Bud Rot Disease of Coconut—A Reappraisal of Associated Factors

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Abstract

Bud rot disease of coconut caused by *Phytophthora palmivora* (Butl.) Butl. often tends to be fatal. None of the environmental factors associated with the disease was found to be solely responsible for its development. Manifestation of the disease requires a combination of favourable factors, of which high relative humidity and low temperature are the most important factors. Number of "favourable days" determined the incidence and severity of the disease, which in turn was dependent on the monsoon rains. Palms aged 3-20 years exposed to suitable microclimate were the most susceptible.

The role of *Phytophthora palmivora* in the incidence of the disease, the nature of damage, and the possible implication of secondary invaders, such as bacteria in aggravating symptoms have been assessed. Production of oospores in infected tissues suggests the mode of survival of the pathogen in the cabbage of affected palms. Under favourable conditions an infection cycle could be completed in about a week by the pathogen.

Introduction

Bud rot disease of coconut was first observed in Grand Cayman (West Indies) in 1834 (Tucker, 1926). Since then, it has been reported from several coconut growing countries. Intensive work on the etiology of the disease has been carried out from 1902. (Busck, 1902 ; Earle, 1903 ; Butler, 1906 ; Petch, 1906 ; Stockdale, 1907 ; Fredholm, 1909 ; Johnston, 1910, 1911 ; Shaw and Sundararaman, 1914 ; McRae, 1923 ; Sharples, 1925 ; Tucker, 1926 ; Gadd, 1927 ; Ashby, 1929). In India, Butler attributed the disease to *Phytophthora palmivora* which was later confirmed by Shaw and Sundararaman (1914) and McRae (1923). Comparative morphological and pathological studies on *Phytophthora* from coconut, arecanut, cocoa, rubber, and colocasia revealed that they are all *P. palmivora* Butl. (Reinking, 1919 ; Gadd, 1927 ; Ashby, 1929 ; Thomas *et al.*, 1947).

Butler (1910) reported that the disease was closely associated with weather conditions particularly relative humidity. Menon and Pandalai (1959) observed that the disease was more common during the monsoon period and in young and middle aged palms upto 40 years. Thorold (1955), working on black pod of cacao, reported that the activity of *P. palmivora* was dependent on relative humidity ; 95-98% R. H. was required for oospore germination. Short periods of high humidity followed by low temperature and free moisture are conducive to formation of swarmspores, their further development and infectivity of *P. infestans* (Crosier, 1934).

Although sporadic in nature, the disease often tends to be fatal. The seasonal development of the disease and the influence of environmental conditions of *P. palmivora* suggest the need for a closer examination of microclimatic factors contributing to the development of disease. A reappraisal of the etiology of bud rot was also felt necessary to explain the extensive wet rot associated with the disease.

Proceedure

1. Studies on the Meteorological and Microclimatic Factors

Data on rainfall, temperature, and humidity were recorded from meteorological observatories on the west coast and east coast of peninsular India, *i.e.*, Kerala and Tamil Nadu. Data on temperature and relative humidity at the leaf axil level of palms of different ages, 3-5 years, 11-15 yrs, and 16-20 yrs were recorded five times a day using an Assman psychrometer. Since the observations recorded till 1970 indicated that the late forenoon and afternoon readings had no bearing on disease development, subsequent observations were confined to early forenoon only, during 07.30-09.30 hr. Occurrence of the disease was also recorded during the same period.

2. Laboratory Studies

Glucose nitrate medium (Hendrix, 1965) with thiamine HCl (2 ml of 1000 ppm solution/l) was the most favourable medium for isolation of *Phytophthora* among a number of other media tried using antibiotics, rose bengal, gallic acid, cholesterol, etc.

Sporangial suspension prepared from 4-day old cultures of *P. palmivora* isolated from coconut, arecanut, palmyra, oil palm, and rubber in tap water having approximately 1200 sporangia/ml and 3-day old broth cultures of the bacteria *Pseudomonas* sp., *Xanthomonas* sp., and *Erwinia* sp. were used for inoculations. Ten ml inoculum was applied at the leaf axil, as axillary infection was found to exist in nature. Experiments on the pathogen were carried out under controlled conditions at 22-24°C and 95-100% R. H.

Results

Meteorological and Microclimatic Factors

The "favourable days", i.e , days having temperature below 24°C and R. H. above 95% were seen to be related to the total precipitation received and the incidence of disease was directly related to the frequency of "favourable days" (Table 1).

TABLE 1. Rainfall and disease incidence at Kayangulam and Kasaragod (May-August in 1968 and 1969)

Variable	Kayangulam		Kasaragod	
	1968	1969	1968	1969
Rainfall in mm	1955	1118	3561	2053
No. of rainy days	68	55	72	61
No. of favourable days*	84	66	41	33
Disease%	1.8	0.5	1.2	0.1

* See text for explanation

The correlation between meteorological factors, microclimate, and disease incidence was further indicated in the studies (Tables 2 and 3). The influence of favourable environment on the development of disease as related to the age of palms is represented in Tables 4 and 5.

TABLE 2. Meteorological factors and microclimate (May-September) at Kayangulam

Variable	1968	1969	1970	1971	1972
Rainfall in mm	2234	1502	1379	1619	1022
No. of rainy days	89	81	77	63	56
No. of favourable days	13–20	3–6	3–4	7—13	—
Disease incidence %	1.6–5.4	0.3–1.2	Trace	Nil	Nil

TABLE 3. Weather factors, microclimate, and disease incidence at Kayangulam and Kasaragod (1970-71)

Variable	Kayangulam	Kasaragod
Rainfall in mm (SW monsoon)	1379	3568
No. of rainy days	77	89
Minimum temperature	22.5–24.8°C	21.1–21.6°C
Maximum temperature	31.3–33.3°C	29.6–33.6°C
No. of favourable days*	4	15
No. of palms diseased	1	24

* See text for explanation

TABLE 4. No. of favourable days and disease incidence in relation to age of palms (Kayangulam : June, August, 1968-1969)

Age of palms	1968		1969	
	No. of favourable days	% disease incidence	No. of favourable days	% disease incidence
Below 5 years	13	0	3	0
6–10 years	16	1.6	6	1.0
11–15 years	20	3.9	3	1.2
16–20 years	18	5.4	4	0.3
21 years and above	—	—	4	0

TABLE 5. Disease incidence and microclimate in relation to age of palms (1970-71)

Age of palms	Kayangulam		Kasaragod	
	No. of favourable days	Disease incidence (no. of palms)	No. of favourable days	Disease incidence (no. of palms)
3–5 years	3	0	15	0
6–10 years	4	1	13	13
11–15 years	4	0	15	2
16–20 years	3	0	13	4
Above 20 years	4	0	11	5

The data collected at Muthupet (Tamil Nadu in 1970) showed that the microclimatic parameters hardly touch the favourable level during the period. Disease incidence was not also recorded there.

Field observations revealed the incidence of disease at Ratnagiri (Maharashtra) in 31 out of 3000 young palms, where the annual precipitation was 3400 mm. On the contrary, in Saurashtra, the plantations of young palms were free of disease. Here, total pecipitation was about 75 mm.

2. Laboratory Studies

P. palmivora could be isolated from the cabbage of bud rot affected coconuts. The pathogen produces a dry rot, which primarily damages the cabbage. Under favourable environment, secondary wet rot sets in and hastens the deterioration of the cabbage. *Fusarium* sp. and species of bacteria belonging to *Pseudomonas*, *Xanthomonas*, and *Erwinia* were associated with the wet rot. The failure often met with in isolating *P. palmivora* from affected crown is attributed to possible collection of

samples having the wet rot, because *P. palmivora* grows ahead of the wet rot. *P. palmivora* can be easily isolated from tissues affected by dry rot.

In laboratory trials, *P. palmivora* was able to penetrate uninjured tender tissues establishing primary infection. Neither the fungus *Fusarium* sp. nor the bacterial species could do this. However, rotting progressed faster when *P. palmivora* inoculation was followed by bacteria and wet rot.

Under favourable environments in the laboratory, *P. palmivora* infected varieties and hybrids of coconut and young arecanut and oil palm. Similarly, the five isolates of *P. palmivora* infected young coconut palms responded to artificial inoculation (Table 6). Seedlings of Malayan

TABLE 6. Infectivity of *P. palmivora* isolates

Isolate	Coconut		Arecanut		Oil palm	
	Inoculated	Infected	Inoculated	Infected	Inoculated	Infected
Coconut	59	33	4	4	5	3
Rubber	6	4	4	4	3	1
Oil palm	10	6	4	4	3	1
Palmyra	10	8	4	4	5	4
Arecanut	7	6	4	4	3	1

Dwarf and the four hybrids tested, Tall × Dwarf, Dwarf × Tall, Tall × Gangabondam, and Dwarf × Gangabondam, were susceptible.

P. palmivora survives as mycelium or as oospores in infected soil as well as tissues. In trials, it survived for eight weeks as mycelium in steamed soil and tender petiole of coconut which were inoculated with sporangial suspension. Infected petiole was kept buried in steamed soil after inoculation.

Development of oospore has been observed in culture medium as well as infected tissues. Oospores appear within two weeks in the vicinity of tissues cultured for isolation. *P. palmivora* produced oospores when the cultures were contaminated with *Thielaviopsis* sp. Oospores development occurred also in the tissues of tender petiole inoculated by the fungus.

P. palmivora requires six days to complete an infection cycle. On uninjured tender petiole, it produces primary infection within 72 hr. Secondary sporangia are produced in 48 hr and further rotting develops after another 24 hr.

Discussion

The controversial problems of bud rot disease of palms and the identity of the casual agent as *P. palmivora* (Butl.) were accepted at international level in 1924. In India, following the report of Butler in 1906 on this

disease, Shaw and Sundararaman (1914), McRae (1923), and Sundararaman (1924) proved the pathogenicity of *P. palmivora* on coconut, arecanut, and palmyra palms. Yet, the many unsuccessful efforts to isolate the pathogen from coconut and the occurrence of wet rot associated with the disease suggested the need for determining the role of *P. palmivora* and that of other pathogens in the incidence of disease. The fact that isolations from the basal parts of naturally infected palms exhibiting only dry rot yield *P. palmivora*, whereas tissues affected by wet rot harbour mainly bacteria and *Fusarium* sp. indicates that *P. palmivora* plays the primary role in bud rot with bacteria occurring as secondary invader in the injured and weakened tissue. Failure of bacteria to initiate rotting and its effect on aggravating rotting initiated by *P. palmivora* are considered suggestive of the secondary role of bacteria in contributing towards the final breakdown of the host.

Bud rot disease of coconut is season-bound and can be classified as a rain-favoured disease. Its outbreaks can be well correlated with periods of rain (Keitt and Jones, 1926). The observations made on the influence of microclimate in the development of bud rot are in line with those of Crosier (1934) and Kyron (1967) in the case of potato blight and of Hicks (1967) in pod rot of cacao, both caused by *Phytophthora* sp. Crosier (1934) showed that relative humidity and temperature are the two cardinal factors that determine sporulation, germination, and infection in the potato late blight. Laboratory trials with *P. palmivora* have shown that it requires neary a week from the time of inoculation as sporangial suspension to complete one cycle, i.e., for the production of secondary sporangia. Several such cycles are required for the onset of the disease to enable the pathogen to penetrate the thickly set whorls of leaves and reach the bud region from the foci of infection. The disease has been seen to develop in a minimum period of five weeks after inoculation under controlled conditions, and in the field, after the break of south-west monsoon. Under field conditions, inoculation of 5—7 years old palms caused infection which penetrated to the upper and lower parts of the crown. However, this failed to cause the disease as the post inoculation period was not favourable for the activity of the pathogen.

Production of oospores in single spore culture of *P. palmivora* in synthetic culture when contaminated with *Thielaviopsis* sp. has its parallel in the observation of Brasier (1971, 1972) that sexual reproduction could be induced in *P. palmivora* in the presence of *Trichoderma viridae*. Development of oospores in artificially inoculated and infected palm tissues perhaps suggests the bisexual nature of the organism, due to the involvement of secondary invaders and possible chemical stimulation. Nevertheless, the occurrence of oospores can serve as potential inoculum for a pathogen which is highly dependent on weather factors.

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Discussions

Thomas : You have suggested that microclimate plays a great role in the incidence of bud rot. If so, will wider spacing be of any help to counter this condition ?

Radha : Premonsoon spraying will provide protection.

Sarma Y.R. : 1. Is there any correlation between sporangial production at the crown region on the so called 'conducive microclimate' for disease development ?

2. Is there any spatial separation of fungal and bacterial infection at crown region (wet rot and dry rot) ?

Radha : 1. Yes

2. Again yes. Bacterial infection follows the fungal and causes wet rot resulting in collapse of tissue and inhibition of the fungus.

Pattanshetti : If the incidence of the disease bud rot of coconut, is high during monsoon, is it possible to forecast the occurrence of the disease after taking into consideration important factors of weather ? Are there effective preventive measures for the disease ? If the preventive measures are adopted timely, is it possible to induce cent per cent protection to the palms ?

Radha : More extensive studies are to be made for forecasting the disease. With the existing facilities in our methodological observations it is possible to forecast the weather factors for only 48 hrs and this period is not sufficient for adopting prophylactic treatments.

Ninan : Dr. Radha, have you observed any varietal difference in the incidence of infection by this pathogen ?

Radha : No, but only WCT, Dwarfs, any hybrids have been tested.

Rangaswami : 1. What are the bacteria involved and do they act as secondary pathogens causing spot rot ?

2. What is the percentage incidence of the disease ? Is there any information available on the endemic occurrence of the disease in different parts of India ?

Radha : 1. *Erdisina*, *Pseudomonas*, and *Xanthomonas*.

2. Survey has been conducted in only Kerala. The incidence varies from 2 to 40% and the average is 2-3% only. A high incidence (of upto 40%) has been observed only in rare instances and is confined to one or two gardens.