Proceedings of the Iowa Academy of Science

Volume 49 | Annual Issue Article 31

1942

Diseases of Cereals and Flax in Iowa

I. E. Melhus
Iowa Agricultural Experiment Station

D. R. Shepherd
Iowa Agricultural Experiment Station

Marie A. Corkle
Iowa Agricultural Experiment Station

DISEASES OF CEREALS AND FLAX IN IOWA*

I. E. Melhus, D. R. Shepherd and Marie A. Corkle

Information relating to the prevalence and destructiveness of diseases of plants has been recorded in various journals and papers ever since the beginning of agriculture in Iowa. Most of these records are specific and valuable; some, however, especially for the early years, are so general as to have little value. In this paper an attempt has been made to summarize available records of the prevalence and destructiveness of the diseases of cereals and flax in Iowa and to interpret the early general reports on the basis of our present knowledge of plant pathology.

DISEASES OF CORN

Some diseases were observed in the Iowa corn crop as early as 1870 (Pammel and King, 1909), but previous to 1914 smut and rust were considered practically the only serious diseases of this crop. In 1914 (Pammel, Seal and King, 1915) a survey revealed that certain root, stalk and ear rots were responsible for widespread losses throughout the state. Yields in infected fields were reduced 10 to 15 bushels per acre, and a conservative estimate of the loss to Iowa farmers was $15,000,000.

As a result of the research work and surveys conducted during the past 20 years, it is now known that diseases are one of the important limiting factors in corn production in this state.

Smut

Ustilago zeae (Beckm.) Unger

Smut was abundant on corn in Iowa in 1870 and no doubt was present before that time. Bessey (1884) wrote of corn smut, "Some years it is hardly noticeable while in others it is so abundant as to cause 15 percent loss." A few years before he had observed one field with a two-thirds loss. He reported that this disease was severe in 1887. Since 1870 this disease has been reported practically every year and has been general throughout the state. Since 1915 the annual loss has ranged from 1 to 9 percent.

Platz (1929) studied the occurrence of smut in 13 plots of Reid's Yellow Dent corn in different fields near Ames, Iowa, in 1923 and found that 7.9 percent of 17,255 plants examined were in-

*Journal Paper No. J-1012 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 450.

fected with smut. Similar investigations in 1927 revealed that of 3,974 plants examined, 15.7 percent were infected with smut. Archer (Plant Disease Rep. Sup., 1927, p.8) found that 13 percent of the 3,500 plants examined in scattered fields in the northern part of Iowa in 1927 were infected with smut, and 15 percent of 700 plants examined in Cass County were infected. Davis (1936) observed more than 9,000 corn plants near Ames during the period 1930-34 and found smut galls in more than 12 percent of them. These figures tend to indicate that the estimated annual losses from this disease may have been low.

Rust

Puccinia sorghi Schw.

Rust on corn occurs generally through the state and has been observed to some degree practically every year since it was first recorded in 1870 (Pammel and King, 1909). The maximum loss (2 percent) was recorded in 1925 when 90 percent of the fields were affected. Normally the loss is only a trace.

In 1925 when the disease was relatively severe the alternate host, *Oxalis europea,* was generally infected, the fungus having been favored in its development by the warm, wet weather of June. The yearly distribution of the fungus throughout the state probably is dependent upon the distribution of the alternate host and favorable conditions for the development of the æcidial stage.

Diplodia Dry Rot

Diplodia zeae (Schw.) Lév.

Diplodia dry rot was reported first in Iowa by Holway (Gilman and Archer, 1929) in 1882. It was reported for the first time to the Iowa Plant Disease Survey in 1909, and that year it was observed in 16 counties and caused a 1.5-percent loss. It was reported next in 1915 from 28 localities. In 1921 the loss was 4 percent for the entire state. Durrell (1923) reported that of 650 ears collected in the north and east central part of the state in 1921, 11 percent were attacked by this fungus and were unfit for planting. Of 130 ears collected in the south central part of the state 7 percent were infected with Diplodia.

The condition in 1923 was even severer than in 1921. Fifteen percent of the seed planted was infected, which reduced the stand considerably. Later the rot of the stalk, ear and shank became prevalent, causing a loss of about 9 percent.

Since 1921 this disease has been responsible for severe damage each year. Losses have ranged from 1 to 10 percent. Losses for

the past nine years were as follows: 1933, 4 percent; 1934, 9; 1935, 4; 1936, 10; 1937, 1938, and 1939, 1; 1940, 4; and 1941, 5 percent. In a study of the relative prevalence of the various fungi in carloads of corn that reached the terminal markets from Iowa, Hoppe and Holbert (Plant Disease Rep., 1936, p. 26) found 35 percent of the cultured kernels taken from damaged samples of the 1933 crop to be rotted by Diplodia. Eighteen percent were rotted by Diplodia in 1934. In 1935, 3.7 percent of the samples from 68 cars were affected by Diplodia (Plant Disease Rep., 1936, p. 312).

Porter (1925) in 1925 studied this disease in commercial fields throughout the state and analyzed the weather data for each locality for that year. He concluded that the amount of infection in a given growing season is dependent upon (1) abnormal August precipitation, (2) fairly high temperature, (3) the time when the corn plant loses weight, and (4) the presence of the spores of the pathogen.

Durrell (1923) found that during the years when Diplodia was most destructive the rainfall was normal or above at the end of the growing season. The losses since 1923 substantiate these findings. With normal temperatures and excessive moisture in August and September, this disease can be expected to damage the Iowa crop.

Gibberella Dry Rot

Gibberella saubinetii (Mont.) Sacc.

Gibberella dry rot was first recorded by the Iowa Plant Disease Survey in 1909 when it caused a 2-percent loss. It was next recorded in 1914, and in 1915 it was widespread and serious throughout the state. Since that time it has been observed practically every year, the losses ranging from a trace to 6 percent.

Pammel, Seal and King (1915) worked with this disease in 1914 and 1915. They found perithecia of Gibberella associated with Fusarium but were unable to definitely connect Gibberella with the conidial stage. They referred to it merely as Fusarium. This may or may not have been this same fungus.

In recent years Gibberella has been considered along with Diplodia and Nigrospora as one of the troublesome dry rot fungi. It attacks the seed after it is planted in the spring, and later the stalk and ears.

Hoppe and Holbert (Plant Disease Rep., 1936, p. 26, 312) made platings from samples taken from carlots of Iowa corn that ar-

rived at the terminal market in 1933-34-35. Gibberella was found in 3 percent of the samples from 14 cars in 1933, 4 percent from 135 cars in 1934 and 9.1 percent from 68 cars in 1935. These figures probably would be considerably higher if a sampling could be made of all corn on representative farms in view of the fact that the best corn no doubt is marketed.

Nigrospora Dry Rot

Nigrospora oryzae (B. and Br.) Petch

This dry rot was widespread in Iowa in 1923 (Durrell, 1925) and no doubt had been prevalent for several years prior to that time. That year it caused a loss of 9.1 percent for the state, and in a few fields, 50 to 60 percent of the ears were infected. Since 1923 this fungus has been found general throughout the state. The 9.1-percent loss in 1923, however, is the highest recorded.

In Iowa Nigrospora attacks the ears, stalks, shanks and husks. Under Iowa conditions Durrell (1925) found that this organism developed best when there was excessive moisture at the time the crop was maturing. The optimum temperature is 25°C. In years when this disease was destructive, August and September rainfall were normal or above. Reddy (1933) found that seed corn strains requiring high temperatures for germination were severely injured by this organism.

An indication (Plant Disease Rep., 1936, p. 313) of the prevalence of this fungus can be obtained from the isolations made from diseased samples that were taken from 68 carlots of 1935 corn at the terminal markets. Nigrospora was found in 13.9 percent of the plates.

Brown Spot

Physoderma zeae-maydis Shaw

Brown spot of corn was reported first in 1917 when it was found in three different localities. It has been recorded for only two years since that time, 1919 and 1928. In 1928 it was observed in one field in Boone County and in another in Mahaska County. In Mahaska County many stalks were broken over because of the severe infection. The disease does not occur generally throughout the state although it no doubt has been present more years than the records would indicate.

Stewart's Disease

Bacterium stewartii (E. F. S.) Stevens

Stewart's disease no doubt has occurred in some locality in Iowa every year since its introduction although it has been recorded for

only six different years. In 1933 it became severe, causing a 5-percent loss. The 5-percent loss reported for this disease in 1905 is referred to as the bacterial disease of Burrill, and this is not *Bacterium stewartii*.

This disease seemingly has been confined to restricted sections of the state and has not spread to any great extent. There apparently is no logical reason why this disease has not become severer. Stevens (Plant Disease Rep., 1934) studied this trouble in various sections of the United States with the idea of finding an explanation for the variation in destructiveness from one year to another. He concluded that there was no obvious relation between the incidence of disease and the total rainfall during any season or between the incidence of the disease and the temperature during spring, summer and fall. He did find, however, a possible correlation between the temperature indices for the winter months (sum of the mean temperature for December, January and February) and the incidence of the disease. He accepted as a working hypothesis the idea that this disease usually will be absent following a winter with an index below 90 and present in destructive amounts following a winter with an index above 100, with intermediate conditions following a winter between 90 and 100.

Following this line of thought for 1931 and 1933 when this disease caused considerable loss in field corn in Iowa, the index was found to be 91 for 1931 and 77 for 1933. Thus the winter temperature index might explain the condition in 1931 but not in 1933. In all probability this index would be different if it were figured for the counties where the disease occurred rather than for the state as a whole.

Purple Leaf Sheath Spot

Various Fungi and Bacteria

The purple sheath spot has been observed in Iowa since 1916, and it probably had been here some time before that. Durrell (1920), having studied this disease from 1916 to 1920, concluded that it was generally present in Iowa. During the latter part of the summer of 1918 he examined 9,620 stalks in representative fields and found 86 percent badly spotted with the purple leaf sheath spot. Although this disease can be found in Iowa to some extent each year, it normally does not cause any loss.

Other Diseases

Several other diseases have been observed occasionally on corn in Iowa, but they have not been found of economic importance.

Black bundle, caused by *Cephalosporium acremonium* Cda., was recorded by the Iowa Plant Disease Survey four different years, considerable damage occurring in 1929. Downy mildew, caused by *Sclerospora graminicola* (Sacc.) Schroet., was first recorded on corn in Iowa in 1925 by Melhus and Van Haltern (1925). That was the first instance where this organism was identified on corn in the United States. Holcus bacterial spot, caused by *Pseudomonas holci* Kendrick, has been known to occur in Iowa annually since 1916, but it never seems to become destructive.

DISEASES OF SWEET CORN

Sweet corn is an important canning crop in the state. The late varieties such as Country Gentleman have been largely used. Recently, however, certain of the new yellow hybrids are replacing the late varieties. Sweet corn, like dent corn, suffers from several diseases that may cause considerable damage. These are smut, rust, bacterial wilt, Diplodia dry rot, Nigrospora dry rot, Pythium root necrosis, etc.

SMUT

Ustilago zeae (Beckm.) Unger

Most varieties of sweet corn are more susceptible to smut than varieties of dent corn, which in part may be due to the fact that sweet corn is more likely to sucker than field corn. Corn smut has existed in the state for over forty years, but there are no detailed records of its destructiveness to sweet corn from year to year. It was officially recorded for the first time in the Iowa Plant Disease Survey in the year 1909. That year it was said to be common in the state and caused a loss of 1.5 percent. Smut injury varies from year to year and from one season to another and frequently causes losses ranging from 1 to 20 percent. Smut on sweet corn not only interferes with the growth and development of the plant but creates a problem by virtue of its presence on the kernels. Such infected ears have to be discarded or trimmed.

RUST

Puccinia sorghi Schw.

Rust on sweet corn is common throughout the state and causes some loss every year. It was first recorded in the Iowa Plant Disease Survey in 1905 when it was collected in 11 different counties. A 3-percent loss occurred in 1924 and 1925. The alternate host of this rust is *Oxalis europea,* which is generally distributed in the state but seldom heavily infected. The accidial stage on Oxalis was studied by Smith (1926, Phytopath.).

Bacterial Wilt

Bacterium stewartii (E. F. S.) Stevens

Previous to the past decade bacterial wilt was not a serious disease in Iowa. This in part may have been due to the practice of growing the late varieties of sweet corn, which in general are more resistant than the early varieties. During the past ten years there has been a tendency to discontinue the late varieties and to grow the early varieties. These seem to be more susceptible than the late ones. Severe losses were reported in the vicinity of Des Moines, Cedar Rapids, Oskaloosa, Fort Madison and Muscatine in 1932. In isolated cases from 40 to 50 percent of the plants in the field of early varieties were killed. In 1940 the estimated loss was less than 2 percent. The unusual prevalence and destructiveness of this disase from 1928 to 1932 cannot be explained alone by the increase in acreage of early varieties. It is possible that certain other factors were extant, but what these were is unknown. Recently very desirable resistant strains have come into existence that are higher yielding and more disease resistant than the old varieties. One of these, known as Ioana, has been developed and distributed by Haber at the Iowa Agricultural Experiment Station.

Diplodia Dry Rot

Diplodia zeae (Schw.) Lév.

Diplodia dry rot is most destructive to the roots and crowns of the plant although it may occur also on the ears and on the seed. In 1923, 15 percent of the seed was infected. It is not unusual to find 70 to 80 percent of the crowns discolored and infected with *D. zeae* in the fall after the crop is harvested. In August, 1927, Raleigh (1930) found Diplodia pycnidia on the stalk just above the crown of sweet corn plants. These plants were dead whereas apparently healthy plants had ears in the late milk stage. As a rule the ears sustain little injury, but occasionally there may be considerable ear infection. This was especially true in August, 1939. In some fields in Story and Hamilton Counties it was necessary to discard 20 to 30 percent of the ears in the field. In fact, it seemed for a while that the crop might not be worth picking. The ear rot developed at an astounding rate especially in the low lands north of Jewell. The later plantings were freer from rot than the early crop. Still further, rainfall ceased in August, and the infection seemed to be checked. Diplodia caused losses estimated as 7 percent for the entire state in 1940 and again in 1941.

Nigrospora Dry Rot

Nigrospora oryzae (B. and Br.) Petch

Nigrospora dry rot is of importance chiefly on seed. It was estimated in 1923 that 4 percent of the seed was injured by this disease. Losses in 1927, 1932 and 1933 were estimated as 4, 3 and 5 percent, respectively.

Other Diseases

The scab organism, *Gibberella saubinetii* (Mont.) Sacc., and species of Fusarium and Pythium may cause considerable damage to the roots and crown, but so far no critical study has been made of the losses caused by these organisms.

DISEASES OF OATS

Oats have always been an important Iowa crop and since 1890 have ranked second in the acreage planted. Diseases on oats became so severe in the 1890's that there was question (Speer, 1890) as to whether Iowa could continue to grow oats as a profitable crop.

In 1915 the Iowa Agricultural Experiment Station undertook cooperative work with the United States Department of Agriculture on the disease resistance of oats. Dr. L. H. Pammel and Dr. William Diehl started the work in Iowa. In 1916 the senior author was assigned to this project. Doctors L. W. Durrell, R. S. Kirby, S. M. Dietz, H. C. Murphy and Mrs. Florence Willey Nichols are among those who have contributed notably to the disease resistance problem in Iowa.

The rusts and smuts probably were present in this crop from the time of the first planting, although the first record (Ia. Agr. Soc., 1858) of rust dates back only to 1858 and of smut, to 1884 (Bessey, 1884). In 1858 the oats crop failed throughout Iowa, and the majority of reports attributed the loss to rust.

The common diseases of oats in Iowa are crown rust, stem rust, smut, blast, scab, halo blight and Pythium root necrosis.

Crown Rust

Puccinia coronata Corda

The early references to rust damage in the oat crop (Ia. Agr. Soc., 1858) probably referred to either or both crown and stem rust. Stem rust and crown rust were both known to be present in the state in 1882, but the records on prevalence previous to 1900 are too meager to make any definite statement relating to prevalence. It is thus problematical as to which of these diseases was more serious prior to 1900.

The first specific report of severe damage from crown rust came in 1907, at which time Pammel (I. S. C. Plant Disease Surv.) found the disease generally severe and estimated that it caused a loss of 50 percent of the crop. In 1908 it was reported from 34 counties and caused an estimated loss of 25 percent. Since that time crown rust has been reported every year except three, and it is logical to believe that crown rust was present to some degree even those years. The losses since 1908 have ranged from zero to 30 percent. The heaviest recent losses were those of 24 and 30 percent in 1938 and 1941, respectively. Crown rust occurs throughout the entire state wherever oats are grown.

The aecidial host (Rhamnus spp.) The common buckthorn was introduced into Iowa for hedge and ornamental purposes as early as 1854 (Ia. Agr. Soc., 1858, p. 265). In 1900 C. V. Stout (Pammel and Weems, 1900) of Grundy County reported that he had observed for a number of years that oats were very badly rusted in the vicinity of these hedges and had learned not to plant any oats in the immediate neighborhood.

Crown rust infection had been found on the buckthorn by Bessey (Arthur, 1924) in 1874. Pammel and Weems (1900) reported that the æcidia of crown rust frequently were found on the native buckthorn (*Rhamnus lanceolata*). Near Hinton, Iowa, in Plymouth County in 1920-21 (Melhus, Dietz and Willey, 1922) a serious epiphytotic of crown rust developed on a 120-acre farm completely surrounded by a buckthorn hedge. In 1921, 40 acres of oats surrounded on three sides by this hedge were entirely killed, and adjoining fields were seriously injured. Since 1930 many local epiphytotics of crown rust near buckthorn plantings have been observed. In some cases the oat crops have been complete failures. In one community in eastern Hamilton County, crown rust has become so severe near buckthorn that farmers have discontinued growing oats.

Dietz (1924) studied the effect of crown rust on yield of oats near Winthrop, Iowa, in Buchanan County in 1923. The initial infection was started by a hedge of *Rhamnus cathartica* adjoining an oat field. These oats were not cut, as many of them did not head. Oats planted in adjoining sections yielded 10 bushels per acre whereas the average yield in more remote sections of the same township was 50 bushels per acre.

The common buckthorn occurs generally throughout Iowa although most plantings for hedge and ornamental purposes are possibly in the east central counties. There are two native species,

Rhamnus lanceolata and *R. alnifolia,* and two introduced species, *R. cathartica* and *R. frangula.* Only *R. cathartica* and *R. lanceolata* are susceptible to crown rust of oats under Iowa conditions.

Overwintering centers in Iowa. This phase of the epidemiology of crown rust in Iowa is not well understood. Melhus and Durrell (1919) were of the opinion that the rust might overwinter on volunteer grain in southern Iowa during mild winters, but they presented no positive evidence.

Overwintering centers in southern states. Dietz (1924) made a thorough study of the initial crown rust infection during the period 1916-24 and found that during each of these years the aecidial infection was observed on the *Rhamnus* spp. before it could be found on *Avena sativa.*

It is believed that during some years, especially years of serious epiphytotics such as 1941, crown rust spores were blown into Iowa en masse from infection centers in southern states and were directly responsible for the severe losses. During these epiphytotic years the rust seemed to appear simultaneously in all parts of the state and the degree of infection was correspondingly uniform in all regions. This indicated that there was a general shower of spores over the entire state and that during these years weather conditions were favorable for the subsequent development and spread.

Crown rust development is very dependent upon a combination of certain moisture and temperature conditions. An abundance of moisture and moderate temperatures in May favor the development of the æcidial stage on the Rhamnus. When these same conditions prevail in June the fungus makes a subsequent rapid development in the oats. During epiphytotic years the development and spread of the fungus have been influenced by weather conditions and also by the condition of the oat crop. Usually the crop is later than usual, stands are heavy and the growth rank. The fact that the crop is late has provided time for more generations of spores to develop on the host at a time when the oats are most susceptible to injury.

Black Stem Rust
Puccinia graminis Pers.

Pammel and King (1909) reported that black stem rust was present in Iowa in 1870. The first report (Arthur, 1924) of this disease that referred to a specific collection was made in 1882. There were reports of rust damage in oats in 1858, which may

have referred to either or both rusts. Severe damage was reported in 1876, 1879, 1888, and 1893 (Ia. Agr. Soc., 1876, p. 25; 1879, p. 281, 282; 1888, p. 62; 1893, p. 57, 85).

Stem rust occurs generally throughout the state and occasionally causes serious losses. Since 1905 it has been present every year and was severest in 1926 when the loss was 10 percent of the crop. Losses for the past 10 years were as follows: 1932, 1 percent; 1933 and 1934, 0 to trace; 1935, 1 percent; 1936, trace; 1937 and 1938, 0.5 percent; and 1939, 1940, 1941, a trace.

It is difficult to explain the stem rust infection on oats some years as it is impossible each year to carefully study the local and general epiphytotics. There are three probable sources of stem rust in Iowa.

The aecidial host (Common barberry). Early in the history of Iowa agriculture the common barberry was found to be responsisible for stem rust losses in the oat crop. In 1876 C. L. Watrous (Ia. Hort. Soc., 1876, p. 196) of Des Moines described spreads of stem rust to oats in Dallas County. Moore Briggs (Ia. Hort. Soc., 1879, p. 389) of Wyoming, Iowa, in 1879 described how oats growing near his barberry hedge had rusted every year since he planted the bushes. More recently similar cases have been observed. Melhus, Durrell and Kirby (1920) described spreads of stem rust to oats in Dubuque County in 1920. In 1926 spreads to oats were observed by Melhus and Smith (1927) in Fayette, Woodbury and Ringgold Counties. In 1934 a definite spread was observed in Fayette County.

The two other possible sources of stem rust of oats in Iowa are overwintering of uredospores and wind-blown inoculum from states south of Iowa. These have been discussed under "Wheat".

Normal Iowa June rainfall and temperatures slightly below normal are favorable for the development of the organism. These weather conditions also delay the maturity of the crop, and the host is thus subjected to an abundance of inoculum at a time when it is easily injured. The longer the time between the first infection and the ripening of the crop the severer will be the loss.

Smut

Ustilago avenae (Pers.) Jens. and *U. levis* (K. and S.) Magn.

This disease was first specifically reported by Bessey (1884), who called it black smut and the organism *Ustilago segetum.* It was reported (Pammel, 1894) as abundant in 1894, and in 1901 Hume (1901) reported that it was severe each year. Bowman and Burnett (1905) took data from 80 fields where seed treatment

this disease, but without doubt the black stem rust fungus was at least partially responsible for the widespread losses referred to as rust damage in 1858 (Ia. Agr. Soc., 1858).

It is problematical as to which rust was more destructive prior to 1900. If conditions were such as they are today, each of the rusts was severer in certain years. Pammel and Weems (1900) observed that orange leaf rust was more destructive in 1889 and in 1893 whereas in 1891 and 1892 black stem rust was more destructive. Carlton (1899) stated that stem rust year after year caused more damage to the wheat crop than did leaf rust. Burnett (1912) found that leaf rust was severer than stem rust in tests run on 10 of the best of 40 varieties of wheat grown at the state college each year during the period 1906-1910.

In the first reports on agricultural conditions in Iowa rust is listed as the principal cause of reduced yields and small grain failures. It seems safe to assume that this disease was prevalent when small grains were first grown in the state.

The epiphytotic in 1858 is the earliest on record. That year practically every county reported (Ia. Agr. Soc., 1858) considerable loss from rust or wet weather and most of the wheat and oat crops were almost a complete failure. Typical of the reports for that year is that of Harrison County—"The wheat crop this year was small, probably one-third crop. Failure caused by rust," and of Jones County—"Wheat—This crop proved almost a total failure; thousands of acres not being touched, save by the 'torch.' The cause of the failure is attributed to the rust. Oats—a perfect failure—doubtful whether enough was raised, at any rate saved, for seed—cause of failure, the rust."

The losses from rust in 1858 were undoubtedly severer than usual for those early years. It is evident, however, that the crop was reduced materially in some parts of the state every year and that during years when there was an over-abundance of moisture in the spring drastic losses resulted. Two reports in 1859 (Ia. Agr. Soc., 1859) exemplify the condition that year: Davis County —"Wheat practically a failure—rust." Jefferson County—"Rust is the cause of reduced yields over a period of years."

Serious losses occurred again in 1865, 1866, 1869, 1872 and 1876. In 1876 the condition in the early summer was somewhat similar to 1858. There was an abundance of rainfall, and temperatures were high during the critical period for the small grain crops. County reports (Ia. Agr. Soc., 1876) for that year again

point to rust as the critical factor in production. Typical of these are Black Hawk—"Rust injured wheat," Cherokee—"Rust almost destroyed crop," Decatur—"Spring wheat entire failure because of rust," Jackson—"Rust injured wheat," Jones—reference was made to rust and blight injury, Kossuth—"Rust seriously injured the crop," Allamakee—"The earlier part of the season was wet and this followed by hot weather produced a blight that ruined many wheat fields and seriously affected all growing grains," Warren—"Wheat badly damaged by rust and wet weather. Not more than one fourth."

A similar condition existed in 1898 when many counties reported partial to complete failure from rust, blight and wet weather, the latter two no doubt being synonyms for rust.

Serious losses were reported in many parts of the state in 1880, 1882, 1888, 1889, 1890, 1893, and 1897. Serious losses were reported again in 1898 with many counties reporting partial to complete failure from rust, blight and wet weather.

Since 1900 the records of plant disease losses have been more specific, and on the basis of these figures it is obvious that black stem rust has been prevalent in the state every year. The most severe loss, 19 percent, was suffered in 1937. It is known that there were severe epiphytotics in Iowa in 1904 and 1916: however, no actual loss figure was recorded for those years. It is believed that the rduction in yield was even greater those years than it was in 1937.

In Iowa there have been three possible sources of rust: (1) the æcidial host, the common barberry, (2) local overwintering centers and (3) overwintering centers in states south of Iowa.

The common barberry was first introduced into Iowa about 1851 and has been an important potential source of rust each year since that time. It was not long after the introduction of the barberry into Iowa that people began to suspect it as the source of early stem rust inoculum. The evidence against the barberry soon became conclusive, and in many communities it lost its popularity as a shrub for hedge and ornamental plantings. In the communities where it was planted it was definitely found to be a source of stem rust. Typical of the early reports is one made by C. L. Watrous (Ia. Hort. Soc., 1876, p. 146) of Des Moines in 1876: "This society has sometimes discussed the barberry as a hedge plant. I have to report one experience with it. In 1874 A. Nighswander of Dallas County planted 100 yards or so of barberry hedge, using two year old plants. The same season oats growing

close by rusted badly, while the balance of the field escaped. In 1875 wheat growing near it was killed, the injury shading off one-half to three-fourths of a mile south and west. North and east was prairie. Wheat generally suffered from rust but that near the hedge to a far greater extent. In 1876, oats near it was utterly killed and left on the ground the injury gradually shading off as before."

There were many similar instances of early rust spreads traceable to barberry. In 1879 Moore Briggs (Ia. Hort. Soc., 1879, p. 348) of Wyoming, Iowa, condemned the barberry after having observed spreads to wheat and oats for six successive years. In 1881 W. L. Brockman (Ia. Hort. Soc., 1881, p. 315) reported: "I sold plants of the barberry to a farmer for a garden hedge. His wheat has been blighted by a rust resembling that on the barberry. As this complaint has often been made, I think it will be well to stop its propagation in the nurseries."

Melhus, Durrell and Kirby (1920) in 1918 recorded 16 local epiphytotics of stem rust traceable to the barberry. Muncie (1922) reported spreads observed in 1923. In 1925 Smith (1926, U. S. D. A.) listed 10 cases where rust was found to have spread from barberries, and in 1928 Rohrbaugh (1928) recorded the spreads from barberries observed that year.

Evidence based upon experimental work and observations of Bolley (1891), Lambert (1929) and Smith (1926, U. S. D. A.) indicates that local overwintering centers are not significant as a source of early spring infection in Iowa. In fact the evidence based on observations made over a period of years indicates that black stem rust does not overwinter in Iowa.

The rust overwintering in Mexico and Texas spreads north progressively to grain fields in Oklahoma and from there into Kansas, Missouri, and other states to the north some years when conditions of wind, temperature and moisture are favorable. Since 1930 slides have been exposed each year in an effort to determine to what extent rust is carried into Iowa by the wind from southern states. These exposures have shown conclusively that rust does move into Iowa and that the amount of inoculum varies with the amount of rust in the southern states as well as with the time of and the velocity of the prevailing south winds.

Years when spores are blown in from the south a general sprinkling of rust appears almost simultaneously in all parts of the state about the middle of June. This general infection is

easily distinguished from the early local spreads that have originated from infected barberries.

It has been observed that serious losses result from the wind blown inoculum only during those years when there is an abundance of rust in the southern states, when winds from the south prevail for several days during the growing season, when Iowa crops are later than usual and when environmental conditions favor the infection and spread of the fungus.

The Elimination of Spring Wheat as an Iowa Crop

Diseases have had a profound effect on wheat culture in Iowa and obviously have been largely responsible for the almost complete elimination of spring wheat as an Iowa crop.

Prior to 1860 there was a larger acreage of winter wheat than spring wheat in Iowa. The varieties, however, were not hardy, consequently spring wheat became the predominant crop. In the reports to the Iowa Agricultural Society, 42 counties reported winter wheat in 1857, only three counties reported winter wheat in 1870, and in 1872 there was so little that the secretary of the society did not differentiate between spring and winter wheat.

After 1880 there was a gradual reduction in all wheat and farmers were gradually changing back to the fall sown crop. Spring wheat continued to go out of the picture, and during the 50-year period 1875 to 1925 the acreage was reduced from more than 3,000,000 acres to 29,000, about a 90-percent reduction.

Iowa farmers did not discontinue spring wheat production because they wanted to. There had always been a real need for a profitable spring crop to fit into the rotation with corn. Oats have been used because spring wheat has been uncertain and unprofitable. If it were not for the annual losses in spring wheat from plant diseases, especially black stem rust, Iowa no doubt would have continued growing large acreages of this crop instead of oats, which over a period of years have not been profitable.

Probably no one factor or combination of factors has been more responsible for the elimination of spring wheat in Iowa than has black stem rust. It is true that previous to 1900 the records refer to the cause as rust, blight and wet weather; however, there are many indications that the three terms were synonyms and that the rust was the most damaging. The fact that the blight and rust invariably attacked the crop just before harvest is circumstantial evidence that the rust was black stem rust. The extent of the damage year after year is also an indication that stem rust was the prevalent disease.

ORANGE LEAF RUST

Puccinia rubigo-vera (DC.) Wint. var. *tritici* (Erik. and Henn.) Carl.

This rust was first reported (Bessey, 1884) specifically in 1884 and that year was observed to be more prevalent than was black stem rust. Bessey wrote of this disease this year: "This is the gray colored rust of wheat. It is much more harmful than the common rust (*Puccinia graminis*) and every year causes a great loss in the wheat crop." The records of rust prior to 1884 do not distinguish between the two common wheat rusts; consequently we can only assume that both rusts were present.

Orange leaf rust occurs throughout the entire state where wheat is grown. Pammel and Weems (1900) found the disease very destructive in 1889 and 1893. It was very severe in 1927, 1935, and 1938, causing losses of 15, 20 and 28 percent in those respective years.

During the early years of Iowa agriculture the losses from this disease obviously were underestimated. Orange leaf rust attacks the crop early in the season, and often many lower leaves are completely destroyed. The upper leaves with fewer pustules persist and remain green, the heads develop normally and the plants remain upright so that the loss of the lower leaves is not always noticeable. Other diseases become prevalent later, cause discoloration of the stems and leaves and cause lodging just prior to harvest. These other diseases have received the blame for the damage done earlier in the growing season by the leaf rust. The reduction of the leaf surface by this leaf parasite obviously has always been responsible for considerable damage.

The fact that orange leaf rust has not been considered serious accounts for the fact that most of the common varieties of spring and winter wheat grown in Iowa have been developed without considering resistance to the fungus. Marquis, Ceres, Komar and Thatcher are completely susceptible. Of the winter wheats, Iowin and Iobred have some resistance, but Turkey Red is very susceptible.

Leaf rust overwinters in Iowa and appears in the fields early each year. It becomes most destructive during years when the growing season is prolonged by a cool, dry spring and when there is an abundance of moisture and high temperatures early in summer. The use of semi-resistant varieties of winter wheat such as Iowin and Iobred is the only protective measure.

Scab

Gibberella saubinetii (Mont.) Sacc.

The earliest report of scab was made in 1865 (Ia. Agr. Soc., 1865, p. 15) when it was reported to have greatly damaged the crop in many locations. It was reported again in 1866, 1869, and 1878 (Ia. Agr. Soc., 1866, p. 353; 1869, p. 276; 1878, p. 354). Pammel (1892) reported this disease specifically for the first time in 1892 when it did serious damage.

The plant disease survey reported general scab epiphytotics in Iowa in 1918, 1919, 1924, 1931 and 1938 with heavy losses in 1918 and losses of 22, 5, 15 and 5 percent of the other four years, respectively. Scab was also severe in some fields in 1935 although the loss for the state was only 1½ percent.

This fungus in Iowa is favored by abundant June rainfall and relatively low June temperatures. Usually the losses have been general throughout the state (Plant Disease Rep. Sup., 1919, p. 133; 1920, p. 31; 1924, p. 264). Both the spring and winter wheats are damaged by this disease.

Scab presents a difficult problem in that the causal organism also causes a disease of corn. Inoculum is readily available on the old corn stalks and refuse in the field, and thus it is hazardous to follow corn with wheat.

Covered Smut (Bunt)

Tilletia levis Kühn and *T. tritici* (Bjerk.) Wint.

Pammel and King (1909) reported that bunt, or covered smut, was present in Iowa during the period 1871-1877. In 1863 Clark (Ia. Agr. Soc., 1864, p. 207) of Pottawattamie County described a procedure that he followed in treating his seed wheat with blue vitriol to control smut. If he obtained control by this method, he must have been dealing with covered smut. Other farmers (Ia. Agr. Soc., 1878, p. 353) referred to smut injury prior to 1871; however, it is not known to which of the two wheat smuts they referred. Referring to bunt in 1900 Pammel said:

"*Tilletia tritici* is not common in Iowa but it has been found several times since 1891 in the field and also from the screenings from local mills. The damage is very small in Iowa."

Since 1900 bunt has been observed practically every year. Usually the loss has been spotted, some fields having considerable loss and others having none. In 1918 Melhus (Plant Disease Rep., 1918, p. 116) said: "*Tilletia tritici*, a trace. It is general and nom-

inal in quantity except in spots. Usually there is only a trace but cases have been found where 25 percent disease occurs." In 1926 Elmer (Gilman and Porter, 1927) made a survey of the bunt conditions in Iowa and found that although the yield was reduced over the state by only 0.5 percent, in some fields severe losses occurred. In one field in Plymouth County 40 percent of the heads were infected, and frequently 5 to 10 percent of the heads in a field were destroyed. Reports (Plant Disease Rep., 1932, p. 62) in 1931 from 21 farmers comprising 475 acres where seed wheat was not treated listed the average loss caused by bunt as 1.16 percent. This disease occurs wherever wheat is grown in the state. Since infection originates from spores that are carried to the soil on the seed, effective control can be obtained by the use of chemical seed disinfectants. Although *T. tritici* has been observed often in Iowa, *T. levis* is the common species.

Loose Smut

Ustilago tritici (Pers.) Jens.

Bessey (1884) reported this organism first in 1884 under the name *Ustilago segetum*. In one field 60 percent of the heads were affected. It is very likely that some of the reports of smut made by growers in 1864 and 1866 (Ia. Agr. Soc., 1876, p. 10; 1866, p. 353) were of this disease. Pammel and Weems (1900) wrote: "Loose smut (*Ustilago tritici*) occurs wherever wheat is grown. We have observed it abundantly in many portions of Iowa." They considered that the annual loss was not far from 0.5 percent.

Since 1900 this disease has been reported in all but three years, and it probably was present during these years. The loss of 4 percent in 1916 is the highest; losses of 1 percent have been common. Since 1930 the writer has observed this disease in practically every wheat field inspected, but losses have been only a trace to 1 percent.

Black Chaff

Pseudomonas translucens var. *undulosum* S., J. and R.

Black chaff was found for the first time in Iowa in 1917 by Erwin F. Smith (Plant Disease Rep., 1917, p. 40). In 1918 (Plant Disease Rep., 1918, p. 99) it was found in samples from Plymouth, Woodbury, Harrison, Pottawattamie, Mills, Adams, Montgomery, Warren, and Story Counties. In 1919 (Plant Disease Rep., 1919, p. 85) this disease was reported as severe and common. It was found in 104 out of 208 fields inspected and was most common on winter varieties. Since 1919 black chaff has been rel-

atively unimportant, the losses in most years amounting to only a trace. It is probable that during this period the disease has been overlooked and that losses have been severer than the records show.

Other Diseases

Disases of less importance that have been observed on wheat in Iowa are leaf spot caused by *Septoria tritici* Desm., glume blotch caused by *Septoria nodorum* Berk., powdery mildew caused by *Erysiphe graminis* DC., anthracnose caused by *Cladosporium graminum* Cda. and ergot caused by *Claviceps purpurea* (Fr.) Tul. The yearly reports for these diseases are incomplete largely because the losses are relatively unimportant.

It has been observed that *Helminthosporium gramineum* (R.) Erik., a species of Fusarium and *Pythium debaryanum* Hesse cause some seedling blight and root necrosis each year.

DISEASES OF BARLEY

Plant diseases annually decrease the yield of barley. This crop is very susceptible to stem rust, scab, stripe, spot diseases, Helminthosporium blight, root rots, smut and bacterial blight. Barley probably suffers more injury from diseases than any other cereal crop grown in the state.

In field experiments testing the response of barley varieties to disease in Iowa, Burnett and Reddy (1937) found several instances from 1928 to 1935 when diseases became the critical factor in the production of the crop. In 1928 and 1935 scab was severe. In 1932 the destructive diseases were Helminthosporium root rot and bacterial blight.

Black Stem Rust

Puccinia graminis Pers.

Stem rust occurs generally throughout the state and causes greater losses than any other disease of barley. The first specific report of this disease on barley was made by Bessey (1884) in 1884. Since 1918 stem rust has been reported each year, with losses varying from a trace to 17 percent. The losses sustained in 1920, 1935 and 1937 were 17, 10 and 15 percent, respectively.

Barley Scab

Gibberella saubinetii (Mont.) Sacc.

The disease not only reduces the yield but makes the grain unfit for feed and for malting purposes. Scab was first reported on barley in 1909 (Plant Disease Rep. Sup., 1920, p. 48). It was

observed to be generally severe in 1919, causing a loss of 5 percent. In 1928, 1932 and 1935 scab caused losses of 8, 6 and 15 percent, respectively.

In a survey following the 1935 epiphytotic (Plant Disease Rep., 1936, p. 11) *Gibberella saubinetii* was found to constitute 84 percent of the organisms isolated from infected seed from the southeast to south central section, and 80 percent of the organisms isolated from seed from the north central to northwest section of Iowa.

BARLEY STRIPE

Helminthosporium gramineum (R.) Erik.

Stripe in barley was reported to have been present in Iowa in 1892 by Pammel and King (1909). By 1900 it was considered (Pammel and Weems, 1900) as one of the most destructive diseases of the barley crop. Since then it has been prevalent each year, frequently causing losses of 5 percent. Fields have been observed often (Plant Disease Rep., 1929, p. 106) where 30 to 35 percent of the plants were affected.

Archer (Plant Disease Rep. Sup., 1927, p. 6) observed a large number of barley fields in 1927 and made this comment:

"The greater number of the fields in the state had some stripe but it was very slight and occurred only on the lower leaves. It was reported, however, to be quite destructive in a number of localities in scattered fields."

SPOT BLOTCH, BLIGHT, ROOT ROT

Helminthosporium sativum P., K. and B.

Helminthosporium sativum causes spot blotch, blight and root rot in the barley crop. In 1909 when it was reported for the first time it was found in nine counties and in some fields caused a 50-percent loss. There were reports of discoloration, wet weather damage and blight in 1865, 1882 and 1891 (Ia. Agr. Soc. 1867, p. 423; 1882, p. 23; 1891, p. 371) which may have been caused by this organism. Since 1909 this disease has been observed practically every year and occasionally has caused severe local losses.

This organism is found as widespread in the state as in the scab organism. It appears to be more prevalent and destructive on the heads at periods of high temperatures and fairly low humidity.

Burnett and Reddy (1937) considered *H. sativum* to be one of the most destructive organisms occurring in Iowa. They found root rot caused by this organism to be one of the critical factors in

barley production in the varietal test plots in 1932. The disease was unusually severe in 1931 and 1933 (Porter and Layton, 1936). The greatest recent loss was 6 percent in 1937.

Loose Smut

Ustilago nuda (Jens.) K. and S.

This disease was reported by Bessey (1884) in 1884. In 1866 there was a report (Ia. Agr. Soc. 1866, p. 381) of smut on barley in Jefferson County, which may have been either the loose or covered smut. Since 1892 loose smut has been observed practically every year, and although the loss has not been severe it has been fairly consistent year after year. This disease occurs generally throughout the state.

Burnett and Reddy (1937) consider loose smut as one of the important barley diseases, especially since the smooth-awned varieties have been introduced. The varieties Colsess, Glabron and Spartan are very susceptible, but Manchuria and O. A. C. 21 are very resistant under Iowa conditions.

Covered Smut

Ustilago hordei (Pers.) K. and S.

Covered smut on barley in Iowa was first reported by Pammel (1894) in 1894. He indicated at that time that it was more common than loose smut. This disease has been observed practically every year since the first report, the annual losses ranging from a trace to 3 percent. It occurs generally throughout the state.

Bacterial Blight

Pseudomonas translucens J., J. and R.

This disease has been considered of importance as a barley disease in Iowa only in recent years. It was recorded first by the Plant Disease Survey in 1927. In 1932 it caused 2 percent loss and was responsible for 8 percent damage in 1937. In the varietal tests in 1932 (Burnett and Reddy, 1937) bacterial blight was one of the critical factors in production. All the important commercial varieties grown in Iowa are very susceptible to this disease.

Scald

Rhynchosporium secalis (Oud.) Davis

Scald was responsible for a slight loss to this crop in 1925 (Plant Disease Rep., Sup. 1926, p. 337). No loss has been recorded prior to that time, and since then the disease has not been observed in Iowa.

European Net Blotch

Helminthosporium teres Sacc.

This disease was reported consistently in Iowa during the period 1921 to 1929 and some years caused a 5-percent loss. It appears, however, that the loss was overestimated during some of the years.

Root Rot

Pythium graminicola Subr.

This organism was first found on barley in Iowa in 1936 (Ho, Meredith and Melhus, 1941). That year barley stands were unusually thin and the plants yellow and stunted in many fields in central Iowa. Pythium root rot has occurred each year since to some extent and caused considerable injury in 1936 and 1938.

In soil heavily infested with *P. graminicola* the seeds may be attacked and become soft, water-soaked and rotted, thus greatly reducing the stand. Necrotic lesions may be found on the roots of infected seedlings one week old, followed by yellowing of the leaves two or three weeks later.

Other Diseases

Less destructive diseases of barley are powdery mildew, leaf rust, anthracnose and Septoria leaf spot. The records of these diseases are incomplete largely because they are of minor importance.

DISEASES OF RYE

Rye is the least important of our cereal crops in this state. It is grown only on the light sandy soils. The two diseases common on rye are ergot and stem rust.

Ergot

Claviceps purpurea (Fr.) Tul.

Ergot was common in the state from 1871 to 1877. It occurs annually but seldom becomes destructive. Ergotism in livestock is said to have been common in the eighties.

Stem Rust

Puccinia graminis Pers.

This disease occurs every year but rarely causes serious injury to rye. This in large measure is probably because the crop matures the latter part of June, which is too early for a rust epiphytotic to develop. It has been shown, however, that where rye grows adjoining common barberry, severe losses to the crop may result. In 1938 near Sharpsburg in Taylor County, stem rust spread early

from infected barberries to nearby rye fields. Fifty acres of this crop grown on two different farms were completely destroyed. This was a very interesting observation in the light of what is known of stem rust injury in Europe, where rye is a much more important crop than in this country and where stem rust has frequently caused very serious losses to the crop.

Other Diseases

The diseases of less importance that have been observed on the rye crop in Iowa are as follows: Smut, caused by *Urocystis occulta* (Wallr.) Rabenh.; powdery mildew, caused by *Erysiphe graminis* DC.; scab, caused by *Gibberella saubinetii* (Mont.) Sacc.; leaf rust, caused by *Puccinia rubigo-vera* (DC.) Wint. var. *secalis* (Erik. and Henn.) Carl.; and leaf spot, caused by *Septoria secalis* Prill. and Del.

DISEASES OF TIMOTHY

Although timothy is grown generally throughout the state, there have been only a few reports of the occurrence of diseases on this crop, and these were not considered serious. The two best known diseases of timothy are stem rust and smut. These occur generally over the state but seldom become destructive.

Stem Rust

Puccinia graminis Pers.

Stem rust was first observed on timothy in Iowa by Pammel and King in 1910. Only occasionally has it been prevalent and destructive. Infection apparently takes place early in the spring because the teleutospore stage is fully developed by July 1.

Smut

Ustilago striaeformis (West.) Niessl.

Smut on timothy is systemic and perennial. It was first observed in the state in 1889 and has occurred annually since 1916. Smut occurs generally wherever timothy is grown but seldom becomes prevalent and destructive.

Spot Diseases

Scolecotrichum graminis Fckl., *Sporotrichum poae* Pk., and an Unnamed Bacterium.

The spot diseases caused by *Scolecotrichum* and *Sporotrichum* occur on the foliage and cause premature dying of the leaves. It is believed that in some seasons these organisms result in considerable injury. The bacterium that causes the spot disease

on this crop has not been named, and little or no information is at hand regarding the causal organism. The symptoms are water logging of the parenchyma between the veins, followed by the deposition of a thin layer of exudate. This exudate is highly charged with bacterium. Later the affected spots turn brown.

DISEASES OF SORGHUM

Diseases have been observed on sorghum since early in the nineties of the last century. Sorghum is only a minor crop in Iowa.

Bacterial Stripe

Pseudomonas andropogoni E. F. S.

Bacterial stripe is the only bacterial disease that causes important losses, and these are usually local in scope. This disease was observed (Pammel and King, 1909) in Iowa in 1890. In 1905 the disease was found in scattered localities and 1 percent of the crop was injured. Occasionally since 1905 the disease has been serious, and in 1916 (I. S. C. Plant Disease Surv.) 4 percent of the crop was injured. In 1924 (I. S. C. Plant Disease Surv.) the disease was severe in northwest Iowa and caused a 2-percent loss. No observations have been recorded since 1924, although it is probable that the disease has been present in some parts of the state.

Bacterial Leaf Spot

Pseudomonas holci Kendrick

Bacterial leaf spot has occurred annually since it was first described by Kendrick (1926). He determined by field observations and greenhouse inoculations that the following were hosts: 22 varieties of *Sorghum vulgare* (sorghum), *S. vulgare* var. *technicum* (broomcorn), *S. vulgare* var. *sudanense* (sudan grass), *S. halepensis* (Johnson grass), *Pennisetum glaucum* (pearl millet); 20 varieties of *Zea mays,* 11 of which were dent corn, 2 flint corn, 6 sweet corn and 1 pop corn, and *Setaria lutescens* (foxtail). The following plants could not be infected in repeated greenhouse inoculations: *Triticum aestivum, Avena sativa, Bromus inermis, Arrhenatherum elatius, Dactylis glomerata, Lolium perenne, Phalaris* sp., *Agrostis alba, Phleum pratense, Festuca eliator* and the Japanese, Siberian, common, Hungarian and broomcorn varieties of *Setaria lutescens.*

The disease on the species of Sorghum is characterized by light-centered, red-bordered, round, elliptical lesions on the leaves. Very small lesions are red throughout. Often the spots are so numerous

as to cause the death of the entire leaf. On *Sorghum vulgare* variety *Shallu,* the lesions have a dark brown instead of a red border, and on *Pennisetum glaucum* and *Setaria lutescens* the spots are a dark brown throughout with a narrow light green halo.

Head Smut

Sorosporium reilanum (Kühn) McAlp.

This fungus was collected (Hume, 1901) first in 1894. It occurs regularly every year in all parts of the state, frequently becoming very destructive. In 1940, 48 percent of the heads were smutted in a field of sorghum at Cherokee.

Another smut, kernel smut, caused by *Sphacelotheca sorghi* (Lk.) Clint., occurs on sorghum, but it is relatively unimportant in Iowa.

DISEASES OF FLAX

In Iowa as in practically all other states, flax remained an important crop only as long as new land was available for its culture. In the early period of Iowa agriculture it was generally thought that flax depleted the soil to such an extent that subsequent flax crops were either very mediocre or complete failures. It is estimated that 322,000 acres were sown to this crop in this state in 1885, and by 1922 this number had been reduced to less than 6,000. In recent years, since disease-resistant varieties of flax have been developed, Iowa farmers are again growing it. In 1932 more than 23,000 acres were harvested, and in 1941, 234,000 acres were harvested in this state.

Flax Wilt

Fusarium lini Bolley

The cause of the flax wilt disease was discovered in 1901 by Bolley (1901) who showed that the presence of a species of Fusarium in the soil was responsible for flax failures. In recent years wilt-resistant varieties have been developed, and flax growing is no longer restricted to new land. In 1931, 1932, 1933 and again in 1935, after cropping to corn in 1934, a wilt-resistant variety of flax was successfully grown on the same piece of land at Kanawha, which demonstrates the great difference between the new resistant varieties and those grown when flax was considered only a "new land" crop. Each year it was possible to find some wilt, but the injury was never severe. That the soil was infested with the wilt organism was shown in 1933 when all the plants of a suscept-

ible variety that were planted in a strip across the same field were killed by the wilt pathogen. This prevalence of *F. lini* in the soil is interesting because of the fact that only wilt-resistant varieties had been grown during previous years.

Wilt was reported first in Iowa in 1906, but from then until 1921 no records of its occurrence were kept. Since 1921 it has been observed and recorded only during occasional years, the greatest loss, 5 percent, coming in 1927. Commenting on the disease and crop that year Archer (Plant Disease Rep. Sup., 1927, p. 22) said:

"Twenty years ago flax production was an important industry in the state but the severity of losses from wilt brought about general discouragement so that the acreage shrank to practically nothing. In recent years, however, the universal use of wilt resistant varieties has reduced wilt losses and the acreage is increasing."

Flax wilt occurs every year where the resistant varieties are used, but in no case does the wilt organism seriously injure stand or yield.

RUST

Melampsora lini (Pers.) Lév.

Rust of flax has been recorded only twice by the Plant Disease Survey, although it is known to occur to some extent practically every year. The restricted acreage probably has kept this disease under control, but the disease may increase as the acreage increases. In 1941 it was said to be prevalent in northwestern Iowa.

SEED DECAY, SEEDLING DAMPING-OFF AND ROOT NECROSIS

Pythium debaryanum Hesse and *Rhizoctonia solani* Kühn

Flax stands are reduced considerably each year in Iowa through seed decay, damping-off and root necrosis. Buchholtz (1935) showed that *Pythium debaryanum* caused seed decay and seedling injury of flax. Both *P. debaryanum* and *Rhizoctonia solani* occur in most Iowa soils, but the former organism is the more destructive. Losses caused by *P. debaryanum* were estimated as 20 percent in 1935 and 1936 and as 10 percent in 1937, 1938 and 1939.

It has been found that seed treatment will increase the yields of early sown flax in all probability by controlling these soil-borne organisms. In 1935, 1936 and 1937 treatment of seed of Redwing and Bison increased field stands 68.0, 20.7 and 9.6 percent, respectively.

Pasmo Disease

Phlyctaena linicola Speg.

Pasmo, has been recorded only once, in 1932, by the Plant Disease Survey. It was estimated to have damaged 1 percent of the crop that year.

Botany and Plant Pathology Section
Iowa Agricultural Experiment Station
Ames, Iowa

Literature Cited

Iowa Agricultural Society Report. 1858.
Ibid. 1859.
Ibid. 1864.
Ibid. 1865.
Ibid. 1866.
Ibid. 1867.
Ibid. 1869.
Ibid. 1876.
Ibid. 1878.
Ibid. 1879.
Ibid. 1882.
Ibid. 1888.
Ibid. 1891.
Ibid. 1893.
Iowa Horticultural Society Transactions. Vol. 11. 1876.
Ibid. Vol. 14. 1879.
Ibid. Vol. 16. 1881.
Iowa State College Plant Disease Survey—Card file, Botany Department. 1903-1941.
The Plant Disease Reporter, 1917. Vol. 1. U. S. Dept. Agr., Bur. Plant Ind.
Ibid. 1918. Vol. 2.
Ibid. 1919. Vol. 3.
Ibid. 1929. Vol. 13.
Ibid. 1932. Vol. 16.
Ibid. 1934. Vol. 18.
Ibid. 1936. Vol. 20.
The Plant Disease Reporter Supplement. 1919. No. 2. U. S. Dept. Agr., Bur. Plant Ind.
Ibid. 1920. No. 8.
Ibid. 1924. No. 35.
Ibid. 1926. No. 48.
Ibid. 1927. No. 58.
Arthur, J. C. 1924. The Uredinales (rusts) of Iowa. Proc. Iowa Acad. Sci. 31:229-255.
Bessey, C. E. 1884. A preliminary list of Cryptograms. Iowa Agr. College. Bul., Dept. of Botany, 134-148.
Bolley, H. L. 1891. Wheat rust, is the infection local or general in origin. Agr. Science 5:259-264.

———————— 1901. Flax wilt and flax sick soil. North Dakota Agr. Exp. Sta. Bul. 50.

Bowman, J. L. and L. C. Burnett. 1905. Oats. Iowa Agr. Exp. Sta. Bul. 96.

Buchholtz, W F. 1935. Factors influencing the pathogenicity of the pythiaceous parasites of sugar beets (*Beta vulgaris* L.), alfalfa (*Medicago sativa* L.) and flax (*Linum usitatissimum* L.). Unpublished thesis. Library, Iowa State College, Ames, Iowa.

Burnett, L. C. 1912. Growing winter wheat in Iowa. Iowa Agr. Exp. Sta. Bul. 133.

———————— and C. S. Reddy. 1937. Barley in Iowa. Iowa Agr. Exp. Sta. Bul. 367.

Carlton, Mark. 1899. Cereal rusts of the United States. U. S. Dept. Agr., Division Vegetable Physiology and Pathology. Bul. 16.

Davis, G. N. 1936. Some of the factors influencing the infection and pathogenicity of *Ustilago zeae* (Beckm.) Unger on *Zea mays* L. Iowa Agr. Exp. Sta. Res. Bul. 199.

Dietz, S. M. 1924. Studies on the relation of *Puccinia graminis* Pers. and *Puccinia coronata* Corda to *Avena* species. Unpublished thesis. Library, Iowa State College, Ames, Iowa.

Durrell, L. W. 1920. A preliminary study of the purple leaf sheath spot of corn. Phytopath. 10:487-495.

———————— 1923. Dry rot of corn. Iowa Agr. Exp. Sta. Res. Bul. 77.

———————— 1925. Basisporium dry rot of corn. Iowa Agr. Exp. Sta. Res. Bul. 84.

Gilman, J. C. and W. A. Archer, 1929. The fungi of Iowa parasitic on plants. Iowa State College Jour. Sci. 3:299-502.

———————— and D. R. Porter. 1927. Observations on plant diseases in Iowa from 1924-1926. Proc. Iowa Acad. Sci. 34:95-109.

Ho, Wen-Chun, C. H. Meredith and I. E. Melhus. 1941. *Pythium graminicola* Subr. on barley. Iowa Agr. Exp. Sta. Bul. 287.

Hughes, H. D. and P. C. Taff. 1913. Smut in small grains. Iowa Agr. Exp. Sta. Cir. No. 11.

Hume, H. H. 1901. Ustilaginae of Iowa. Proc. Iowa Acad. Sci. 9:226-240.

Kendrick, James B. 1926. Holcus bacterial spot of *Zea mays* and *Holcus* sp. Iowa Agr. Exp. Sta. Res. Bul. 100.

Lambert, E. B. 1929. The relation of weather to the development of stem rust in the Mississippi Valley. Phytopath. 19:1-71.

Melhus, I. E. and L. W. Durrell. 1919. Cereal rusts of small grains. Iowa Agr. Exp. Sta. Cir. No. 62.

———————— L. W. Durrell and R. S. Kirby. 1920. The relation of the common barberry to stem rust in Iowa. Iowa Agr. Exp. Sta. Res. Bul. 57.

———————— S. M. Dietz and Florence Willey. 1922. Alternate host and biologic specialization of crown rust in America. Iowa Agr. Exp. Sta. Res. Bul. 72.

———————— and F. H. Van Haltern. 1925. Sclerospora on Corn in America. Phytopath. 11:720-721.

———————— and M. A. Smith. 1927. Small grain rusts and the progress of barberry eradication in Iowa. Iowa State College Ext. Serv. Bul. 141.

Muncie, J. H. 1922. Annual report of barberry eradication in Iowa. U. S. Dept. Agr., Bur. Plant Ind.

Pammel, L. H. 1892. New fungus diseases of Iowa. Jour. Mycol. 7:95-103.

———1894. Diseases of plants at Ames, 1894. Proc. Iowa Acad. Sci. 2:201-208.

——— and C. M. King. 1909. Notes on factors in fungus diseases of plants. Proc. Iowa Acad. Sci. 16:41-97.

——— J. L. Seal and C. M. King. 1915. Corn stalk and corn root diseases in Iowa. Iowa Agr. Exp. Sta. Cir. 21.

——— and J. B. Weems. 1900. Grasses of Iowa. Iowa Agr. Exp. Sta. Bul. 54.

Platz, Gustav A. 1929. Some factors influencing the pathogenicity of *Ustilago zeae* (Beckm.) Unger. Iowa State College Jour. Sci. 3:177-214.

Porter, D. R. 1925. Diplodia and Basisporium dry rots in Iowa. Unpublished thesis. Library, Iowa State College, Ames, Iowa.

——— and D. V. Layton. 1936. Small grain diseases in Iowa and their control. Iowa State College Ext. Serv. Cir. 226.

Raleigh, W. P. 1930. Infection studies of *Diplodia zeae* (Schw.) Lév. and control of seedling blights of corn. Iowa Agr. Exp. Sta. Res. Bul. 124.

Reddy, C. S. 1933. Resistance of dent corn to *Basisporium gallarum* Moll. Iowa Agr. Exp. Sta. Res. Bul. 167.

Rohrbaugh, P. W. 1928. Annual report of barberry eradication in Iowa. U. S. Dept. Agr., Bur. Plant Ind.

Smith, M. A. 1926. Annual report of barberry eradication in Iowa. U. S. Dept. Agr., Bur. Plant Ind.

———1926. Infection and spore germination studies with *Puccinia sorghi*. Phytopath. 16:69.

Speer, R. P. 1890. Our rusted and blighted wheat, oats and barley in 1890. Iowa Agr. Exp. Sta. Bul. 10.