

STUDIES ON LEAF RUST (UROMYCES ELEGANS)

OF

CAROLINA CLOVER

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CAROLINA CLOVER

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INTRODUCTION

The rust fungus Uromyces elegans Berk. appears to cause the most common and destructive disease of Carolina clover (Trifolium carolinianum Michx.). The disease has been known for approximately 75 years. The common name of the disease may be misleading in that it might seem to imply that there is only one rust of Carolina clover; in fact there are two species of rust fungi recorded as occurring on Carolina clover in North America¹. The disease discussed in this thesis is, however, the more common, and may be conveniently called "leaf rust". The rust has attracted very little attention from pathologists, therefore information and data on the disease is meager. Available literature records only one instance of the fungus being cultured on susceptible plants.

SUSCEPTS

As far as can be determined this disease is known to affect only certain species of the Leguminosae, or Pulse family. Apparently it is restricted to the genus Trifolium and to the two species carolinianum and ciliatum Nutt. In Arkansas and Oklahoma the rust is more common on T. carolinianum. The disease was erroneously reported on T. arvense².

VARIETAL SUSCEPTIBILITY

There is only one variety of Carolina clover, therefore varietal susceptibility is of little importance, however in 1939 the writer observed many cases of marked resistance to the disease in pastures. Healthy plants were observed growing close to, in fact touching other plants practically

1. A. B. Seymour, Host Index of the Fungi of North America, p. 422.

2. J. C. Arthur, Rusts of the United States and Canada, p. 300.

covered with sori of the fungus. The plants were observed throughout the spring and produced a normal amount of foliage and seed.

THE DISEASE

The name usually applied to this disease by American pathologists is merely "rust". Arthur speaks of it as "clover rust"³. Wolf and Heald refer to the disease as "rust on the leaflets"⁴.

HISTORY AND RANGE

The history of the disease probably begins with its identification in 1874. Records of its occurrence in North America are scarce. It is mentioned as occurring in the vicinity of San Antonio, Texas in 1911⁵. Arthur records the presence of the rust in Alabama in 1913⁶. The fungus was reported from Heavener, Oklahoma in 1939⁷. The writer observed the disease near Little Rock, Arkansas in 1938, and in 1939 and 1940 the rust was found in many pastures throughout central Arkansas. Dr. W. W. Ray collected specimens of the rust in Tulsa County in 1940. The rust is prevalent in other states but the date of occurrence is not mentioned.

The rust occurs in a greater or lesser extent in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina, Texas, and Oklahoma. It is quite possible that the disease is prevalent in other states but available literature does not reflect its occurrence.

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3. J. C. Arthur, Cultures of Uredineae, Mycologia, Vol. 7, p. 85.
 4. F. D. Heald, and F. A. Wolf, A Plant Disease Survey in the Vicinity of San Antonio, Texas, B. P. I. Bul. 226, p. 91.
 5. Ibid.
 6. Arthur, Op. cit., p. 300.
 7. C. C. Brown, Contribution Toward a Host Index to Plant Diseases in Oklahoma, Okla. Exp. Sta. Mimeographed Cir. No. 33, p. 60.

IMPORTANCE

Although present to some extent every season this rust is much more destructive some seasons than others.

The principal injury is to the foliage. The mycelium of the fungus injures the leaves severely, frequently causing the death of the plant.

It is difficult to estimate losses caused by leaf rust. Carolina clover furnishes a fair quantity of early spring grazing in many pastures in central Arkansas, therefore when this clover is injured severely the carrying capacity of the pasture is decreased temporarily. It is the opinion of some farmers that hop clover Trifolium procumbens soon occupies the areas where Carolina clover is killed.

SYMPTOMS AND SIGNS

The disease is easily recognized by its symptoms and signs. Although it is generally thought of as a leaf disease, sori frequently occur on the bracts and occasionally on the stems.

In this rust there is no pycnial stage, and the first evidence of the disease is the appearance of small, yellow, cup-like aecial sori on the under surface of the leaf. These sori become more conspicuous as the plant and the disease advance with age. Frequently as many as 150 sori occur on a single leaflet. When the aeciospores mature the sori assume a dark brown color eventually resulting in a small cylindrical or irregular hole through the leaf. Stunting of the plant usually accompanies the appearance of the yellow sori. Occasionally the upper surface of the leaf takes on a light pink color. As a rule the affected leaflets appear somewhat wrinkled. (See plate 1.)

Shortly after the appearance of the yellow sori, dark brown telial sori appear on the under surface of the lower leaves. Uredial sori apparently are never produced. Although the lower leaves are usually affected more

PLATE 1.



Plants of Carolina clover showing characteristic aecial and telial sori on under surface of the leaves. Left - Aecial sori. Right - Telial sori.

Enlarged view of leaf with aecial sori.



severely, frequently the dark brown telial sori appear more generally distributed over the plant even extending up to the leaves nearest the blossoms. These sori, as in the case of the yellow sori, finally result in a cylindrical or irregular hole through the leaf. As many as 650 sori of this kind have been counted on a single leaflet. (See plate 1.)

The mycelium of the fungus is usually distributed throughout the leaf. Hyphal branches often extend entirely through the leaf from epidermis to epidermis. Frequently cells are completely surrounded by hyphae. Haustoria are sent into practically every cell near the aecial or telial sori.

ETIOLOGY

The rust fungus was first described and named Aecidium orobi elegans by Berkeley in 1874⁸. The assignment of the fungus to the genus Aecidium indicates that Berkeley's identification was made on finding the aecial stage only. In 1895 Lagerheim found the one-celled teliospores and emended the previous description placing the fungus in the genus Uromyces, calling it Uromyces elegans⁹. Arthur, following the American code of nomenclature, placed the fungus in the genus Pucciniola in 1913, applying the name, Pucciniola elegans to the fungus¹⁰. The proper name applied to the fungus is, however; Uromyces elegans.

This fungus is a Basidiomycete, belonging to the Uredinales (Rust fungi) the Family Pucciniaceae and the tribe Uromyceae.

8. J. C. Arthur, Rusts of the United States and Canada, p. 300.

9. Ibid.

10. Ibid.

The causal relation of Uromyces elegans to the rust disease of Carolina clover has apparently never been questioned. The organism is constantly associated with the yellow and dark brown sori occurring on the leaflets. Arthur made an infection experiment in 1913 by sowing aeciospores from Carolina clover on the same host, resulting in telia, without appearance of uredia or secondary aecia¹¹.

The life history of Uromyces elegans is of a simpler type than presented by some rust fungi. The rust is autoecious, having no alternate host, and produces all but one of the spore forms, the pycniospore being absent.

The aecia are hypophyllous, and cupulate, produced from a systemic mycelium. The aeciospores are globoid or elliptical measuring from 10 to 19 μ . by 13 to 21 μ . The spore wall is nearly colorless with a thickness of 1 - 1.5 μ . The aeciospore is covered with fine wart-like projections. The uredia are not formed, however, urediospores are occasionally found in the telia. The urediospores are 15 - 18 by 18 - 22 μ . having a yellowish-brown wall 1.5 μ . thick. The spore is covered with fine point-like projections. The spore has three or four distinct pores which are equatorial.

The chestnut brown telia are amphigenous found in small groups. The teliospores are globoid or ellipsoid one-celled, 15 - 19 by 19 - 27 μ . The color of the wall is also chestnut brown and is uniformly 1.5 to 2 μ . thick. The spore has a terminal pore covered by a hyaline papilla. The spore is minutely ridged having a short, broad, colorless pedicel or stalk which is very fragile. (See plate 2.)

This rust apparently overwinters in the form of mature teliospores on the leaflets, bracts or stems.

11. J. C. Arthur, Rusts of the United States and Canada, p. 300.

PLATE 2.



Teliospores of Uromyces elegans.

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It is highly probable that the way in which the disease is spread is similar to that of a closely related clover rust, Uromyces trifolii. U. trifolii is spread from place to place primarily by the teliospores on pieces of leaves and stems.

As Carolina clover is seldom planted in pastures the disease is probably introduced to a new place through the use of hop clover or lespedeza seed containing bits of leaves and stems of Carolina clover bearing teliospores of the fungus. Frequently hop clover seed contain small amounts of Carolina clover. The writer made observations which are not at all conclusive but support this belief.

In 1939 a plot was seeded to hop clover which had been in clean tilled crops for at least 10 years previous to 1939. The plot was approximately one mile from any Carolina clover. In the late spring of 1939 many plants of Carolina clover appeared in the plot affected with the fungus. Most of the hop clover and lespedeza seed planted in central Arkansas comes from regions where Uromyces elegans is prevalent. It is unlikely that urediospores spread the disease to a great extent because they are only occasionally produced, while basidiospores are well known to be unable to spread rust diseases beyond very short distances, not over a few hundred yards.

EPIPHYTOLOGY

Of the environmental factors affecting the occurrence and severity of this disease, moisture is probably the most important. When moisture is abundant the disease becomes more severe. In the spring of 1940 heavy rains were frequent over the central part of Arkansas, resulting in widespread occurrence of the disease. In the spring of 1939 the rainfall was somewhat less and the disease was not as severe as in 1940.

Temperature is probably a factor of much less importance in the incidence of the disease than moisture. High temperatures appear to be unfavorable to germination and invasion of the susceptible by the spores. It is a common observation that cool rainy weather favors outbreaks of the disease.

From common knowledge of rust diseases of other plants, it may be assumed that fertilizers high in nitrogen would increase the injurious effects of the fungus, while phosphorus and potash should reduce the injury.

CONTROL

Until the disease is reported on varieties of clover that are grown more extensively than the host discussed in this thesis, control of the disease is of minor importance.

The writer carried on an elementary experiment on the dusting of Carolina clover with sulfur dust in the spring of 1940. Six plots of 100 square feet each were staked out in the spring of 1939. The plots were selected in a pasture where Carolina clover was the predominating vegetation. The clover was heavily infected with the rust fungus. Two plots were dusted with commercial flowers of sulfur. These plots were dusted only once. Two other plots were dusted with the same quantity of sulfur but were dusted twice, 10 days elapsing between applications. Two plots were untreated and served as check plots.

All plots were clipped when the majority of the plants were in blossom and weighed immediately after clipping. The average yield for the two plots receiving one dusting was 830 pounds of green forage. The two plots receiving two applications yielded an average of 1190 pounds of forage while the untreated plots yielded only 515 pounds per acre.

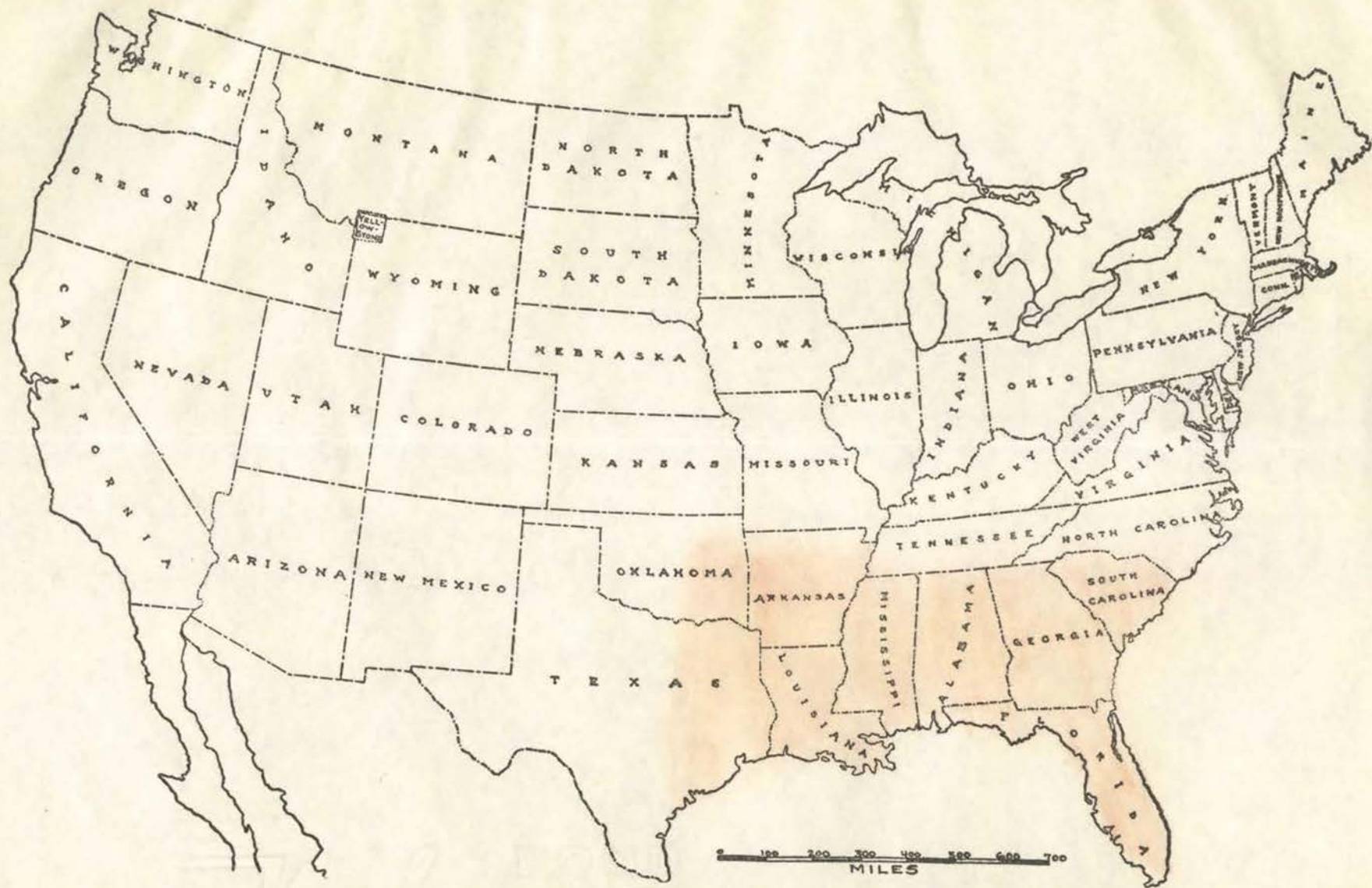
Although the results of this experiment are not conclusive they show that the disease was causing a loss of 57 per cent to the clover. While

dusting is impractical under ordinary conditions it may be used to an advantage in experimental plots and under conditions where seed production is desired.

If uncontrolled, this loss caused by leaf rust proves a serious weakness in Carolina clover and would certainly affect its choice in comparison to other legumes in establishing a permanent pasture.

SUMMARY

The fungus Uromyces elegans, Lagerheim 1895, causes the most destructive disease of Carolina clover. Trifolium carolinianum and T. ciliatum are the only susceptibles. The disease occurs in Ala., Ark., Fla., Ga., La., Miss., S. C., Tex., and Okla. Principal injury is to the foliage. Yellow, cup-like aecial sori are first indications of the presence of the disease. The rust is autoecious, producing all spore forms except pycniospores. The fungus apparently overwinters as teliospores. The disease probably spreads by means of leaves and pieces of stems infected with the fungus in hop clover and lespedeza seed. Moisture and temperature are the most important environmental factors affecting occurrence of the disease. Dusting with sulfur more than doubled the production of green forage.



The distribution of *Uromyces elegans* in the United States is indicated by the shaded area.

ORIGINAL DIAGNOSIS OF UROMYCES ELEGANS (SACCARDO:

"SYLLOGE FUNGORUM" 14:272-273. 1899.)

Uromyces elegans (Berk. et Curt.) Lagh. Ured. herb. Fries. 1895, p. 34, Aecidium elegans B. et C., in Ravenel, Fung. Carol. n. 188; Uromyces Trifolii Har. Urom. Lég. p. 12 ex p. — Aecidiis hypophyllis, sparsis, cupuliformibus, brevibus, ore recurvato; aecidiosporis angulato-rotundatis, 16-18 μ . diam., membrana tenui, achroa, aequabili crassitudine, verruculosa, contentu aurantiaco; soris uredosporiferis et teleutosporiferis hypophyllis, sparsis, non confluentibus, parvis, obscure brunneis, pulveraceis; uredosporis ovoideo-rotundatis, circiter 22 μ . diam., membrana tenui, pallide luteola, aculeata, ad poros germinationis quaternos leniter incrassata; teleutosporis basi lata ovoideis, 24-28 \times 16-20, membrana aequabili crassitudine, fusca, cymatiis longitudinalibus (ut in U. striato Schröt.) ornata, pedicello hyalino, caduco.

Hab. in foliis vivis Trifolii Caroliniani in S. Carolina Amer. bor. (Ravenel).

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