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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

BOTANICAL SECTION

SOME PLANT DISEASES OF 1908

AMES, IOWA
Some Plant Diseases of 1908

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MILLET SMUT.

*Ustilago crameri* Koern.

During the fall of 1908, we received the following letter from Mr. L. B. Sager of Seymour, Iowa:

"I am sending you a sample of German millet. I wish to know what is the matter with it and what is the remedy. Of a 20-acre field, I should judge one-fourth is affected. This crop followed corn on most of the field. The man who furnished the seed says there was no smut on the crop last year, and lays the smut to the dry weather."

After a cursory examination of the smut, we concluded that it was distinct from the common smut found on pigeon-grass, and submitted it to Professor Clinton of New Haven, Connecticut, who classified it as *Ustilago crameri*.

Fig. I. Heads of Millet; a, unaffected by smut; b, affected by millet smut (*Ustilago crameri*)
CHARACTER OF THE FUNGUS.

The smut occurs in the smaller spikelets and completely destroys the ovaries, leaving only the outer wall. At maturity the ovary becomes considerably enlarged and the lower part is much darker in color. The wall of the spikelet breaks readily, exposing the spores to the air. The interior is filled with a mass of brown spores which are smooth, spherical to oblong, somewhat angular, from 6 to 8 \( \mu \) broad by 10 to 12 \( \mu \) long, but varying considerably in shape and size. These spores germinate readily in nutrient or lactose, or cane sugar solutions, or sterilized rain water. The spores in germination produce a slender, septate, promycelial tube with lateral sporidia. The sporidia enter probably at the time of the germination of the seed.

HARMFULNESS AND DISTRIBUTION.

This smut may become so serious at times as to ruin the crop. It is apparently widely distributed in the northern States, being reported, according to Dr. Clinton, from the District of Columbia to the Dakotas. A smut similar if not identical was reported by Mr. Field of Shenandoah, who found it in green foxtail seed occurring as an impurity of clover seed. Saccardo reports it from Germany to Hungary and Winter from several points in Germany.

Fig. 2. Millet smut; a, spores; b, glunes of millet grains filled with powdery mass of spores.

This fungus is undoubtedly related to the *Ustilago paniciglauci*, which is abundant on pigeon grass in this state and is very general in this country and in Europe. In Europe this fungus has been reported upon *Setaria verticillata* and *S. viridis*: Clinton, however, reports it on *Setaria glauca* only. This smut, like the millet smut (*Ustilago crameri*), converts the contents of the ovary into a powdery mass leaving the thin wall of the ovary, which readily breaks and
exposes the spherical or somewhat irregular ovoid echinulate spores which are considerably larger than the spores of the smut found on millet. Another ally to millet smut is the *Ustilago kolaczakii*, which was described by Kuehn in 1886 from *Setaria geniculata* grown in the botanical gardens in Berlin. The spores of this are also somewhat larger than the spores of millet smut.

**SOURCE OF INFECTION.**

Of the source of infection nothing can be said definitely, although Mr. Sager stated that the seed was apparently free from smut the year before. We are inclined, however, to think that there must have been some of the smut present or that it must have occurred upon wild foxtail in the vicinity. There is reason for believing that the latter may be true, for Mr. C. R. Ball found this smut upon foxtail (*Setaria viridis*) some years ago in the vicinity of Ames and Mr. Hume also records it from Ames. However, fresh sources of infection may have been brought to us from Europe, since large quantities of millet seed have been imported from Russia and Germany in recent years.

**EXPERIMENTS WITH FUNGICIDES.**

To test whether fungicides will destroy the spores of this fungus, an experiment was made treating the spores with different strength solution with formaldehyde and bichloride of mercury. The results are tabulated below.

**SPORES OF MILLET SMOOT TREATED WITH FORMALDEHYDE.**

1 part formaldehyde to 320 parts of water, no germination.

1 part formaldehyde to 500 parts of water, no germination

1 part formaldehyde to 1000 parts of water, free, abundant germination.

**SPORES OF MILLET SMOOT TREATED WITH CORROSIVE SUBLIMATE.**

1 part corrosive sublimate to 1000 parts of water, no germination.

1 part corrosive sublimate to 3000 parts of water, no germination.
I part corrosive sublimate to 5000 parts of water, no germination.
I part corrosive sublimate to 10,000 parts of water, no germination.
I part corrosive sublimate to 15,000 parts of water, free germination.
I part corrosive sublimate to 20,000 parts of water, abundant, free germination.

TREATMENT.

Judging from reports received concerning this smut, it is evident that it may become a serious parasite to millet in the state of Iowa. In order to prevent its further introduction we would suggest the planting of seed which is known to be free from this smut. American grown seed is less likely to be affected than seed introduced from Europe.
That the seed is the source of infection has been shown by the experiments made by Stuart, who gives formalin as an effective means of prevention. His method of treatment is as follows: Use formalin at the rate of 1 pound to 45 gallons of water, soaking for two hours, placing seed in sacks and shaking thoroughly, then spread the seed out to dry on a clean floor or canvas. Care should be taken that after the seed has been treated it is not allowed to come in contact with any implements that have been used in handling the infected grain. The treatment recommended above does not injure the grain but it does destroy the spores of smut.

Hecke also has reported successful treatment with several fungicides. He found the hot water treatment effective. This has, however, no advantage over the formalin treatment.

HISTORY.

The disease has been known for a considerable length of time in Europe. The fungus was described by Koernicke. It was also reported by Winter and Fischer in Europe, Brefeld made it the subject of some investigations in his work on the Ustilaginaceae, and it is referred to by Tubeuf. In the United States it has been referred to by Clinton from Illinois, Connecticut, the Dakotas, Michigan, and Ohio; Hume in Iowa; Stuart in Indiana, and by one of the authors in Iowa.

SOME LITERATURE ON THE SUBJECT OF Ustilago crameri KOERN.

Winter. Die Pilze 90.
Fischer Aperc 13.
Tubeuf. Diseases of Plants, 292.

DOWNY MILDEW OF MILLET.

Sclerospora graminicola Sacc.
The downy mildew is more or less widely distributed in
this state, more frequently upon the wild foxtail than upon the cultivated millet, although during the last few years it has been reported to us upon the cultivated millet from several different sections of the state. The cause of this disease is a fungus known as \textit{Sclerospora graminicola}. This fungus is easily recognized by the white, frosty appearance of the under surface of the leaf and a pale yellow, discolored area which frequently involves the whole leaf. During the early stages of the growth of millet the disease may cause complete destruction of the leaves by softening, in very much

Fig. 4. Downy mildew of millet; leaves torn into shreds filled with oospores,

the same way as in potato rot fungus. Later the older leaves are frequently torn into shreds and are easily broken up. The disease often involves the seed bearing portion of the plant, in that the flowers and spikelets are greatly enlarged. The white frost-like substance consists of a mass of short branches or conidiophores on the ends of which the spores are borne. The mycelium found within the interior of the plant vegetates between the cells. From this mycelium are
produced thick-walled oospores that tide the fungus over the winter season.

HOST PLANTS.

This fungus has been found in this state only upon the wild millet or foxtail (*Setaria viridis*) and upon the cultivated Hungarian grass and German millet (*Setaria italica* and *S. germanica*). A very closely related fungus has been described by a German investigator as occurring upon Indian corn. In many of its characteristics this fungus closely resembles the one found upon the millet, but so far as known the fungus has never been found upon the corn in this state.

Fig. 5. Downy Mildew on leaves of Millet; a, portion of leaf; b, spores; c, branch bearing spores. (Pammel and King).
TREATMENT.

The oospores of this fungus are undoubtedly widely distributed with millet seed as the leaves or spikelets break up so easily that the spores are scattered out and adhere to the glumes of the "seed". No doubt, too, infection takes place from adjacent plants. Some varieties of plants are much more subject to the disease than others, especially the Golden Wonder millet. From the nature of the plant, treatment with fungicides can not be resorted to, but care may be used to plant the millet in clean fields. The epidemic is much more severe in moist seasons—especially when it is moist during the early part of the season, than later when drought starts in.

HISTORY.

The fungus was first recorded in this country by Dr. Trelease and later by Farlow, on specimens found by one of the present writers in western Wisconsin in 1882 or 1883. Later it was described by Dr. Halsted from Iowa, and since then, has been found in Nebraska by Webber, and in North Dakota by Bolley. In a paper by one of the writers, the opinion is expressed that this fungus is identical with one found upon Indian corn by Raciborski in Java.

SOME LITERATURE ON THE SUBJECT OF Sclerospora graminicola Sacc,

Trelease. Parasitic Fungi of Wisconsin. 7.

SPOT DISEASE OF MILLET.

Piricularia grisea (Cke) Sacc.

In July 1907 we received from Mr. A. Folker of Mt. Sterling Iowa, some diseased specimens of common millet with the statement that the crop was very seriously affected. The disease had been observed at several other points in the state.

The spots developed two different fungi, one known as Piricularia grisea and the other as Cladosporium herbarum. The latter fungus appeared in peculiar abundance when the leaves were kept under a bell jar. Cultures made from the
leaves developed an abundance of the *Cladosporium*, but the cause of disease is evidently *Piricularia*.

![Fig. 6. Spot Disease of Millet. Leaf affected by *Piricularia grisea*; b, mycelium; c, spores. (C. M. King)](image)

**GENERAL CHARACTERS OF THE SPOT DISEASE.**

The disease is easily recognized by the pale green or yellowish appearance of the leaves, the spots appearing in definite areas of purple or reddish color and changing to brownish. The spots are usually elongated and two or three of them may become confluent, forming irregular areas. The center of the spot contains dead tissue of the plant and collapses with the progress of the disease. When the spots are abundant the spots turn yellowish. Where the fungus fruits freely the leaf has a slightly grayish appearance owing to the pale color of the fruiting threads. Where the fungus is abundant the leaves die from the tip and becoming gradually shriveled finally droop and dry up. If, however, the leaf when attacked is quite well advanced in growth, later in the
season the spots may become quite definite but the leaf will not be destroyed.

MICROSCOPIC CHARACTERS OF THE FUNGUS.

The vegetative threads of the fungus growing in the interior of the leaf produce during their growth a ferment which changes the color of the cells and causes the same to collapse. The fungus threads collect at these spots, break through the epidermis or come out through the openings of the stomata, causing a number of conidiophores (spore bearers of the fungus) to be found on one side of the leaf. The conidiophores are brown or pale brown in color and produce at the apex somewhat pear-shaped, three-celled, slightly colored spores or conidia. The color of the spores is variable, some being quite pale while others are tinged with a little brown. The conidiophores are also variable in length and as to their branching and twisting.

HOST PLANTS.

This fungus has long been known as a troublesome parasitic disease, frequently epidemic upon crab grass (Panicum sanguinale and P. glabrum). We have frequently seen large patches of crab grass destroyed by this fungus, and it has been reported on a number of other hosts, like the common pigeon grass (Setaria glauca), foxtail (Setaria viridis), rice-cut grass (Leersia virginica and L. oryzoides) and dropseed grass (Muhlenbergia glomerata). Unless it shall be proven that we are here dealing with a different biological form the presence of crab grass would be a common way of scattering the fungus.

TREATMENT.

No experiments have been made in the treatment of this disease caused by Piricularia; in fact it would seem from the nature of the plant that spray would not be effective nor practicable. However, some varieties seem to be less subject to the disease than others, like the common German millet, and it would seem wise to cultivate only resistant kinds.

HISTORY.

The literature contains a good many references to the occurrence of the fungus upon crab grass. These may be
found in lists of fungi published by Trelease, Bessey, Webber, and others. Tubeuf reports a species of *Piricularia*, *(P. oryzae)* parasitic upon rice, with a statement that it is usually accompanied with other fungi, just as we have found in this particular case. Jackson describes and figures this fungus as a common and destructive disease in Delaware.

**SOME LITERATURE ON THE SUBJECT OF *Piricularia grisea* (Cke) Sacc.**

Trelease. Preliminary List of the Parasitic Fungi of Wisconsin. 15.
Bessey and Webber. Report of Botanist on Grasses and Forage Plants and the Catalog of Plants 1889:82.
Tubeuf. Diseases of Plants. 503.
During the month of June, 1908, our attention was attracted to an unusual case of powdery mildew on cultivated wheats in the experimental plats at the Iowa State College. Several varieties were badly affected, notably Malakoff and other imported varieties. Acclimated varieties were not exempt from infection and were almost as seriously affected as the less hardy kinds. This same mildew appeared in considerable abundance about the edges of the plats of Big Frame and Turkey Red wheat during the first week in June, 1909.

**CHARACTER OF THE FUNGUS.**

The fungus produces a white cobwebby mycelium over both surfaces of the leaf, more generally, however, on the upper surface. The mycelium is more or less persistent, either scattered or in patches, at first white, then becoming pale brown or grayish. The mycelium give rise to erect branches that bear the spores in chains. Perithecia produced later are large, averaging about 225 μ in diameter, scattered or clustered, globose, usually more or less immersed in the persistent mycelium, the latter being sparingly branched, curved, and thick-walled, or of solid hyphae interlaced; appendages numerous, rather short, simple or sparingly branched, pale brown. On breaking the perithecia, the numerous asci, 9 to 30 in number, are found, each ascus containing from 4 to 9, usually 8, ascospores 20-23 by 10-13 μ in size, usually formed after the host dies. The ascospores of this fungus germinate in the spring, each spore producing several tubes, one of which becomes an haustorium. Conidia make their appearance in about ten days. If the germ tubes fail to reach the proper host plant, they perish.

**OCCURRENCE.**

The fungus has been recorded by numerous local observers in different parts of the United States, especially as it occurs upon various grasses. Among these observers, mention may be made of Trelease, who noticed the fungus in Wisconsin,
Peck, Dudley, and Day in New York; Farlow in Massachusetts; Selby in Ohio, Earl in Alabama, Arthur in Indiana; Beal in Michigan; Harkness in California; Walters in Kansas; and Pammel in Iowa and Colorado. The last named has also observed it commonly in the following states: Wisconsin, Minnesota, Illinois, Missouri, Utah, and Montana.

In looking over the literature on the subject, we find that in other parts of the world, this disease has appeared in epidemic form on wheat, rye, and other grasses. It is mentioned as serious in Germany by Sorauer, Frank and Wolf. Its occurrence in Austria has been noted by Von Thumen, in France by De Candolle, Marchal, Loverdo, Vesque; in Australia by Cobb, in England by W. G. Smith and Salmon.

This fungus occurs on a large number of host plants. At times it is so abundant on bluegrass as to completely destroy

Fig. 8. *Erysiphe graminis*. a, the mildew of leaf of wheat; b, chains of spore borne on the mycelium; c, spore. (King)
Occasionally it is abundant enough on fowl meadow grass to completely destroy the lower leaves. The same thing has been observed in the case of redtop and Texas bluegrass. Salmon reports 57 host plants belonging to 25 distinct genera and Marchall found the mildew on 55 species of grasses.

**Remedial Measures.**

The conditions favorable to the production of powdery mildew are heat and moisture; therefore when the common grains are too thickly sown, this fungus may prove troublesome. Varieties of grains not acclimated seem to be especially susceptible to invasion by the fungus. The obvious remedy is to sow grains less thickly; and to select varieties well acclimated to the region where they are to be grown.

**Biologic Species of* Erysiphe graminis.**

Dr. Salmon experimented with this mildew. He found that the form found on wheat will not normally infect rye; but when the leaves of rye were injured by cutting or bruising they could be infected by the fungus from the wheat.

During the summer of 1908 there were placed under observation in the greenhouse, plants of the following grasses: Perennial rye, bluegrass, timothy, quack grass, barnyard grass, brome grass, foxtail, orchard grass, and wild barley. These plants were placed in contact with leaves of wheat affected by powdery mildew. Not one of the grasses was found to be affected by mildew in consequence.

Dr. G. M. Reed, who has carried on a series of experiments with *Erysiphe cichoracearum* has shown conclusively that the fungus "occurs on at least 11 species of the cucurbits belonging to 7 genera, infection occurring in these cases in 50 per cent or more of the trials. Only 3 species belonging to 2 genera are entirely resistant to the mildew." It is evident also that this fungus will produce the mildew upon other forms of plants. In the record by Dr. Reed out of 54 leaves of common plantain 10 were affected.

The sunflower was likewise infected in 35 per cent of the trials, but he failed to inoculate mildew of cucurbits on asters and goldenrod.
LITERATURE ON THE SUBJECT OF *Erysiphe graminis*.

Farlow. A Provisional Host Index of the Fungi of the United States, 155.
Harkness and Moore. Catalog of the Pacific Coast Fungi.
Frank. Krankheiten d. Pflanzen. 1. (Ed. 1) 264. f. l. (Ed. 2)
De Candolle. Fl Franc. 6:106. For Summary, see Loverdo. Les Maladies Crypt. 212.
Loverdo. Les Maladies Crypt. des Cereales. 1892.
Salmon. Monograph of the Erysiphaceae, 209.
Smith, Diseases of Field and Garden Crops, 126-134.
Saccardo Syll. Fung. 1:19.

BLACK BLIGHT OF WHEAT AND OATS.

*(Cladosporium herbarum* Pers.)*

During the summer of 1908, the black blight appeared as a general infection of wheat in the fields of the Experiment Farm. This disease has been commonly observed upon wheat and oats, for the past three seasons in various parts of the state.

APPEARANCE AND CHARACTER OF THE FUNGUS.

Upon the leaves of wheat, the fungus forms spots between the veins, first grayish in color, becoming brownish. These spots are at first separate, at a later stage they become confluent. As the affected heads of wheat ripen, the presence of the fungus is indicated by the grayish color of the chaff. Upon leaves of oats, the spots are elongated, grayish, becoming brownish.

The *Cladosporium herbarum* has a grayish septate mycelium, or vegetative portion, which applies itself closely...
to the surface of the leaf, penetrating into the tissues. Upon this mycelium are borne erect conidiophores, giving off from the apex or from lateral processes, oval, one or more-celled conidia.

When heavy frost has injured the plants, the disease may be much more severe than during normal seasons.

Fig. 9. *Cladosporium herbarum* on wheat; a, spore; b, conidiophores. (C. M. King)
The fungus occurs as a parasite upon many hosts. In 1894, Harvey reported it upon oats in Maine; Pammel has also reported it as destructive, at times, upon wheat and oats in Iowa. Prillieux and Delacroix report the occurrence of *Cladosporium herbarum* form of *C. fasciculare* as the cause of a leaf disease of apple in France.

Von Thumen records it upon 70 host plants. The most exhaustive report of this disease has been made by Cobb of Australia, who found it a most destructive disease to grain in that country. This fungus is widely scattered in nature and may be found on many different plants, not only dead and half dead plants, but living leaves of apple, pine, raspberry, cycads, agave, cotton, peas, beans, corn, sorghum, etc.

**PREVENTIVES.**

The best preventive measure is to keep the fields and neighboring grounds free from weeds upon which the disease is likely to be growing, thus chances for its being communicated to the grain crop are lessened.

**SOME LITERATURE ON THE SUBJECT OF Cladosporium herbarum** Pers.

Link Observ. Mycol. 11:37.
Comes. Crittogamia Agraria. 1:297. 1891.
Constantin. Journ. de Botanique 1889:
BEAN ANTHRACNOSE.

*Colletotrichum Lindemuthianum* Sacc et Magn.

For a number of years, reports have come to the Botanical Section of the Iowa Experiment Station of the injuriousness of bean anthracnose, a disease which is both common and severe in the state. On some varieties of beans it is especially severe.

Fig. 10. Bean affected by anthracnose (*Colletotrichum lindemuthianum*).

CHARACTERS OF THE DISEASE.

The disease makes its appearance in small reddish brown spots, which rapidly increase in size, soon forming large and
irregular spots. The center becomes dark with a brownish border. Throughout the spot occur small irregular raised portions in which may be found the reproductive bodies. The fungus also occurs on the leaves and stems. It is frequently so severe on the stems that they are more or less riddled with holes. It not infrequently occurs on the young seedlings in the form of brown, discolored, sunken spots. The spots or cankers may be so severe that many seedlings are killed.

The colored or nearly colorless branching septate mycelium penetrates the tissues of the pod and bean. Masses of threads collect at points, which causes a collapse of the cells of the host plant and a breaking of the epidermis. From the mass of mycelium a spore-bearing layer is produced. This layer contains brown hyphae, known as setae, which do not produce spores, and ordinary erect threads or basidia which bear the one-celled spores or conidia. The small pustules contain a large number of spores which are held together by a mucilaginous substance. The common expression is that they “ooze out” forming pink masses. Water causes the mucilage to dissolve and the spores become separated. Infection of the bean occurs largely perhaps, by infection of seed in fruit, to which Dr. Halsted first called attention.

According to Sorauer, “the conidia falling upon the surface of the bean pod, send out a protuberance or germ tube on one side, which presses close against the epidermis, and becomes transformed into a round, flattened body with a thick violet membrane. From this there soon protrudes a colorless hypha that bores through the outer wall of the epidermal cells and grows within them into a convoluted mycelium which fills their cavities and extends rapidly downward and laterally.”

Fig. 11. Anthracnose of bean; a, hyphae bearing spores; b, spores; c, seta; d, mycelium in cell.
The disease spreads rapidly from pod to pod (as for example in the market-place), as has been shown by repeated inoculations in the laboratory, when, under the most favorable conditions, a spot may be established upon an otherwise healthy plant or pod in thirty-six hours. The infection is from without and may be by means of wind, dripping water bearing the spores, or through the agency of insects, which visit the bean flowers for their honey and incidentally convey the germs with the pollen they are distributing among the flowers.

Prof. Whetzel calls attention to the mode of infection in bean plant. The disease makes its first appearance on the bean seedlings, as they come up. It may then be detected as brown discolored sunken spots or cankers on the seed-leaves or the stem. The early appearance of the disease is due to the fact that the fungus is usually carried over winter in the seed and so is already in the bean when it is planted. Gain found that the disease spread from infected seed, or from presence of spores placed on a seed or in the soil.

Dr. Halsted, in a series of inoculation experiments, transferred the fungus to watermelon, and Dr. Farlow reports it on watermelon and nutmeg melon. It is found in England, according to Carrothers.
Fig. 13. Watermelon affected by anthracnose.

Fig. 14. Musk melon affected by anthracnose.
Not only is it a troublesome disease in various parts of the United States and Canada, as indicated by Selby, Beach, Halsted, Whetzel, McCarthy, Chester, Scribner, and others, but it has been noted as a destructive bean parasite by Tubeuf, Frank, Sorauer, Passerini, and Penzig in Europe and by Kirk in New Zealand.

HISTORY.

The fungus was described by Passerini as *Fusarium lagerorum* in 1868. It was, however, first discovered by Lindemuth in Poppelsdorf, Germany and described by Saccardo and Magnus as *Glucosporium lindemuthianum* Briozi and Cavara distributed the fungus as *Colletotrichum lindemuthianum* in 1889. The first American reference to the importance of the fungus was made by Trelease. Lamson-Scribner, 1887, described it in the Report of the U. S. Department of Agriculture under the name of *Glucosporium lindemuthianum*.

PREVENTIVE MEASURES.

Mr. H. F. Whetzel after long observation, finds that selection of clean seed is the best means toward control of the rust.
BEAN RUST.

Uromyces appendiculatus Pers.

For a number of years we have had under observation a rust occurring rather abundantly on the common bean, especially the pole bean. During the summer of 1908 specimens of the rust were sent in by a correspondent from Grinnell, Iowa, where it was common and destructive. During the same season the cluster-cup stage was collected by one of us at La Crosse, Wisconsin.

The finding of the cluster-cup stage on the cultivated bean has not heretofore been mentioned by American writers on economic fungi, although it is commonly observed on some of the wild beans. That this stage has been found is of especial interest as it accounts for the source of infection of the cultivated bean.

Fig. 16. Bean Rust, Uromyces appendiculatus a, early or cluster cup, stage; b, lateror uredo stage.

CHARACTER OF THE FUNGUS.

This bean rust in its development is not unlike the common
wheat rust, which has three stages. In the case of wheat rust, the first stage is upon the barberry, but in the case of the bean all three stages occur upon the same host plant.

The aecidium or cluster-cup stage occurs upon the under surface of the leaves in definite spots. The color of the leaf in the vicinity of the spots does not differ materially from the color of the remainder of the leaf. The number of the cups (aecidia) varies from 4-6 in the smaller spots to 20-25 in the larger spots. They are pale in color, the peridial cells being colorless. The spores are spherical to elliptical 10-26 μ in diameter, minutely roughened. The spermogonia are on the upper surface of the leaf, minute; the spermatia small, spherical. The uredospores occur in spots which are at first roundish, but later, becoming confluent, form irregular patches frequently quadratic in form; the sori or pustules of the fungus occur on both surfaces of the leaf, and not infrequently on the pod and peduncle, varying from a few to many in a spot. The uredosori which contain the summer spores are yellowish brown and appear dur-

![Fig. 17. Bean Rust, *Uromyces appendiculatus*. a, cluster cup stage; b, uredospores; c, teleutosphores.](image-url)
ing the summer, occasionally as early as the middle of June. The sori contain 1-celled, globose or oval, minutely roughened spores from 18 by 19 μ to 21 μ by 21 μ. The teleutospores or the winter spores appear in the places previously occupied by the uredospores or in new spots. They are darker in color and do not appear until the middle to the end of August and from then until the frost kills the vines. The teleutospores are elliptical, or sub-rotund, or rarely pyriform in shape with a prominent hyaline point; the epispor is thick and the prominent pedicel hyaline, from one to two times the length of the spore. The spores vary considerably in size. They average about 20 by 30 μ, although extreme measurements are 18–24 μ by 27–32 μ.

HOST PLANTS.

This rust is found on various hosts, especially the pole bean (*Phaseolus vulgaris*), on the black bean (*Dolichos lablab*), the cow-pea (*Vigna sinensis*), and on two of the wild species of bean (*Strophostyles pauciflorus* and *S. angulosa*).

SOURCE OF INFECTION BY FUNGUS.

It has been suggested by Dr. Halsted that the wild beans are responsible for communicating the rust to the cultivated beans. This, however, is not the case where the bean has been observed in La Crosse, Wisconsin and in Iowa. At the former point, the disease has appeared annually for a number of years. The observer was at a loss to know how it had originated until last summer (1908) when the aecidium stage of the fungus was found at that place. There were no wild beans anywhere in the vicinity. There can be no doubt that the aecidium stage occurs in such abundance there because of the decaying of old leaves that contained the winter spores, which germinated in the spring and affected young plants.

NATURE OF INJURY.

The bean rust sends its mycelial threads into the tissues of the bean plant. It has been observed in some instances to destroy the cells so completely that the leaves turned black and fell off.
AMOUNT OF LOSS.

While usually not one of the most troublesome diseases of the bean, it occasionally becomes so severe as to cause serious loss. It is recorded by Pammel and by Beach as destructive to late varieties, particularly to the wax bean.

PREVENTIVE MEASURES.

Careful selection of seed grown in regions where the rust is not found, the burning of old bean leaves likely to contain winter spores, and the destruction of wild beans in the neighboring grounds are the best means to hold the bean rust in check.

DISTRIBUTION.

The bean rust has been recorded from New Jersey by Halsted; from New York by Beach, Whetzel, and Peck; from Ohio by Selby; from Wisconsin by Trelease; from Illinois by Burrill; from Nebraska by Bessey and Webber, from California by Harkness; and from Massachusetts by Farlow. It has also been observed in Minnesota, Missouri, Nebraska, and Illinois by Pammel.

As to its more general distribution, this fungus has been found in many parts of Europe, Asia, Australia, North America, and South America wherever the bean and related plants are cultivated.

LITERATURE ON THE SUBJECT OF *Uromyces appendiculatus*.

Trelease. Parasitic Fungi of Wisconsin. 20.
Bessey and Webber. Grass and Forage Plants and Catalog of Plants. 60.
Harkness and Moore. Catalog of Fungi of Pacific Coast.
Farlow and Seymour. A provisional Host Index of the Fungi of the United States. 30.
Saccardo. Sylloge Fungorum. 12.