THE YELLOW RUST OF RASPBERRY CAUSED BY PHRAGMIDIUM IMITANS[1]

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INTRODUCTION

Although *Phragmidium imitans* Arthur is distributed from the Atlantic to the Pacific coast in the northern United States and southern Canada, it is not prevalent enough to be of economic interest except in the Pacific Northwest. Its geographical range is from Newfoundland and Massachusetts to Colorado and northern California, and northward into Canadian Provinces.

Phragmidium imitans occurs autoeciously on species of the genus Rubus, having been reported on *R. leucodermis* Douglas, *R. occidentalis* Linn., *R. spectabilis* Pursh, and *R. strigosus* Michx. The widest distribution is on the latter host, upon which it has been reported in Canada from Newfoundland and Nova Scotia to Ontario, and in British Columbia; and in the United States from Maine and Massachusetts to Montana and Colorado, and in Oregon and Washington. On the other species of Rubus, *P. imitans* is distributed as follows: On *R. leucodermis*, from northern California to British Columbia; on *R. occidentalis*, in Massachusetts, Newfoundland, Oregon, Washington, and British Columbia; and on *R. spectabilis*, in Oregon and Washington. The severest attacks are on *R. strigosus* and *R. spectabilis*.

TAXONOMY

The organism causing this disease was first described by Farlow[2] in 1879 as *Phragmidium incrassatum* Link *gracile* and later (1884) by Arthur[3] as *P. gracile*. Since the latter name was preoccupied (*P. gracile* Cook, 1871) and the fungus is similar to these other species, Arthur finally gave the name *P. imitans*.[4]

MORPHOLOGY

There is nothing strikingly distinctive in what is known of the morphology of *Phragmidium imitans*. It is very similar to the European species, *P. Rubi-Idaei* Karst. In *P. imitans* the pycnia, which are flattened lenticular bodies opening by irregular clefts through the overlying epidermis of the host, are typical of the genus. Under Oregon conditions they first appear on the upper surface of the leaves in April and early May. They are located at the centers of slightly elevated spots, occurring singly or more often in groups of two to four. These elevated spots are less than a millimeter in diameter,

[1] Received for publication Jan. 22, 1927; issued June, 1927. Published by permission of the Director of the Oregon Agricultural Experiment Station.

[2] ELLIS, J. B. NORTH AMERICAN FUNGI. Century III, no. 282. 1879.

[3] ARTHUR, J. C. PRELIMINARY LIST OF IOWA UREDINEAE. Iowa Agr. Col., Dept. Bot. Bul. 1884, p. 161. 1884.

[4] ARTHUR, J. C. AECIDIACEAE. North Amer. Flora 7: 165–166. 1912.

and may be slightly lighter in color than the normal tissues of the succulent raspberry leaves. If it were not for the tiny circular elevations upon which the pycnia occur, they would pass entirely unnoticed at this stage. When mature, pycnia are more conical than lens-shaped and measure 45μ to 90μ in diameter and 30μ to 35μ high.

The tiny elevations upon which the pycnia occur are the unruptured, developing aecia. These break through the epidermis and become noticeable from late in April and early May until late in July. They rupture the epidermis in small circular groups around the pycnia, becoming pulvinate. In color they are a light orange yellow, fading to pale yellow. They may occur scatteringly or so densely spotting the leaves (fig. 1, A) that early defoliation results. The circular aecia (fig. 1, B) are surrounded by incurved clavate paraphyses just inside of the fringing epidermis. The paraphyses are 10 to 15$\times$45 to 100μ, with thin, smooth, hyaline walls.

The aeciospores are globose to broadly ellipsoid, 16 to 24$\times$14 to 20μ in size, with pale-yellow, sparsely and sharply papillose walls.

The uredinia have been found as early as the first of May, but are generally most prevalent in badly infected plantings during the month of June. Nevertheless, they may be found more or less abundantly until the leaves are shed in the late fall. Uredinia occur in lesions on the underside of the leaves and on all types of stems, including the canes (fig. 1, C, D, and fig. 2, C),[5] fruiting laterals (fig. 2, A), and leaf petioles (fig. 2, B). On the leaves the uredinial lesions are roundish, but on stem tissues they are usually elliptical. They soon become so prolific in spore production that the separate uredinia are indistinguishable. The uredinia are circular, small, 0.1 to 0.2 mm. in diameter, the ruptured epidermis disappearing early; paraphyses encircling the sorus are rather numerous, incurved, somewhat clavate, 65 to 100$\times$11 to 17μ in size, with thin, colorless, smooth walls.

The urediniospores are broadly ellipsoid, 18 to 23$\times$15 to 18μ in size, orange to pale yellow, becoming almost white late in the season, with thin walls, sparsely and rather strongly verrucose-echinulate, and with obscure germ spores.

The telia come in the uredinial lesions, wherever they occur. They have been found from the middle of July until late into the winter. In late summer the telia, blackened by the teliospores, are conspicuous on the lower surface of the leaves (fig. 2, D) and on the cane lesions until spring (fig. 2, C).

The telia which range from 0.3 to 0.7 mm. in diameter, are scattered. They are blackish, and become naked early.

The teliospores are cylindrical 26 to 32$\times$80 to 127μ, in size usually rounded below; apex has a blunt, conical hyaline apiculus, 3μ to 13μ long which has from 6 to 10 cells (usually 8 or 9); wall very dark fuscous brown, closely and rather coarsely verrucose; pedicel rugose when dry, sometimes with a twisted appearance, 80μ to 120μ long, the upper portion colorless except near the spore, 9μ to 10μ in diameter, the lower portion colorless but the interior not clear, swelling in water to claviform, 14μ to 27μ in diameter.

[5] FRANK, A. A NEW PHASE OF THE RASPBERRY RUST. Wash. Agr. Expt. Sta. Mo. Bul. 4 (10): 15-16. 1917.

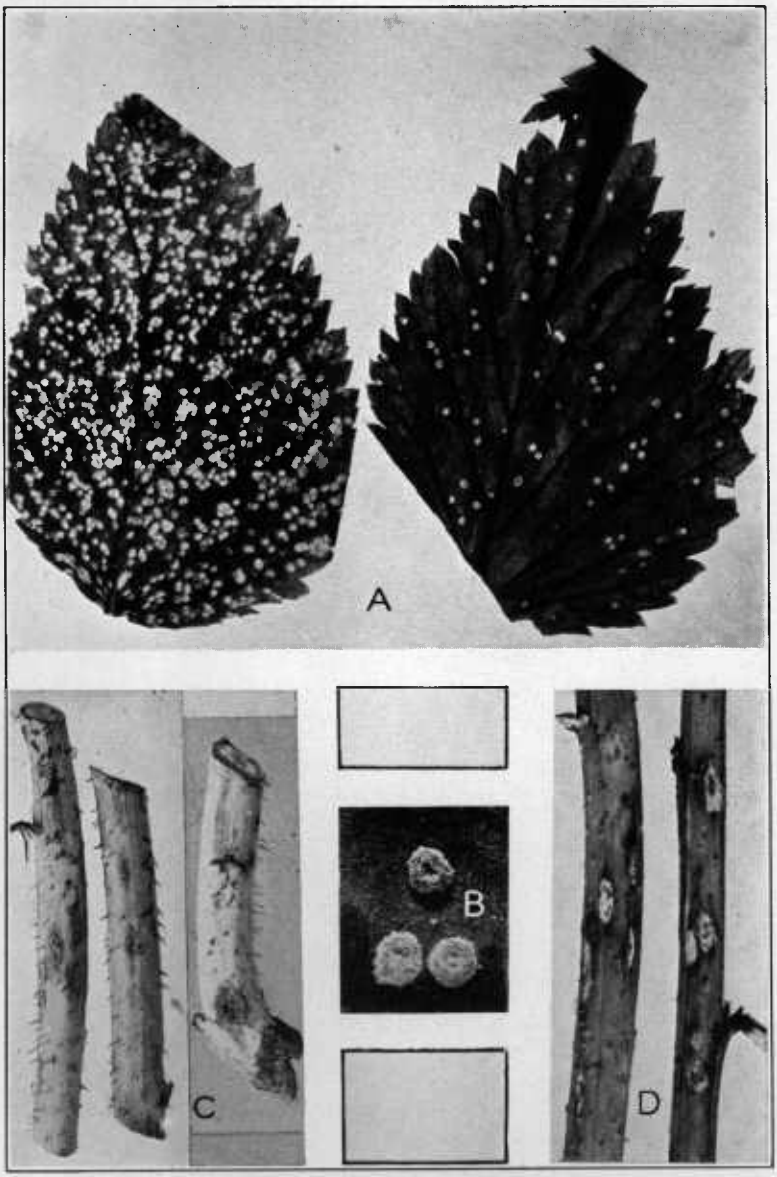

FIG. 1.—A, aecia on the upper surface of leaflets from the Cuthbert red raspberry Natural size. B, three aecial sori enlarged. ×10. C, uredinia on newly grown canes of the Cuthbert red raspberry, showing early stages of cane lesions beginning as dark water-soaked areas. Natural size. D, uredinial lesions on current year's canes late in the summer, showing an abundance of urediniospores. Natural size

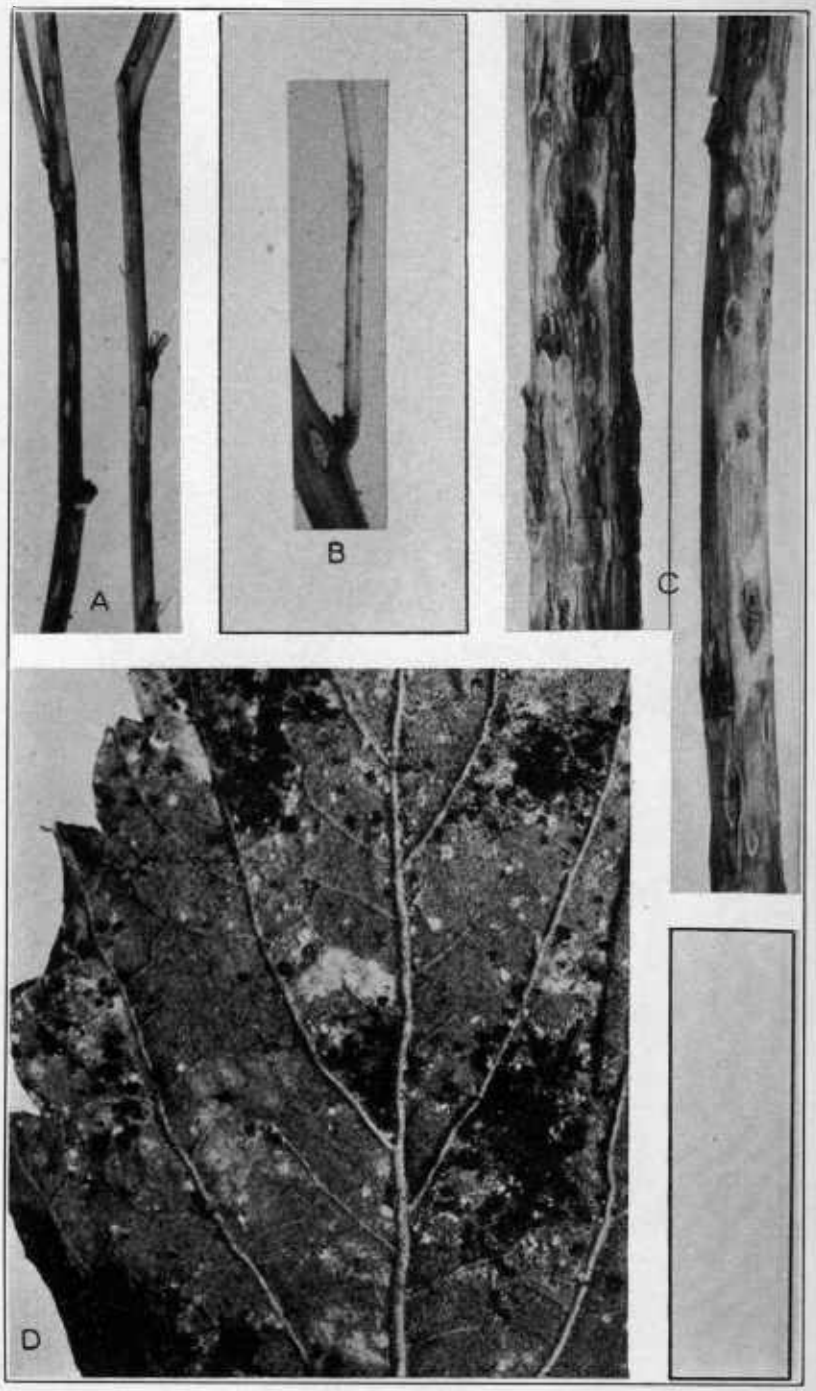

FIG. 2.—A, uredinial lesions on fruiting laterals of Cuthbert red raspberry taken in July. Natural size. B, a uredinial lesion on leaf petiole. Natural size. C, uredinial lesions with telia appearing subsequently in the same lesions near the base or ground line on two canes in their second season. Natural size. D, pale yellow uredinia and black telia on the lower surface of a Cuthbert leaf. ×3

GERMINATION OF SPORES

No infection studies have been conducted, but several attempts have been made to germinate spores on microscope slides moistened with water. All attempts to germinate aeciospores have failed, but a very few teliospores have germinated and a considerable number of urediniospores. All attempts to germinate current season teliospores failed, but a very small percentage held over from the previous year have been induced to germinate in this way. Figure 3 shows a germinating teliospore of *Phragmidium imitans*, illustrating the type of promycelium produced and the subglobose sporidia which are hyaline and measure 4μ to 6μ in diameter. Figure 4 shows the germ tube of an urediniospore issuing from a terminal germ spore.

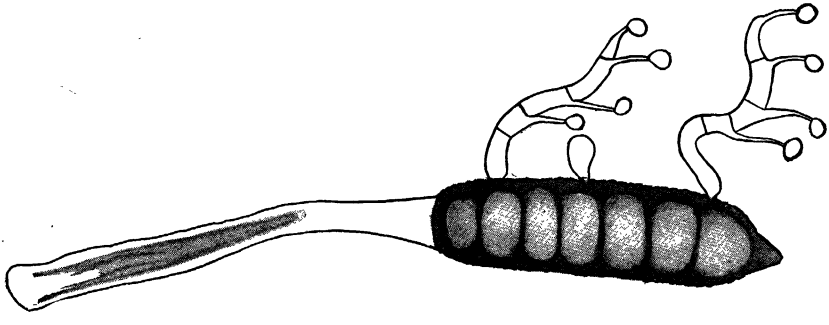

FIG. 3.—Germinating teliospore. ×500

ECONOMIC IMPORTANCE

The disease of the Cuthbert red raspberry caused by *Phragmidium imitans* develops to damaging proportions in the Pacific Northwest, particularly in seasons when the spring rains continue late. Under such conditions leaf infections become so numerous (fig. 1, A) that partial defoliation in badly infected plantings is frequently observed, and often more severe defoliation is reported. Berry pickers frequently have their clothing almost covered with the orange urediniospores. In seasons when leaf infections are so numerous as to produce any appreciable amount of defoliation the disease must have some devitalizing influence on the affected plants. However, the actual loss in crop during the current and subsequent years from this cause would be difficult to ascertain. The infection which causes uredinial lesions on the stems is the most serious and damaging phase of the disease.

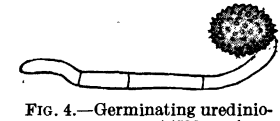

FIG. 4.—Germinating urediniospore. ×500

UREDINIAL LESIONS ON CANES

The greatest economic loss from raspberry rust is caused by the uredinial lesions on the stems. Frank [6] first called attention to these cane lesions in 1917, mentioning the fact that the spores produced in these lesions are doubtless an important factor in the carrying over of

[6] FRANK, A. Op. cit.

the fungus from one season to another. In answer to the writer's inquiry H. S. Jackson states that at the time the original description of *Phragmidium imitans* was made stem lesions were not known but that several years ago he found this disease on stems from western Washington. Although these uredinial lesions on the stems have been known for some years it is only recently that they have received detailed attention by the writer. In the summer of 1923 several growers of Cuthbert red raspberries in western Oregon called the writer's attention to the fact that they were sustaining a considerable loss of canes from some cause unknown to them. An investigation led to the conclusion that the loss was directly attributable to cane lesions.

During the summer when infection of the canes takes place the lesions on the green succulent canes do not present a serious aspect except where the lesions are so close together and so arranged as almost completely to girdle the stem. Comparatively few canes wilt or die during their first year. Losses from rust usually occur during the second or fruiting year of the canes. The infections near the ground have become deep and cankerous by the second year. (fig. 2, C). If they are numerous, they not only hinder the normal rise of sap but also produce brittleness in the canes. Many of the brittle canes are accidentally broken off when the old fruiting canes are trimmed out, and many more are broken out when the canes are trellised. Frequently, also, berries dry on the bushes before they reach maturity. Canes with numerous lesions near the base seldom have enough vascular tissues remaining to allow the passage of the amount of sap necessary to carry the fruit to maturity. In such cases the fruit of the whole cane suffers, while in the case of infections on the fruiting laterals the fruit of the individual lateral is damaged. (fig. 2, A). Leaves having petiolar infections (fig. 2, B) usually wilt and dry up during the heat of the summer, particulary if they are borne on the second-year fruiting canes and the fruit robs them of some moisture. Not infrequently the cane lesions produced by *Phragmidium imitans* are subsequently infected with *Fusarium viticola* Thüm, in which cases the pinkish sporodochia give to the lesions the appearance of anthracnose spots.

CONTROL

No satisfactory control measures have been found for this yellow raspberry rust. If in badly infected plantings the old fruiting canes are removed as soon after the harvest of the fruit as practical, much of the source of late summer infection will be removed. Where practical, all the fallen leaves and refuse resulting from the removal of the old canes should be raked up and burned. Early spring plowing to cover fallen leaves and refuse before the leaves come out offers the most practical method of control. Immediately after plowing, the refuse should be raked into the furrows before the first cultivation. If these sanitary measures are thoroughly carried out the disease should never become serious, although such measures do not eliminate the possibility of infection from lesions on the new canes. In most seasons, however, such infections are practically negligible.

A few tests have been made to determine the effectiveness of Bordeaux mixture spray, 3–3–50 in preventing infection of the newly

growing canes. One of these tests made in 1924 gave rather hopeful results. The tests made in 1925 and 1926, however, were unsatisfactory as the seasons were not favorable to rust and the unsprayed rows showed no lesions on the new canes. Three applications were given when the new canes were 4 to 12 inches, 16 to 20 inches, and 20 to 36 inches high, respectively. In the 1924 tests the sprayed canes were not infected in stems of leaves, but the unsprayed rows showed some cane lesions and moderate leaf infection. These results are merely indicative, since conditions in 1924 were not favorable for infection by *Phragmidium imitans*. Grove [7] says that in England the spread of *Phragmidium Rubi-Idaei* Karst. is prevented by sprays such as dilute Bordeaux mixture or potassium sulphide solution. A convincing test of Bordeaux spray as a preventive of *P. imitans* is impossible, however, in seasons as unfavorable to the disease as those of 1924, 1925, and 1926.

SUMMARY

In this paper is described the yellow rust of red raspberries caused by *Phragmidium imitans* Arthur. The geographic distribution of the rust and the species and varieties of Rubus upon which it occurs are briefly reviewed. The life history as observed on the Cuthbert red raspberry in the Northwestern Coast States is described, with particular reference to the uredinial lesions on the stems. The infection of second-year or fruiting canes near the ground is the most serious phase of the disease, since the resulting lesions produce brittleness and diminish sap-conducting tissues. Thus canes are easily broken in trellising, and the rise of sap may be insufficient for complete maturity of the fruit.

No satisfactory means of control are known, but extreme sanitary methods for the elimination of old leaf and cane refuse are the most practical methods suggested.

[7] GROVE, W. B. THE BRITISH RUST FUNGI (UREDINALES) THEIR BIOLOGY AND CLASSIFICATION. p. 299. Cambridge. 1913.