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STEM RUST OF SMALL GRAINS AND GRASSES

Economic Importance

Stem rust, caused by the fungus *Puccinia graminis*, is a serious disease of wheat, oats, barley, and rye, as well as of many cultivated and wild grasses. It is present in Illinois every year on one or more of the small grains and grasses.

The prevalence and severity of stem rust varies from year to year, depending chiefly on the weather, the amount of rust inoculum (spores) blown into Illinois in the spring by southerly winds, and the reaction of small grain and grass varieties to the races of rust present in the inoculum. Wheat losses are now quite small in most years but have run as high as 12 percent. In oats, the estimated annual loss is 0.1 percent, yet one loss of 16 percent has been recorded for Illinois. Reductions of up to 3 percent for barley have occurred in the northern half of the state (see Illinois Natural History Survey Circular 48). Rust can also reduce both hay and seed production in many economic grasses.

Losses from stem rust have been reduced because of the extensive use of resistant, early maturing cultivars and the removal of rust-spreading barberries. Barberries once served as an early source of infection and led to new races that were often capable of attacking previously resistant cultivars. With the development of these controls, losses are now greatly reduced.

Figure 1. Where black stem rust is severe, wheat kernels are shriveled and lightweight (right) as compared with plump, healthy kernels (left) from rust-free plants. The number of kernels is the same. Oats, barley, and rye are similarly affected (courtesy U.S.D.A.).

In the United States, stem rust has lowered grain yields by as much as 200 million bushels in a single year. It also lowers test weight, reduces grain quality, and causes shriveled kernels and lodging. The rust fungus uses food and water that would normally be used in the growth and development of the kernel (Figure 1).

Nature of Stem Rust

When the stem rust fungus was described, the name included "forma specialis" (abbreviated f. sp.), which is used to indicate the host on which it was identified. For example, *Puccinia graminis* f. sp. *tritici*, was first described on wheat, but also infects barley and a number of other grass hosts. The following is a list of several forma specialis of stem rust:

1. *Puccinia graminis* f. sp. *tritici* chiefly attacks wheat, barley, triticale, wheatgrasses, wild barley, and wild ryes.

2. *Puccinia graminis* f. sp. *avenae* occurs mostly on oats and grasses–including oatgrass, orchardgrass, timothy, bromegrasses, fescues, mannagrass, velvetgrass, and bluegrasses.

3. *Puccinia graminis* f. sp. *specialis* principally attacks rye. Other hosts include barley, wild rye, wild barleys, quackgrass, bromegrasses, dropseed, and wheat-grasses.

4. *Puccinia graminis* f. sp. *phlei-pratensis* is found primarily on timothy, but fescues, orchardgrass, and wild ryes may also be infected.

5. *Puccinia graminis* f. sp. *poae* attacks bluegrasses.

6. *Puccinia graminis* f. sp. *agrostis* infects redtop, bentgrasses, orchardgrass, and bluegrasses.

7. *Puccinia graminis* f. sp. *lollii* infects ryegrasses and orchardgrass.

Physiologic Races

Each forma specialist that infects a specific cereal or grass may be further subdivided into numerous physiologic races. Races are defined by their ability to infect or not infect a series of differential cultivars. Ideally each differential cultivar would have only one resistance gene, but some or most cultivars have multiple resistance genes. Isolates of the pathogen can then be described in terms of the resistance genes that are either effective or not effective. The number of races present during a specific year is not as important as the proportion of isolates capable of infecting cultivars with specific resistance genes. Therefore, cultivars that are resistant to stem rust in one year or one location, may be susceptible in another year or location depending upon the races of the pathogen present.

More than 350 physiologic races of the wheat-attacking form *tritici* are known. Fortunately, only a dozen or so are common and able to cause damage in the U.S. each year. In Illinois, about three to six races of this type are identified in any given year.

There are more than 51 known physiologic races of the form *avenae*, which attacks oats, and also several races of the form *secalis*, which attacks rye.

SYMPTOMS

Stem rust produces elongated, reddish brown pustules on the stem, leaf sheaths, leaf blades, glumes, beards, and occasionally on the young kernels (Figure 2). The pustules, which usually begin to appear in late May or early June in southern Illinois, increase in number until the cereal or grass has headed and the seed (grain) is ripe.
Soon after the pustules appear, they rupture the epidermis, exposing a powdery, reddish brown mass of summer spores (urediospores). A single pustule may produce 350 thousand spores over a period of time. The elongated shape of the pustules, their larger size, and the fragments of

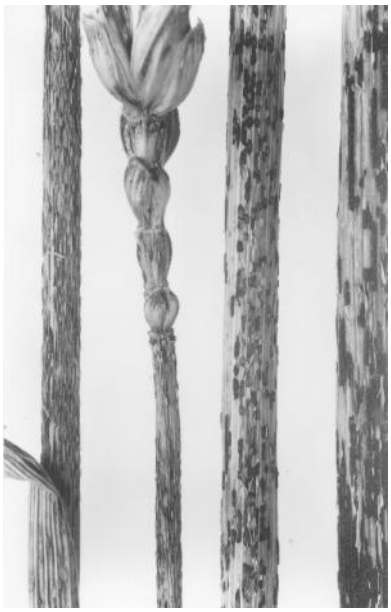

Figure 2. Wheat stems (culms) heavily infected with stem rust.

epidermis that adhere to their sides and ends and give them a ragged appearance are the characteristics that distinguish stem rust from leaf rust. Individual stem rust pustules may be 1/4 inch or more long. If rust is abundant, two or more pustules may merge to form a streak. As the crop matures, the reddish brown pustules gradually turn black as a result of the formation of overwintering spores (teliospores).

DISEASE CYCLE AND PATHOGEN VARIABILITY

The disease cycle of the stem-rust fungus involves several different kinds of spore forms. The fungus also requires an alternate host, the European or common barberry (*Berberis vulgaris*), to complete its full cycle (Figures 3 and 4). The alternate host is important in two ways: (1) New races of rust may be produced on barberry as the result of the hybridization or cross-fertilization of existing races. (2) Rust spreads from barberry to nearby cereals and grasses two or three weeks before the rust spores are normally carried by the wind from the south into Illinois. With this early start, rust can severely damage young grain plants.

Figure 3. A rust spreading common barberry bush in a fencerow (courtesy U.S.D.A.).

New races of stem rust are believed to originate largely by mutation, but also by recombination due to hybridization on barberry. Since this fungus has the capacity to develop new races that infect previously resistant cultivars it greatly complicates the work of the plant breeder in developing and maintaining rust-resistant cultivars of wheat, oats, barley, rye, and grasses. New races, occurring in the large summer population or from barberry, may be blown south in the fall to infect winter grains and grasses. Here they may overwinter, multiply in spring, and spread northward to attack Illinois grain crops that were previously resistant. Every common barberry bush is a potential source of new races of stem rust. Many more races appear in localities where barberries are numerous than in areas where there are no bushes. With the widespread eradication of barberry, however, this problem has been greatly alleviated.

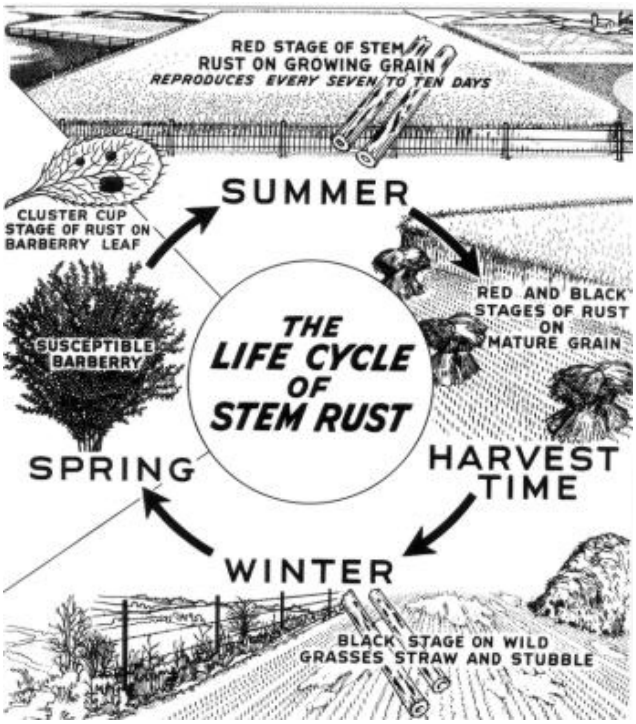

Figure 4. Life cycle of the stem-rust fungus (courtesy U.S.D.A.).

Spring. Black spores (teliospores) of the rust fungus survive the winter in Illinois and other northern states on grain stubble, straw, and various grasses. The overwintering spores germinate in the early spring, producing another type of spore (sporidia or basidiospores) that can infect only the leaves of the common barberry. Within a week to ten days, the spring or "cluster-cup" stage of the rust appears on the undersides of the barberry leaves. Spores (aeciospores) produced in the orange cluster-cups

(Figure 5) are carried by air currents and infect nearby grain and grass plants that are susceptible. Billions of spores may be produced on a single barberry bush.

Figure 5. Stem rust (the aecial or cluster-cup stage) on the lower leaf surfaces of common barberry (Berberis vulgaris) (courtesy U.S.D.A.).

Summer. With favorable weather (high humidity, foggy conditions, frequent heavy dews or light rains, and temperatures of 70°F [21°C] or above), billions of red rust spores (urediospores) are produced on susceptible cereals and grasses. New "crops" of red spores may be produced every 7 to 14 days, causing a local buildup of disease, and may be blown away by the wind to attack other grain and grass plants. The rust spreads rapidly from plant to plant, from field to field, and from south to north until harvest–as long as weather is favorable. Grain fields many miles from a barberry plant or other source of spores may be affected in this manner.

Fall and Winter. As the grains and grasses mature, the black overwintering spores are again produced. These thick-walled spores survive the winter to start another local cycle of infection in the spring. The black-spore form of stem rust cannot infect grains and grasses directly. Removing the alternate host (barberry) breaks the hybridization stage of the life cycle of the fungus.

Barberry Eradication

The rust-spreading barberry is not native to Illinois. Early settlers planted the first barberries in the state at Galena in 1844. Common barberries were used for hedge and ornamental plantings until 1918, when the shrub was outlawed.

Seed produced on barberry bushes is scattered by birds and other natural means to nearby fencerows, woodlots, timbered areas, and stream banks. Today, the problem is principally one of finding and destroying the bushes that are growing wild in difficult-to-reach areas so as to continue to maintain the present level of removal. Until 1975, federal, state, and local agencies in Illinois and eighteen other states cooperated in barberry eradication. From 1975 through 1980, the federal eradication program was gradually terminated. The states now are independently responsible for eradication. The federal program continues to test new cultivars and species for resistance to rust and to inspect bushes in commercial trade.

Since the start of the eradication program in 1918, nearly three million common barberry bushes have been destroyed on over 20,000 Illinois properties. Less than 879 of these locations where bushes have been found still required rechecking by 1973. Areas consisting of more than 55,815 square miles in Illinois were cleared of barberry bushes (Figure 6). The annual cost of this eradication program, including all federal and nonfederal funds, averaged about a hundredth of a cent per acre for the small grains harvested in Illinois each year. However, scattered bushes remain, so it is necessary to constantly watch for common barberry bushes and continue to remove those in the vicinity of small grain and grass hay fields. Currently, there are no known areas in the wheat- and oat-producing areas of the Great Plains of the United States where rust spreads from barberry to commercial fields. There is, however, always a risk of barberry becoming reestablished in fencerows and field areas.

Figure 6. Status of barberry eradication as of July 1, 1973.

How to Identify Barberries

The common barberry that harbors and spreads stem rust is normally about six feet tall. Specimens may range from tiny seedlings to erect, woody, fifteen-foot shrubs. There are both green- and purple-leafed varieties.

The red- and green-leaf Japanese barberries, now widely used for hedge and ornamental plantings are immune to rust. These harmless, low-growing shrubs (seldom more than five feet tall) are easily distinguished from the common barberry, as shown in Figure 7. A few other kinds of harmless barberries (such as Mentor) are sold by nurseries and may be planted wherever desired.

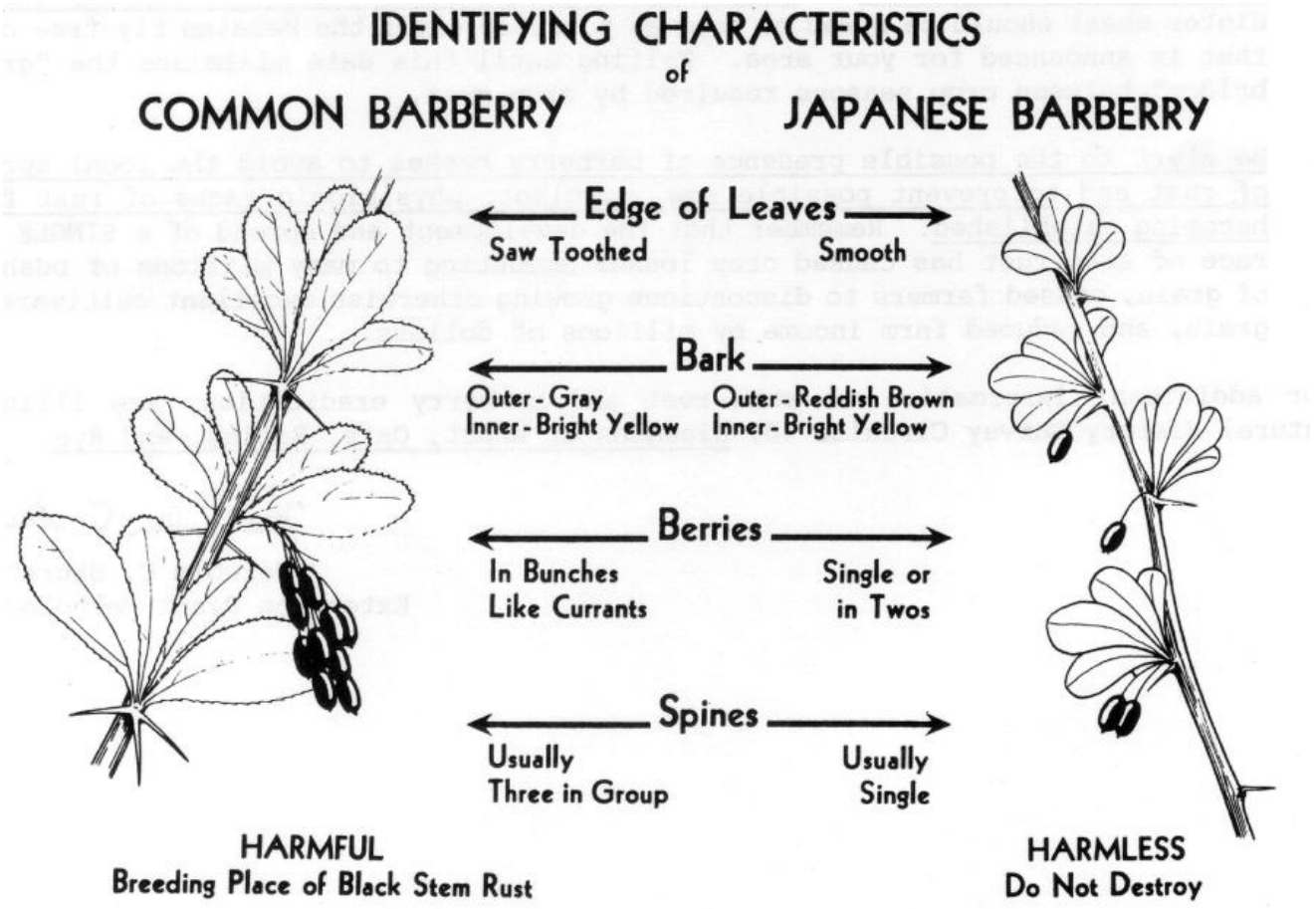

Figure 7. Rust-spreading common barberry bushes are not hard to tell from the harmless ornamental or Japanese barberry. They differ in type of leaf, number of spines, and color of bark–also, in the way in which berries are borne (courtesy U.S.D.A.).

CONTROL

1. **Sow small grain cultivars that are rust-resistant and that mature early**. Use those recommended for your locality by the Department of Agronomy at the University of Illinois and by your nearest Extension adviser.

2. **Use chemical control wisely**. There are several fungicides available that can be applied as sprays, usually by aircraft, that control stem rust and other diseases. Recommended fungicides and their timing for maximum control are given in the **Illinois Agricultural Pest Management Handbook** which is updated annually and available at your nearest Extension office. It is very important to

scout fields and to know when the disease can cause a yield reduction. In Illinois, if rust is present on the flag leaf or leaf below the flag leaf at heading, yield and grain quality losses may occur. Some fungicides must be applied at specific growth stages, so it is important to carefully follow label directions.

3. **Sow spring grains early.** Plant winter crops on recommended seeding dates. Winter wheat should be sowed as soon as possible after the hessian fly-free date that is announced for your area. Waiting until this date minimizes the "green bridge" between crop seasons required by stem rust.

4. **Be alert to the possible presence of barberry bushes to avoid the local spread of rust and to prevent possible new, virulent, physiologic races of rust from becoming established**. Remember that the development and spread of a single new race of stem rust has caused crop losses amounting to many millions of bushels of grain, caused farmers to discontinue growing otherwise excellent cultivars of grain, and reduced farm income by millions of dollars.