Crop Knowledge Master **Fungi**

Hemileia vastatrix

coffee leaf rust (Plant Disease Pathogen)

Hosts Distribution Symptoms Biology Epidemiology Management Reference

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HOSTS

All *Coffea* species.

DISTRIBUTION

Coffee leaf rust was first reported in 1861 by a British explorer on uncultivated coffee in the Lake Victoria region of Kenya in East Africa. In cultivated coffee, it was reported from Sri Lanka in 1869, and completely devastated coffee production in that country within 10 years. By the 1920s it was widespread in Africa and many of the Asian countries where coffee was grown commercially. It was reported and eradicated from Papua New Guinea three different times, until reported to be widespread there in 1965.

In 1970, the disease was discovered in the Western hemisphere for the first time in the state of Bahia in Brazil . It quickly spread to most of the South and Central American countries, and within 16 years was reported from: Paraguay and Argentina, Nicaragua, Bolivia, Peru and El Salvador, Guatemala and Honduras, Mexico and Ecuador, Colombia and Costa Rica, Venezuela, and Cuba and Jamaica in 1986. Coffee leaf rust does not occur in Hawaii, one of the few coffee growing regions of the world where the disease does not occur.

SYMPTOMS

In addition to coffee leaf rust, this disease has also been referred to as coffee rust and orange leaf rust. The rust organism mainly attacks the leaves and is only rarely found on young stems and fruit. Typically, the disease is recognized by the yellow-orange powdery lesions or spots on the underside of leaves. Initially, very young lesions appear as chlorotic or pale yellow spots before sporulation is evident. These spots vary in size and can coalesce during their development. Since sporulation of this pathogen occurs through the stomata, lesions characterized by the ruptured epidermis of most rusts do not occur, and the lesions are not referred to as pustules.

Damage and Losses:

The damage caused by coffee rust is the result of reduced photosynthetic capacity of infected leaves and premature defoliation or leaf drop associated with high infection levels. Vegetative growth and berry growth and size are reduced and is generally related to the amount of rust in the current year. The impact of rust, however, can have a longer term impact. Leaf rust associated defoliation and the strong carbohydrate sink of the berries cause shoots and roots to starve and consequently to dieback, thereby reducing the number of nodes on which coffee will be produced next year. Since next year's production of coffee occurs on wood produced this season, the tip and shoot dieback caused by the rust can seriously reduce the following season's crop. Researchers have estimated losses caused by rust between 30 and 80% (Kushalappa and Eskes, 1989a,b). On average, however, losses are believed to be about 15% annually.

BIOLOGY

For infection to be successful, free water is required and is usually derived from rain. Spores germinate in 2-4 hours under optimum conditions. After uredospores germinate through germ pores in the spore, appressoria are produced which in turn produces a vesicle from which entry into the substomatal cavity is gained. Within 24-48 hours, infection is completed. The presence of free water is required for infection to be completed. High relative humidities will not substitute for free moisture. If free moisture is absent, exposure to high relative humidity is not sufficient to induce spore germination (Nutman, 1963). Loss of moisture after germination has been initiated inhibits the whole infection process. Recovery does not occur even when adequate moisture is reintroduced (Kushalappa and Eskes, 1989b). Spore germination is better on young leaves than intermediate and old leaves.

As a consequence, disease spread and development is usually limited to the rainy season, and rust incidence is very low during dry periods. The incubation period or time between infection and lesion development is approximately 3-6 weeks long so that the disease is often evident in the drier seasons. Temperature is the most important factor other than moisture to influence germination and subsequent infection by the spores. This is also the most important factor influencing disease development.

This relationship between temperature, moisture, and incubation period has been developed empirically and with the aid of computer modelling used to predict rust severity and to schedule appropriate fungicide applications (Kushalappa and Eskes, 1989a).

On wet leaves, temperature is the most important environmental factor influencing germination and infection. The minimum, optimum, and maximum temperatures on agar was reported to be 15.5, 22, and 28 C. On leaves, minimum and maximum temperatures were slightly lower, 12.5 and 32.5 C, respectively.

After infection is successful, the stomatal cavity is colonized and sporulation will occur. The colonization process is not dependent on leaf wetness, but is influenced greatly by temperature and by the level of host resistance. The main effect of temperature is to determine the length of time for the colonization process (incubation period). Elaborate regression equations have been developed to describe the importance of temperature on this aspect of the disease.

Sporulation or the production of uredspores is most greatly influenced by temperature, moisture, and host resistance. A single lesion produces 4-6 spore crops over a 3-5 month period releasing 300-400,000 spores. Hyperparasitic fungi such as *Verticillium haemiliae* and *V. psalliotae,* are frequently associated with lesions and reduce viability of uredospores significantly. Their use as biological control agents, however, remains underutilized or is impractical.

Factors Influencing Disease Development:

The important factors are planting density, host susceptibility, and predisposition of host due to high prior year yields.

The major cultivars are grown are *Coffea arabica.* Resistance is both complete and partial. Specific resistance genes have been derived from *C. canephora,* and some of the major genes have proven to be quite durable. The most successful use of resistance is exemplified by Catimor and Icatu, varieties with *C. canephora* blood, which have been grown widely in several countries. Partial resistance is known and exemplified with lower disease development rates in Catuai and Mundo Novo and to a lesser extent in Ibaar�.

Disease severity is also correlated with planting density and with berry yield. Generally, the lower the host density, the slower the rate of disease development (Bock, 1962) which in turn were correlated with high and low yields. Variation in host density is also dependent on rust severity in the previous year, as severe rust usually induces severe defoliation (Kushalappa and Lagesse, 1981). The relationship to yield and rust severity is complex. When berries are removed while immature, disease severity reduces to almost half (Monaco, 1977). Plant yield is another factor influencing disease severity. Severity of rust increased with increase in berry yield, due to predisposition of the host. Disease severity was twice as high in high yield branches than in leaves of branches from which berries were removed when young. When berries were removed from the entire plant, disease severity was reduced from 38% to 2%. The higher the yield, the greater was the impact of berry removal on reducing rust incidence.

Race and level of inoculum are the most important pathogen factors influencing disease development. More than 30 races are known, only a few occur regularly with number and pattern of occurrence varying by region. Initial inoculum is the most important inoculum factor influencing disease buildup, and depends on rust severity the previous season, local weather conditions for overwintering, and for early initial establishment of the disease. Survival of inoculum from the previous season depends on disease severity that season and the extent of defoliation during winter months. Secondary inoculum is very important for determining the rate of rust buildup.

Environmental factors:

Rain plays the most important role in disease development. It provides moisture for spore germination and aids in dispersal. Seasonal variation in disease incidence is largely due to variation in rainfall patterns. Temperature also influences rust development. The lower limit for germination is 15 C. At temperature extremes, less than 10 C and greater than 35 C, lesion enlargement is limited (Kushalappa et. al., 1983). Inoculum survival also depends on winter temperature.

EPIDEMIOLOGY

In nature, uredospores are disseminated long distances, largely by wind, and over short distances, by both wind and rain-splash. Outside agents such as animals, mainly insects and man, occasionally have been shown to be involved with dissemination. The movement of rust from one continent to another has been attributed to wind currents and the transport of contaminated seeds and/or other plant material (Kushalappa and Eskes, 1989b) or by man. Uredospores can withstand low temperatures, but are particularly sensitive to desiccation. Because viable uredospores have been recovered from spore traps mounted on airplanes at altitudes around 1000 m in Brazil and Kenya, it is believed that continent to continent movement may have occurred by wind.

Uredospores are released diurnally and is highest at noon or miday. In spore trapping studies, more spores were trapped at 1.25 m, decreasing with increasing heights above ground up to 10 m.

Rain is also an important dispersal agent. It is difficult to assess the comparative importance of rain to wind dissemination, but because of high spore numbers in rain water collected within the canopy, wind blown rain or rain splash is important for within tree and within orchard disease buildup. Rust lesions in the upper portion of trees were fewer and more scattered than higher lesion densities in the lower portion of the tree.

Although uredospores were dispersed by insects, such as thrips, larva of flies, and wasps, their importance in epidemics is considered insignificant. Of the higher animals, man is by far the most important agent for short and long distance movement of the disease with plant material, seeds, seedlings, and uredospores of the pathogen.

MANAGEMENT

NON-CHEMICAL CONTROL

Resistance varies with leaf age, particularly for susceptible varieties, with young leaves more susceptible than older leaves on the same plant. Plants with incomplete resistance, however, usually display the opposite response,with high resistance in young and low resistance in older leaves. Cultivars derived from Timor hybrid and the Icatu cultivar display this pattern (Eskes and da Costa, 1983; Eskes and Toma-Braghini, 1982). Light intensity also influences cultivar reactions. Leaves exposed to high light intensity are generally more susceptible to rust, varying up to 10 fold depending upon pre- and post-inoculation light intensity. It is an important consideration in setting up conditions for rust screening or evaluation.

Overbearing coffee may exacerbate rust intensity (McDonald, 1930; Monaco, 1977). Additionally, leaves supporting rapidly growing coffee berries are more susceptible to infection than leaves that only support vegetative growth. High yielding coffee varieties are more susceptible than low yielding varieties.

Nine genes for resistance have been identified, designate SH1 to SH9. Inheritance patterns are more complex than for dominant gene action alone. Several genes are incompletely dominant, particularly in Icatu and Catimor. Most of these genes were derived from the wild species of coffee, *C. canephora* and *C. liberica* (Rodrigues et. al., 1975). Resistance has been relatively stable and only one new race, obtained by mutation, has been identified since 1975. Production of resistant varieties recently have relied on the use of interspecific hybrids, such as Catimor and Icatu, which contain genes from *C. canephora.* Examples are: mixture or multiline of 44 of F5 lines known as "Colombia", other Catimor selections in Kenya and India, and newer advanced selections and crosses involving Icatu (Kushalappa and Eskes, 1989b).

CHEMICAL CONTROL

Fungicides to control of rust have been used successfully for a quite a number of years. The metallic copper fungicides have been the least expensive and most effective, with copper oxychloride formulations being the best. The dithiocarbamate protectant fungicides have been useful, but their short residual life and instability at higher temperatures and humidity have limited their widespread adoption. Their performance is better when mixed with copper fungicides. The systemic triazole sterol biosynthesis inhibitors have been effective, but high cost and occasional problems with severe defoliation (phytotoxicity) have been observed. Among the systemics, triademifon has been the best so far (Kushalappa and Eskes, 1989a). The systemics have also been particularly effective when used in combination or alternately with copper fungicides, reducing the likelihood for the development of fungicide tolerant rust strains. Occasional problems with defoliation associated with the systemics, and their high cost, however, may limit their usefulness.

Fungicide efficacy depends both on timing of application and complete placement or coverage of the toxicant. This latter factor is important, since redistribution by rain is very limited. Important factors are spray volume, droplet size, and coverage.

In timing the application of fungicides, rainfall was generally the most important factor to consider. Sprays during the rainy season were recommended, and sometimes recommended before the onset of the rainy season. Studies showed that initial inoculum level and berry yield varied greatly from year to year, and it was necessary to include these factors in scheduling fungicide applications. Yield in coffee can vary from maximum to 10% of max yield, depending on cultivar and on the extent of defoliation and yield the previous year, due to rust. Only 2-3 fungicide applications were required during low yield years and 4-6 applications during high yield years (Kushalappa and Eskes, 1989b). These schedules were developed empirically.

Subsequently, forecast models were developed to help with timing fungicide applications. These are described by Kushalappa and Eskes (1989a, 1989b). The grower estimates inoculum producing units as percent leaves or leaf-area diseased, and yield as high or low, at two week intervals. By consulting an inoculum table, the recommendation to spray or not is made. After an application, no further sprays are made for one month, at which time another assessment is made by the grower.

Fungicides used for coffee leaf rust control and some suggested application rates:

Fixed Copper Compounds:

Basic copper sulfate (information not available)

Copper oxychloride (1.5 kg a.i./1000 plants/ha, considered optimum)

Cuprous oxide (1.9-3.0 kg a.i./ha, microgranular formulation best)

Copper hydroxide (information not available)

Dithiocarbamates:

Ferbam (information not available)

Ziram (0.75 l a.i./ha)

Maneb, Manzate (1.6 kg a.i./ha)

Zineb (information not available)

Systemics:

Triademifon (Bayleton) (0.2 - 0.6 kg a.i./1000 plants/ha, may stimulate Coffee Berry Disease; 0.5 - 1.0 kg/1000 plants/ha, for soil applications)

Pyracarbolid (Sicarol) (May provoke severe defoliation)

Oxycarboxyn (Plantvax) (Not as effective as Triademifon)

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NOVEMBER 1991

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