterile heads, if any at all. Seedlings of grasses affected with stripe smut are predisposed to drought injury and root rot. Mature plants often are so weakened that they cannot survive severe winters.

Most of the stripe smuts of grasses cannot be told apart by the unaided eye, but they are different enough under a microscope. One of the most common and most virulent is known as flag smut. Many grasses and cultivated wheat are its hosts. Flag smut has several strains, each capable of attacking different groups of grasses.

Another of the common and destructive stripe smuts is the one that has long gone under the name of stripe smut or leaf smut. It has the same effect on its grass hosts as does flag smut and affects many of the same grasses, including some of our best forage grasses—the wheatgrasses, wild-ryes, fescues, and barley grasses. None of the cereals is known to be susceptible to it. Stripe smut is carried on the seed and can be controlled by seed treatment.

Still another type of leaf smut is the "sausage" smut of the grama grasses. It produces small but conspicuous blisterlike (often sausage-shaped) black pustules on the leaves of the grama grasses, which make up a valuable component of our western ranges. It is restricted to the grama grasses, but often is widespread and undoubtedly results in reduced forage. Its life history is not known. Methods of control therefore have not been developed.

Stem smuts (Ustilago species) are represented by several species that develop in significant abundance on economic grasses. All are marked by the development of conspicuous, dusty, brown or black layers of smut around the internodes of the stems. Sometimes nearly all the internodes seem to be smutty. Sometimes only the top one or two seem so. At first the smut is hidden by the leaf sheath that envelopes the stem, but as the stem elongates, the smut is exposed.

The stem smuts occur on some of our most valuable forage grasses—the wheatgrasses, wild-ryes, some of the bluegrasses, the needlegrasses, Indian ricegrass, and a few of the fescues.

Quackgrass is commonly infected. It might indeed furnish a supply of smut for the infection of more desirable grasses such as crested wheatgrass, big bluegrass, and blue wildrye. A peculiar feature about the quackgrass stem smut is that an incubation period of 2 or 3 years is required after infection before the smut appears. The smut is perennial in the plant once it becomes infected. After the incubation period, the plant will produce a crop of smutty stems each year as long as it lives. Infection takes place in the vegetative tissues and thus spreads from plant to plant in a field.

The control of grass smuts is accomplished mainly in two ways: Chemical treatment of the seed in the case of seed-borne smuts and through the use of resistant varieties or strains.

Not all of the grass smuts can be controlled by seed treatment, but most of the head smuts and the stripe smuts can be. Among the grasses that could be expected to respond favorably to seed treatment for the control of smut are the various wheatgrasses, mountain brome, rescuegrass and related bromes, tall oatgrass, Canada wild-rye and other wild-rye grasses, big bluegrass and perhaps other of the bluegrasses, and the barley grasses. Such seed treatment for the control of smut will also help protect the seed and seedlings from seed decay and damping-off.

The procedure of treating grass seed with chemicals for the control of smut is much the same as that employed
with cereal seeds and thus consists in principle of thoroughly applying a certain amount of a seed-treatment chemical to a certain weight of the seed and thoroughly mixing the two. However, comparatively little is known of the effectiveness of such control for many of the grass smuts. This is probably because intensive grass cultivation is relatively recent and the need for such knowledge has not been strongly felt.

The organic mercury dusts and some of the organic sulfur dusts generally are effective in the control of some of the grass smuts. New Improved Ceresan and Ceresan M, 1 ounce to a bushel, have given excellent control. Overdosage, however, hurts the seed and reduces the stands.

The organic sulfur dusts, Arasan, Arasan SFX, and Tersan, at 3 to 4 ounces to a bushel, likewise have given good control but not so consistently as organic mercury materials. They have an advantage, however, in that danger of overdosage is less. In fact, these three fungicidal dusts can be applied at maximum dosage (that is, all that can be retained by the dry seed) with little or no seed injury. This tolerance of grass seed to maximum dosage of certain of the fungicides is an advantage if small lots of seed are to be treated. Then it is not practical to attempt to weigh out minute quantities of fungicide, as needed on an ounce-per-bushel basis. Therefore, it is convenient to be able to apply an excess of the fungicide to the seed and, after mixing thoroughly, shake off the excess fungicide and not have to worry about overdosage. Others of the newer fungicides appear promising and eventually testing may show them to be as reliable as the ones here mentioned or possibly even superior.

Better results are had if the seed is stored in the treated condition for a few days. As much as 8 weeks will do no harm. It is possible therefore to treat the seed well ahead of the rush of planting time.

Comparatively little progress has been made toward the control of grass smuts through the use of resistant varieties. In the various studies that have been made of head smut, stripe smut, stinking smut, and others, and in nursery row observations, it has been noticed repeatedly that resistant lines or strains do exist, but very few attempts have been made to combine that resistance with superior agronomic qualities by the process of hybridization and selection. It is a neglected field of endeavor that merits attention, especially with regard to certain smut-susceptible species of forage grasses.

Certain it is that the smut diseases of grasses are going to come more and more into prominence as our grassland agriculture is extended. We should not delay, therefore, to make studies of the life histories of the grass smuts for which this information is lacking, because only on such a basis can intelligent control measures be devised.

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