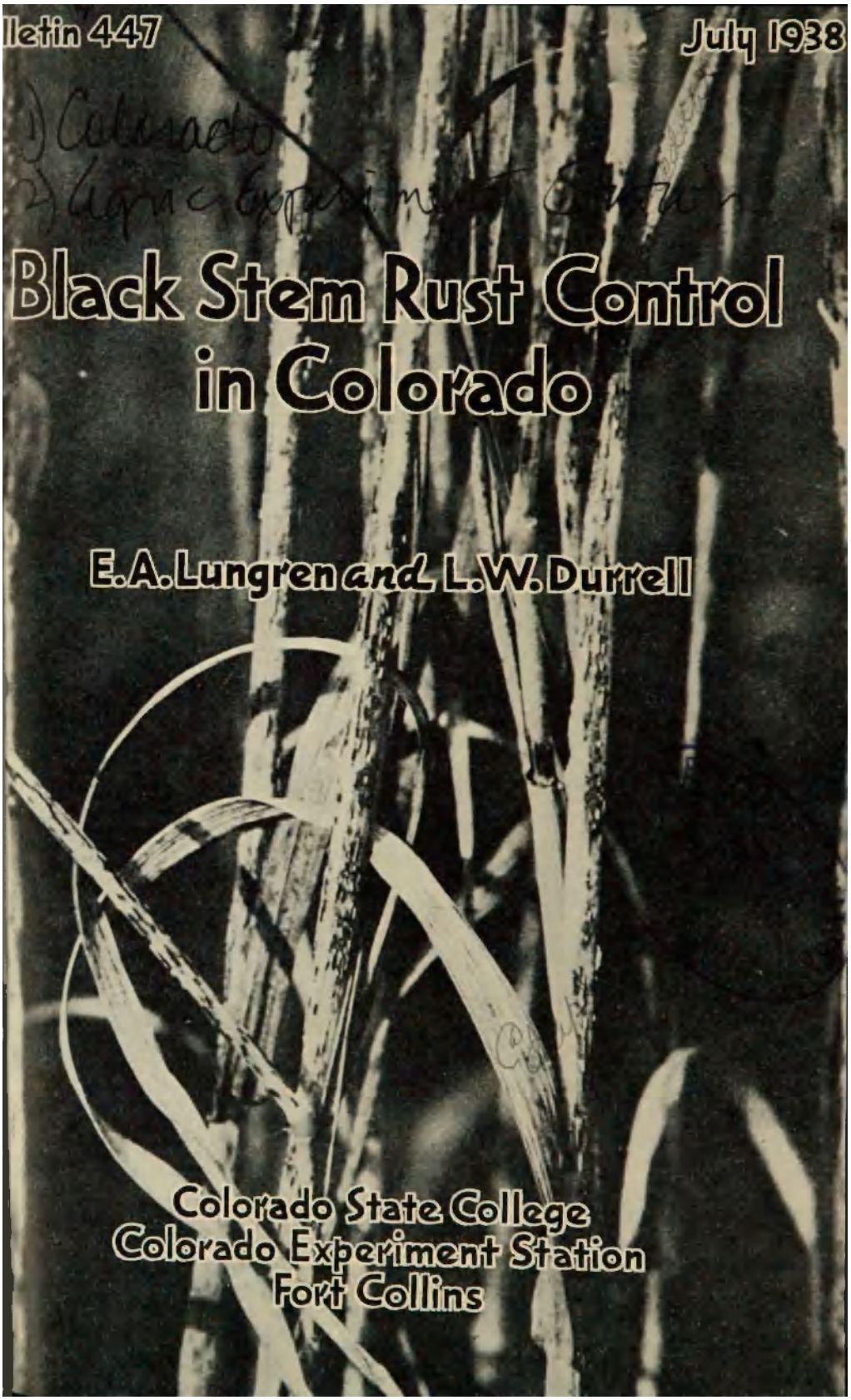
lletin 447
July 1938
Black Stem Rust Control in Colorado
E. A. Lungren and L. W. Durrell
Colorado State College
Colorado Experiment Station
Fort Collins

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Black Stem Rust Control in Colorado

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Controlling Black Stem Rust in Colorado

BLACK stem rust is one of the most destructive of all grain diseases. It is caused by a parasitic fungus that attacks the succulent leaves and stems of wheat, oats, barley, rye, and about 75 different grasses. Grain from fields damaged by rust is shriveled, light weight, and otherwise injured for milling purposes.

There is a direct relationship between weather and the development of rust. The fungus can thrive only when weather conditions favor its growth. Rust spores need moisture for germination just as do seeds of wheat and oats. Because of this close relationship between weather and the spread of rust, many persons have erroneously believed that the disease is actually caused by weather. Regardless of environment, a wheat crop cannot be grown unless seed is put in the ground, and rust will not appear unless spores are present to cause infection.

In the 13 North-Central grain-growing States more than 57 million bushels of wheat were destroyed by rust annually during the period 1916-20. Losses in Colorado in the past have averaged 335,000 bushels annually. The greatest amount of damage to occur in any one year, in this State, was in 1923, when estimated losses amounted to more than three and one-half million bushels.

Although stem rust was recognized by farmers as a distinct hazard in the profitable production of cereal crops as early as colonial

*The authors acknowledge the kind assistance of Dr. D. W. Robertson of the Agronomy Section, Colorado Experiment Station; W. J. Henderson, Extension Pathologist, Colorado State College; and S. B. Fracker and W. L. Popham, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in editing the manuscript.

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times, no organized attempt was made to control the disease until 1918, when 13 North-Central States, including Colorado, undertook the eradication of rust-spreading barberry bushes. Since then steady progress has been made toward the ultimate solution of the problem. Millions of rust-spreading barberry bushes have been destroyed in the important grain-growing States. Varieties of grain have been developed which are highly resistant to the more prevalent forms of the stem rust fungus, and the adoption of certain farming practices, including early seeding of spring grains, has further aided in protecting crops from rust. On the whole, because of these factors, stem rust has been greatly reduced.

It is the purpose of this bulletin to report briefly on the progress that has been made in the eradication of rust-spreading barberry bushes in Colorado, and to point out means by which stem rust losses may be further reduced.

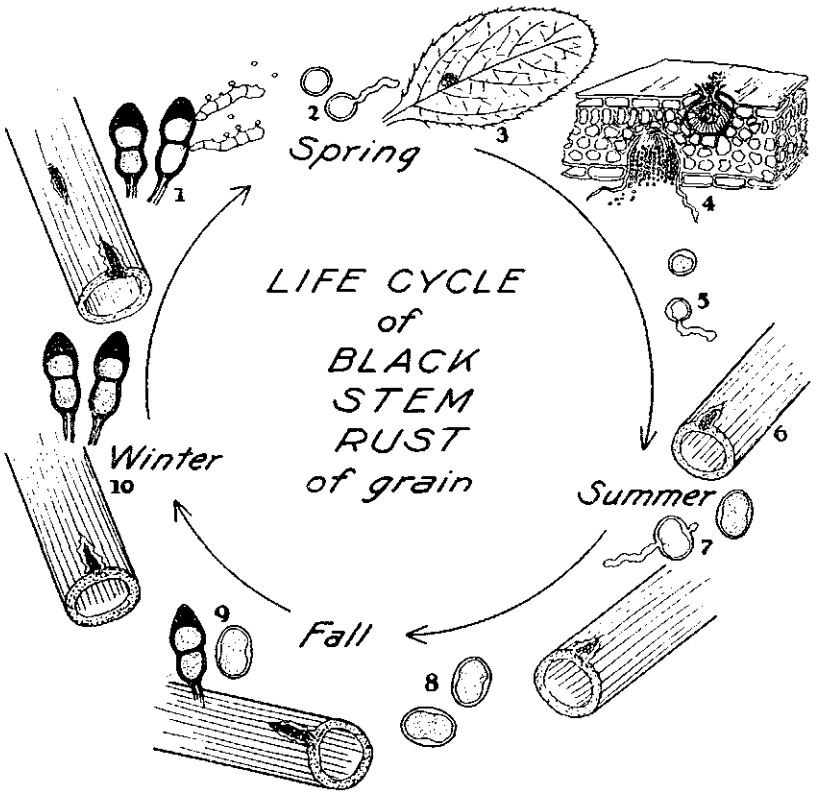

Figure 1.—Life cycle of stem rust of wheat, oats, barley, and rye: Overwintering black spores (teliospores) germinate (1) in the spring. They produce several very small spores (basidiospores) (2) that are carried by air currents to nearby barberry bushes, where they germinate. The resulting infection of the barberry (3) produces spermogonia and cluster cups (aecia) (4). Cluster-cup spores (aeciospores) are blown to grainfields and germinate on the grain plants (5), where they produce rust-infection pustules on the stems and leaves (6). These pustules contain the red or summer spores (urediospores) (7) which reinfect the crop, producing more of their kind (8), until toward the end of the growing season, when the black-spore pustules develop and the teliospores (9) mature and spend the winter on straw and stubble (10), where they germinate in the spring.

Stem Rust Is Caused by a Tiny Parasitic Plant

The fungus *(Puccinia graminis)* which causes black stem rust reproduces and spreads in a manner similar to such organisms as bread mold and the green mold of decaying fruit. There are several stages in the annual life cycle of the stem rust fungus (fig. 1). Probably the one most familiar is the black spore stage which occurs on the stems of ripening grain plants. The black spots, or pustules of rust, found on stubble and straw at harvest time are composed of thousands of tiny spores which live through the winter in a dormant state. Spores of fungi correspond in function to seeds of common plants.

Early in the spring, the black spores germinate and produce very small, colorless, secondary spores, which may be carried for miles by the wind. These tiny spring spores can cause infection only on the leaves of certain kinds of barberry bushes. A third kind of spore appears in cluster cups on the lower side of infected barberry leaves. These in turn infect nearby grains and grasses, producing the red or summer stage of the fungus. During warm, moist weather this stage of the rust spreads rapidly from one grain plant to another, and from field to field. As the weather becomes cooler and crops begin to mature, the black or winter spores again appear. Thus, in Colorado and many other grain-growing States, the common barberry *(Berberis vulgaris* L.) and other susceptible species, including the native Colorado variety *(Berberis fendleri* Gray), play a vital part in the occurrence and spread of the stem rust disease.

Sources of Stem Rust in Colorado

There are two important sources of stem-rust infection for grain fields in Colorado: (1) The remaining rust-susceptible barberry bushes; and (2) rusted grain fields in States farther south, where the summer stage of the disease survives throughout the year.

Barberries have been found rusted in certain counties in this State as early as May 8, and it is not uncommon for nearby grains and grasses to become infected during late May and early June. Thus, local barberry bushes constitute a direct source of infection and usually prove responsible for the first rust that appears in the spring. If barberry bushes are numerous and well distributed throughout a grain-growing area, many local spreads of rust that develop early in the spring may later coalesce to cause regional epidemics before the crops are ready for harvest.

A very striking occurrence of rust spread from barberry was observed on June 26, 1922, at Burlington, Colo., and another in 1923 from bushes growing in the town of Yuma, in Yuma County. In both cases heavily infected barberry bushes were found growing on

town properties. From these bushes stem rust had spread to the wild grasses scattered in vacant lots about the towns and to the surrounding grain fields in the vicinity of the towns to a distance of some 15 miles. Figure 2 shows the distribution of rust within the two miles immediately surrounding Burlington, Colo. The fields closest

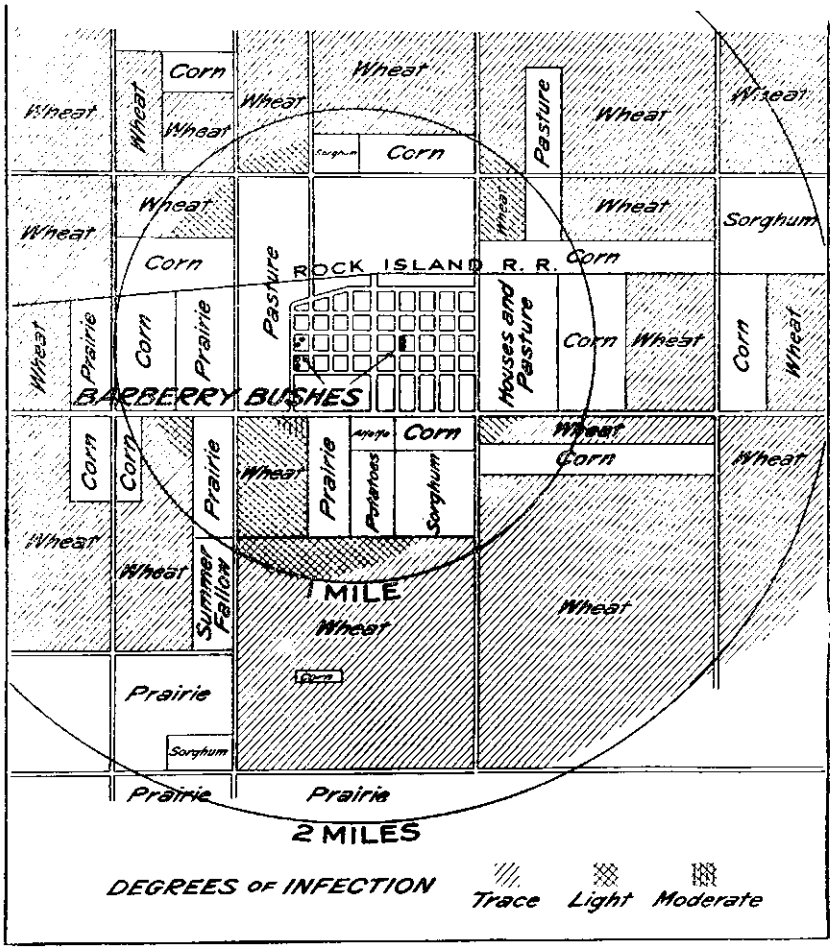

Figure 2.—This map illustrates the spread of rust from infected common barberry to grains and grasses. It records the results of a survey made at Burlington, Colo., in 1922.

to the towns were most heavily infected, and the rust decreased farther away to points beyond 15 miles, where no rust could be found. Before harvest the epidemic had extended to neighboring counties.

Many instances similar to these have been observed, not only in cities and towns but on individual farms in Adams, Arapahoe, Boulder, Douglas, El Paso, Fremont, Jefferson, Kit Carson, Larimer, Morgan, Pueblo, Rio Grande, Weld, and Yuma Counties. In many

cases these local outbreaks reached epidemic proportions, extending over large areas. Since the eradication of the susceptible barberry, no early season outbreaks of stem rust have been evident.

In certain years, rusted grain fields in the Southern States provide a second important source of stem rust infection for Colorado grain crops. Quite often rust becomes generally distributed throughout the eastern part of the State late in the summer as a result of wind-borne spores. Only during occasional years, however, does rust from this source reach Colorado early enough in the growing season to cause extensive damage.

There is some evidence that the summer or "repeating" stage of stem rust may occasionally live over winter on wild grasses in some of the protected mountain valleys in Colorado. This occurs so seldom, however, and in such limited areas, that it is not of sufficient importance to be considered another source of infection for the new crops in locations where freezing temperatures prevail during the winter months. In fact, no natural infection from this source has ever been found in Colorado.

Barberry, the Source of New Physiologic Races of Stem Rust

In addition to constituting an early source of stem rust infection, the leaves of the barberry provide a breeding ground for new parasitic races of the fungus. There are several different varieties of grain rust, and each is made up of many parasitic races that can be distinguished from each other only by their effect on certain varieties of wheat, oats, and rye. More than a hundred such races of wheat stem rust have been identified. Each attacks certain wheat varieties but not others. For example, many races do not attack Kanred wheat; but if two of these cross on the leaves of a barberry, the resulting hybrid may attack Kanred heavily (fig. 3).

Thus, in addition to removing local sources of stem rust infection, the eradication of barberry bushes reduces the likelihood of new races of rust appearing which may attack varieties of grain that are resistant to races now prevalent.

Barberries Common to Colorado

Of the three species of barberry most commonly found in Colorado, two are susceptible to the stem rust fungus and one is immune. The two susceptible species are *B. vulgaris* L., an introduced variety, and *B. fendleri* Gray, which is native to certain parts of the State. The immune species, *B. thunbergii* DC., Japanese barberry, is a popular decorative shrub and it is used extensively for ornamental planting on farms, city lawns, and in parks.

The common barberry, *B. vulgaris* L., is not native to the United States, but it was carried to Colorado and planted for ornamental

and hedge purposes by early settlers. Seeds from the planted bushes were widely scattered by birds, irrigation water, and other natural agencies, with the result that extensive areas in certain counties became generally infested with bushes, adding materially to the cost of subsequent control work.

The common barberry (fig. 4) is a woody, erect shrub, often growing to a height of 10 feet or more, but the average-sized bush is about 4 to 6 feet tall. Its leaves have fine, bristle-tooth edges, grow in clusters on the stems, and may be either green or purple in color. Directly beneath each group of leaves there are from three to five thorns. In the spring, barberry bushes have small yellow flowers; in the summer and fall, oval berries appear, bright red when ripe, hanging in clusters similar to currants. The outer bark of the common barberry is gray, and the inner bark and roots are a bright

Figure 3.—New strains of stem rust develop on barberry. More than a hundred parasitic strains of wheat stem rust alone are known. Each strain can attack some wheat varieties but not others.

yellow. Barberry bushes usually retain their leaves somewhat later in the fall than most other shrubs.

The native barberry, *Berberis fendleri* Gray (fig. 5), is found growing only in the agricultural and mountainous areas of southwestern Colorado, particularly in the San Luis Valley and the San Juan Basin. It is equally as susceptible to attack by the stem rust fungus as the common or European barberry, and its eradication in important grain-growing areas is an essential rust-control measure. While the leaves, thorns, berries, inside bark, and roots of *B. fendleri* resemble closely those of the common barberry, the outer bark is reddish-brown instead of gray. The native barberry, which seldom attains a height of more than 4 or 5 feet, is found growing on hillsides, in pastures, and along fence rows and rivers, often in patches several feet in diameter.

The Japanese barberry, *B. thunbergii* DC., is entirely immune to attack by the stem rust fungus and may be grown where desired without danger to grain crops. It is a low, spreading type of bush, rarely more than 3 or 4 feet tall. Its leaves have smooth edges. The

thorns are usually single, and the berries occur one or two in a place, more like gooseberries. The flowers and berries closely resemble those of the common barberry. The outer bark is reddish-brown, and the inner bark and roots are yellow. The identifying characteristics of both the Japanese and the common barberry are illustrated in figure 6.

Figure 4.—A common barberry bush. It spreads stem rust to wheat, oats, barley, rye, and grasses.

Methods of Eradicating Barberries in Colorado

It is difficult to kill a barberry by digging or pulling, as sprouts often develop from root fragments left in the ground. For this reason chemicals are used wherever they will not endanger other trees or shrubs.

For several years ordinary common salt has been used effectively for treating both native and common barberries (fig. 7). Ten pounds of salt, applied at the base of a common barberry having a crown 1 foot in diameter at the ground line, is sufficient to kill it. A pound of salt to a square foot of ground is equally as effective for killing the native barberry which ordinarily grows in patches. To prevent any possible harm to livestock, the chemical should be worked well into the soil and covered with earth, stones, or boards. Precautions should also be taken not to apply the salt where there is danger of killing other shrubs or trees.

Figure 5.—The native barberry. A low, erect-growing shrub, common in southwestern Colorado. It is susceptible to attack by the stem rust fungus and should be destroyed.

"Calcium chlorate" (proprietary) and salt brine also have been used successfully for destroying native barberries. Eight pounds of "calcium chlorate" dissolved in 5 gallons of water, applied as a spray and soil drench, is sufficient to treat a square rod of ground where native barberries are growing. However, this chemical should be handled only by experienced operators because of the fire hazard involved; clothing that becomes saturated with the solution will ignite readily and burn rapidly if brought in contact with a spark or flame. Salt brine (solution of common salt and water), applied at the rate of 80 pounds of salt to 20 gallons of water per square rod of barberry-infested ground, has given satisfactory results.

About 2 years is required for salt or "calcium chlorate" to leach from the soil sufficiently to permit planting other shrubs or grasses. Figure 7 shows barberry plants that have been treated with salt, and figure 8 shows an eradication crew applying a chemical spray to an area infested with native barberry.

Many Barberry Bushes Destroyed in Colorado

Since 1918, about 4,847,000 barberry bushes, seedlings, and sprouting bushes (fig. 9) have been destroyed on 2,343 properties distributed throughout the State. In connection with control operations, 149 tons of salt and 7 tons of "calcium chlorate" have been used. The accompanying map (fig. 10) shows the relative distribution of properties that have been found infested with rust-spreading barberry. Only common or European barberries were found and destroyed on the many infested properties in Adams, Arapahoe, Boulder, Douglas, El Paso, Fremont, Jefferson, Larimer, Montrose, Pueblo,

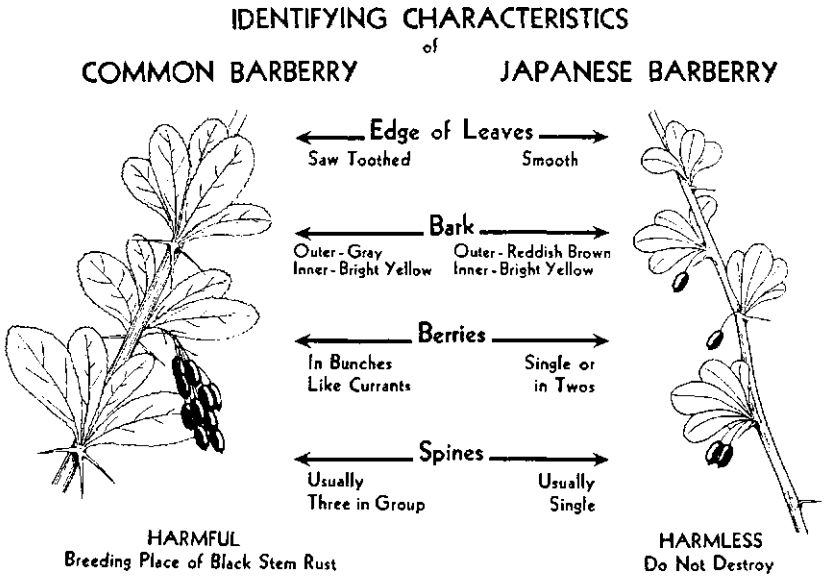

Figure 6.—By examining the leaves, thorns, berries, and roots, barberry bushes may easily be distinguished from other shrubs.

and Weld Counties. Wild native barberries *(B. fendleri)* are widely distributed in Archuleta, Conejos, Costilla, Dolores, La Plata, Montezuma, and Rio Grande Counties.

When barberry eradication was first undertaken in Colorado, it was believed that the common or European variety would be found principally in cities or towns where they were planted for ornamental or hedge purposes. However, the field survey soon demonstrated that many bushes had been planted on farms, and that seed from these bushes, dispersed by birds and other natural agencies, had resulted in areas of infestation often involving all uncultivated lands within a radius of several miles of the original bushes. In such areas two and possibly three detailed inspections, at 4- to 5-year intervals,

of all woodlots, orchards, groves, fence rows, stream banks, and irrigation ditches will be required to prevent the regrowth of bushes from seed distributed before the fruiting bushes were destroyed.

Distribution of Barberry Plants Prohibited

A State law and a Federal quarantine provide further safeguards against the redistribution of barberry bushes in areas where control work is being carried on. Federal Quarantine No. 38 (Revised) prohibits shipment of rust-susceptible species of barberry into or between Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri,

Figure 7.—Apply common salt to the roots of the common or native barberry. Ten pounds is sufficient to kill an average-sized bush with a diameter of about 12 inches at the base.

Montana, Nebraska, North Dakota, Ohio, Pennsylvania, South Dakota, Virginia, West Virginia, Wisconsin, and Wyoming. State Quarantine No. 8, issued by the State Entomologist in 1919, restricts the propagation and sale of these bushes within this State.

These laws and Federal rules and regulations do not in any way restrict the shipment or planting of Japanese barberry *(B. thunbergii)* or of the rust-immune varieties. The varieties so far tested by the Department and found immune are *Berberis thunbergii atropurpurea, maximowiczii, minor, pluriflora,* and *pluriflora erecta.* No Federal permits are required for the shipment of Japanese barberry and the varieties named.

There are 25 other kinds of barberry and Mahonia plants which are also immune or relatively resistant to black stem rust, and these may be shipped into or from Colorado under Federal permit. Application for such permit should be addressed to the Division of Domestic Plant Quarantines, Bureau of Entomology and Plant Quarantine,

Figure 8.—Labor crew spraying areas of native barberry with chemicals.

U. S. Department of Agriculture, Washington, D. C. The species which may thus be shipped under permit are as follows:

Berberis aemulans
Berberis aquifolium (Mahonia)
Berberis beaniana
Berberis buxifolia
Berberis candidula
Berberis chenaultii (hybrid)
Berberis circumserrata
Berberis concinna
Berberis darwinii
Berberis dictyophylla var. *albicaulis*
Berberis diversifolia
Berberis edgeworthiana
Berberis gagnepainii
Berberis gilgiana
Berberis julianae
Berberis koreana
Berberis mentorensis
Berberis nervosa (Mahonia)
Berberis potanini
Berberis repens (Mahonia)
Berberis sargentiana
Berberis sanguinea
Berberis stenophylla (hybrid)
Berberis triacanthophora
Berberis verruculosa

Barberry and Mahonia plants of species and varieties other than those listed under the last two paragraphs are prohibited shipment into and from Colorado, and no permits will be issued for such shipment.

Occurrence of Stem Rust in the Absence of Barberry

The initial control work, involving the eradication of more than 50,000 bushes, sprouting bushes, and seedlings, is approaching completion in extensive areas that were infested with barberry bushes in counties east of the Rocky Mountains. The question is often raised as to why stem rust occasionally occurs here even though the remaining bushes are few and scattered. There are two possible explanations of the source of this rust:

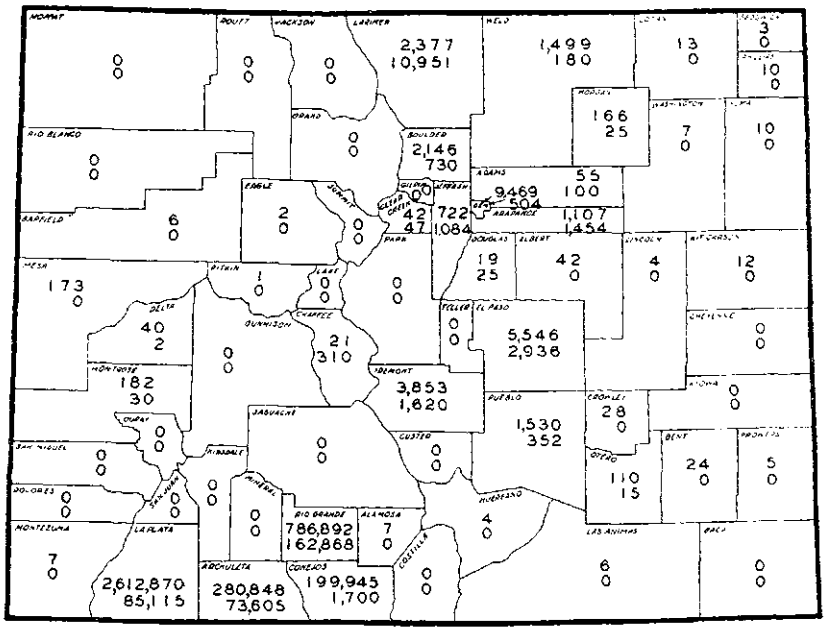

Figure 9.—Numbers of barberry bushes and seedlings destroyed in Colorado, 1918-37. Upper figures in the case of each county indicate the bushes destroyed, a total of 3,909,803; lower figures indicate the seedlings destroyed, a total of 343,653; in addition, sprouting bushes, for which figures are not given on the map, totaled 594,250, bringing the grand total to 4,847,706.

(1) It should be kept in mind that a single barberry bush may liberate billions of spores during a brief period of 2 to 3 weeks in the spring. Rust spreading from an individual bush has been traced for 15 to 20 miles in Colorado. Thus, barberries growing on pastures or other uncultivated lands may be responsible for rust outbreaks in grain fields some distance away.

(2) In certain years an infection of stem rust that cannot be traced directly to barberry may develop over extensive areas rather late in the season. Usually rust appearing under these circumstances is due to spores carried by the wind from neighboring States. It is known that the summer or repeating stage of stem rust lives through

the winter in Texas and sometimes as far north as Oklahoma. In these States the barberry is not a limiting factor in the propagation of the fungus. If weather conditions are such that rust in the South multiplies rapidly, it may gradually spread northward as the season advances, reaching Colorado before crops mature. As previously indicated, however, rust from this source normally appears 2 to 3 weeks later than infection developing near local barberry bushes.

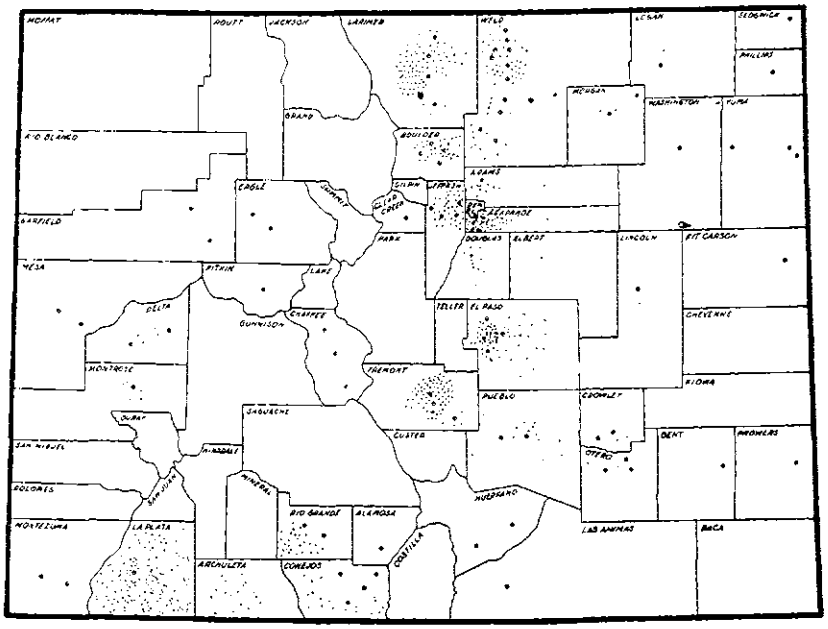

Figure 10.—Progress in barberry eradication in Colorado, 1918-37. The number of properties cleared of bushes totaled 2,343. The small dots indicate the farms on which barberry bushes were destroyed; the large dots indicate the towns in which barberry bushes were destroyed.

Recommendations for Control of Stem Rust

While the eradication of rust-spreading barberry bushes in Colorado is highly important, there are other farm practices which will also help to reduce losses from stem rust. Recommended control measures are as follows:

(1) Rust-spreading barberry bushes should be destroyed at the earliest opportunity. In addition to being responsible for early spring outbreaks of black stem rust, barberries serve as the breeding ground for new parasitic races of the stem rust fungus.

(2) Select for seed varieties of grain that are resistant or immune to the more prevalent forms of stem rust. Hybrid wheats produced by the Agronomy Section of the Colorado Experiment Station are tested each year for rust resistance. When one of these new

varieties meets the requirements of a given region and proves desirable from the standpoint of yield, milling qualities, and resistance to other plant diseases, it is made available to the public. Further information concerning recommended rust-resistant varieties of grain may be obtained by writing the Colorado Experiment Station at Colorado State College.

(3) Adopt farming practices that promote early ripening of small grains. Spring wheat planted early on well-prepared soil stands a better chance of escaping rust damage than wheat sown later. If a choice of land is possible, wheat should not be planted on low, poorly drained soil.

Leaf Rust

Leaf rust is entirely different from stem rust. It usually attacks the leaves or leaf sheaths of the grain plants rather than the stems. Ordinarily it does not cause measurable damage in this State. Leaf rust pustules are about the size of a pinhead, round or oval in shape, and yellowish or orange in color. It is not spread by the barberry.

Stem Rust Control Work Conducted on Cooperative Basis

Barberry eradication in Colorado is administered by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in cooperation with the State Department of Agriculture and Colorado State College of Agriculture and Mechanic Arts. In recent years, men employed with funds appropriated under the several emergency relief appropriation acts have been assigned to work on this project. Property owners have assisted by transporting chemicals and otherwise helping with the removal of bushes from their own land.

In addition to the survey and eradication, demonstrations on stem rust control have been given before school students and other organizations in Colorado. Educational work in advance of eradication crews has proved successful in obtaining leads to localities infested with barberry bushes. As a result of the informational program, many barberries have been reported. One large area of escaped bushes growing along Clear Creek, in Jefferson County, was found as a result of reports sent in by school children. The primary purpose of the educational program is to stimulate local interest and to locate and report undiscovered plantings or areas of escaped bushes. This type of survey has been carried on in 27 Colorado counties. Some 1,145 demonstrations have been given to 35,481 persons. As a result of these demonstrations, 37 properties carrying 459 common barberry plants have been found and the shrubs eradicated.

The Rust Prevention Association, with headquarters in Minneapolis, Minn., takes an active part in the educational work which precedes and accompanies control operations. This organization is supported by many farm owners, grain dealers, and merchants throughout the Northwest who are interested in improving agricultural conditions. The Rust Prevention Association cooperates with the Federal and State departments of agriculture in making available for distribution to grain growers circulars and other information relating to control work.

It is important that not only farmers but all property owners become acquainted with the facts relating to stem rust, as frequent reinspections of areas where the initial eradication of barberry bushes has been completed will be required to prevent the growth of new bushes from seed now in the ground.

Summary

It is estimated that during the past 25 years black stem rust has damaged small-grain crops in Colorado to the extent of 335,000 bushels annually. Barberry eradication and other control measures have materially reduced rust losses in recent years.

Stem rust is caused by a parasitic fungus that lives for a time each spring on the leaves of certain species of barberry. Spores produced on the barberry attack wheat, oats, barley, rye, and about 75 different kinds of grasses. In this State barberry bushes have proved to be the most important source of early stem rust infection. Epidemics of stem rust involving areas of several square miles may originate from a single barberry bush.

In addition to constituting an early spring source of infection, the barberry is a possible breeding ground for new parasitic races of the stem rust fungus which may attack varieties of grain that are highly resistant to races now prevalent.

There are three varieties of barberry common to Colorado: the common or European variety *(B. vulgaris)*, the native barberry *(B. fendleri)*, and the Japanese barberry *(B. thunbergii)*. The common barberry and the native barberry are both susceptible to attack by the stem rust fungus. The Japanese barberry is immune.

The State is cooperating with the U. S. Department of Agriculture in a vigorous campaign to exterminate the common European barberry completely in Colorado, and to destroy the native barberries wherever they grow in or adjoining cultivated lands. The work has been carried on since 1918, and excellent progress has been made, especially during recent years through the use of Federal funds appropriated for unemployment relief.

Many locations of barberry have been reported as a result of demonstrations given before school children and other organizations.

Educational work conducted in advance of the survey has proved successful in obtaining information about localities in which grain rust has occurred and which are infested with barberry bushes.

It is difficult to kill barberry bushes by digging or pulling, as sprouts often develop from root fragments left in the ground. Either common salt, salt brine, or "calcium chlorate" when properly applied will kill barberry bushes and eliminate danger of sprouting.

Occasionally, stem rust spores carried by the wind from neighboring States reach Colorado in time to injure grain crops before they mature. However, infection from this source usually appears 2 to 3 weeks later than that which develops near local barberry bushes.

To reduce losses from stem rust: (1) Eradicate all rust-spreading barberry bushes, (2) select for seed rust-resistant varieties of grain recommended by the Colorado Agricultural Experiment Station, and (3) plant spring wheat just as early as the soil can be properly prepared.

NOTES

BULLETIN SERVICE

The following late publications of the Colorado Experiment Station are available without cost to Colorado citizens upon request:

Popular Bulletins

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423	The Parshall Measuring Flume
424	Grape Growing in Colorado
425	Timber Milk Vetch as a Poisonous Plant
426	Oiled-Gravel Roads of Colorado
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