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LEAF ROT DISEASE

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Leaf rot of coconut assumes importance as it brings about considerable economic loss in association with root (wilt) disease. Perhaps, it is the unwholesome appearance of the leaf rot diseased palm that heralds to the farmer the onset of root (wilt) disease. From the nature of the development of leaf rot and the control achieved through fungicidal treatment, the malady could well be attributed to fungal etiology.

Leaf rot disease of coconut presumably was in existence in the erstwhile states of Travancore and Cochin since 1880s (Menon, 1935; Menon and Nair, 1948, 1952). Varghese (1934) observed that leaf disease of coconut occurred along with the root disease and generally the same palm showed the symptoms of both diseases. Radha and Lal (1968) reported close relationship between occurrence of leaf rot and root (wilt) disease in the field as well as in inoculation trials. They also found development of leaf rot on palms with and without primary infection by root (wilt) disease. However, the latter group of palms exhibited root (wilt) symptoms within 5 months of the infection by leaf rot. Based on the observation of Nagaraj and Menon (1956), Radha and Lal (1968) concluded that these palms had root (wilt) disease latently facilitating secondary infection by leaf rot. According to Menon and Nair (1948) leaf rot appeared in Kanayannur, Mattancherry, Kumbalangi, Thrippunithura and Ernakulam in the erstwhile Cochin State and Kayangulam, Amabalapuzha, Thiruvalla, Changanacherry and Meenachil in the erstwhile Travancore State. There was a disease zone having boundaries between Ochenthuruthu and Thodupuzha in the north and Quilon and Punalur in the south. Within this area, the leaf rot occurred in different intensities. It has been found to flourish with the same degree of intensity on palms growing on hill top, in the plains and in littoral sandy tracts between the sea and backwaters. Radha and Lal (1968) observed that nearly 16 to 40 per cent of the palms in the root (wilt) affected area developed leaf rot and its intensity varied in different types of soil. Menon and Nair (1948) and Menon and Pandalai (1959) observed leaf rot disease on palms of all ages and it generally flourished on palms below 25 years of age. It does not attack seedlings in the nursery. Intensity of the disease increased with age of the palms and the advancement of root (wilt) disease (Radha and Lal, 1968).

'The coconut palm disease of Travancore' (root (wilt) is locally known as 'Kattu' (wind) and it is generally believed that the disease spreads along the direction of the wind (Menon and Nair, 1951). Spread of the leaf rot disease is aerial. Menon and Nair (1952) found that

the spores of the fungus (*Helminthosporium halodes* = *Bipolaris halodes* (Drechs.) Shoemaker) are blown about in the wind. Fungal spores encapsulated in the droplets of dew or rain water land on the susceptible tender leaves of the coconut palms, adhere to the cuticle, germinate and produce infection in the healthy palms (Menon and Pandalai, 1959).

Information on the loss due to leaf rot disease alone is not available as it is generally associated with root (wilt) disease. However, Menon and Nair (1948) estimated the loss at Rs. 5.6 million annually. Having an annual loss to the range of 10 to 30 per cent its average was worked out to be 20 per cent of the total. This is besides the loss in quality of the leaves rendering them unfit for thatching and other purposes. Applying the above criteria the loss due to the leaf rot may be computed at present as 461 million nuts annually as the area affected by the disease in Kerala extends to 0.41 million hectares (Anon., 1985b).

Fungal spores enveloped in drops of dew or rain water adhere to the cuticle of the tender leaflets and germinate within24 hours producing tiny brown spots. These enlarge and coalesce affecting all the tender portions of the leaflets. The rotting may advance to some extent into the interior of the spindle. When the spindle grows the rotten portions dry up, turn black in the dry weather and break off due to wind. The development of the symptoms may be at the distal portions of the leaflets or intermittently on the leaves (Fig. 1). Hardening of the tissues in the maturing leaflets generally slows down the progress of the lesions towards the base of the leaflet so that the basal portions of the affected leaflets remain without the symptoms. This causes the characteristic fan-like appearance of the affected leaves. Ends of these leaflets including the midrib may appear black and shrivelled. There are instances when the tips of leaflets fail to split while the base of the

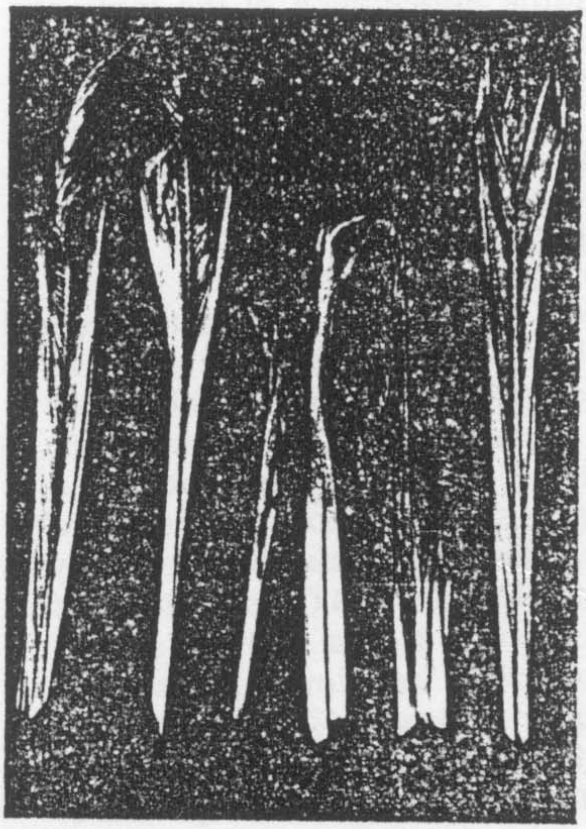

Fig. 1 Sequence of development of symptoms on the spindle leaf. On the extreme right is an unaffected spindle leaf. Arranged R-L are the diseased leaves in the order of increasing symptoms. 1-3 show rotting at the distal ends. 4 has rotting, blackening and drying at the distal portion. 5 has rotting, blackening and drying at the distal end as well or intermittently.

leaflets opens up, due to maturing (Fig. 2). If unhindered, the symptoms would appear on each successive spindle thereby causing development of symptoms on all the leaves of the affected palm (Fig. 3).

Generally the symptoms manifest on the spindle leaves. In severe cases the rotten portions on drying might adhere together preventing the spindle from opening up. The severity of the disease is more pronounced on the tender leaves.

The yield decreases considerably consequent on the reduction in the total area. The leaf rot disease is not fatal, but as the disease progresses the palm steadily declines and becomes unproductive. The disease is most severe during the monsoons and it is observed on trees of all ages (Menon and Nair, 1948, 1951; Menon and Pandalai, 1959).

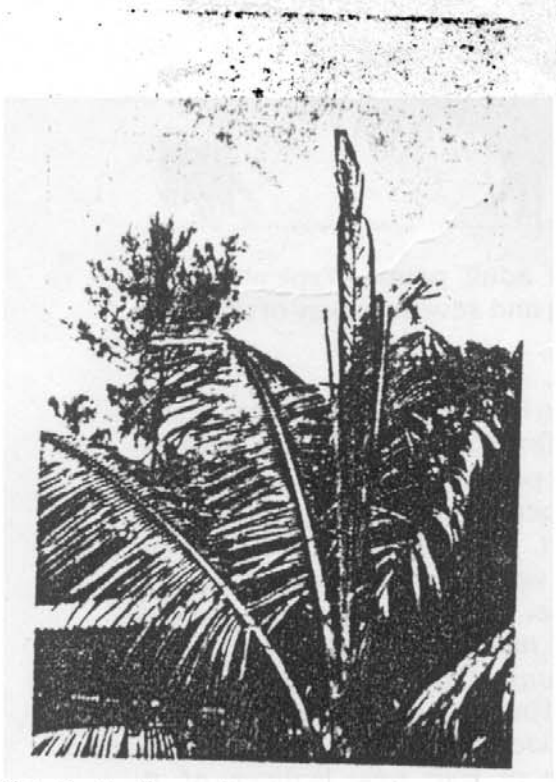

Fig. 2 Rotten spindle of an affected palm is seen in the middle. Affected adjacent young leaf is partially open with the ends of its leaflets adhering together exhibiting a fish-bone appearance.

McRae (1916) and Sundararaman (1925) isolated a salmon coloured Penicillium like fungus from diseased leaves in Cochin. *Helminthosporium halodes*, *Gloeosporium* sp. *Curvularia* sp., *Diplodia* sp., *Gliocladium roseum*, *Pestalotia* sp. and *Fusarium* sp. were isolated from the diseased leaves, besides a large number of saprophytic fungi (Menon and Nair, 1948; Anon., 1985a). Isolation of *H. halodes* from coconut leaves in Kasaragod, a root (wilt) free area having stray incidence of leaf rot was reported by Radha and Lal (1968). They interpreted that the fungus can infect leaves under favourable climatic conditions, eventhough the host is not infected primarily by root (wilt) disease. A genus of nematode, *Panagrolaimus* Fuchs was found on leaf tissues of palms affected by diseases including leaf rot (Nadakal, 1968).

With the aid of aeroscope, Menon and Nair (1948, 1952) were able to collect spores of *H. halodes*, *Gloeosporium* sp., *G. roseum* and *Pestalotia* sp. from 12 m height in Kayangulam. Radha and Lal (1968) reported trapping of *H. halodes*, exposing microscope slides at Kasaragod. Vertical cylinder method also helped in the collection of fungi like *B. halodes* and species of *Aspergillus*, *Cladosporium*, *Colletotrichum*, *Curvularia*, *Diplodia*, *Fusarium*, *Mastigosporium*, *Mucor*, *Spermospora* and *Thielaviopsis* in

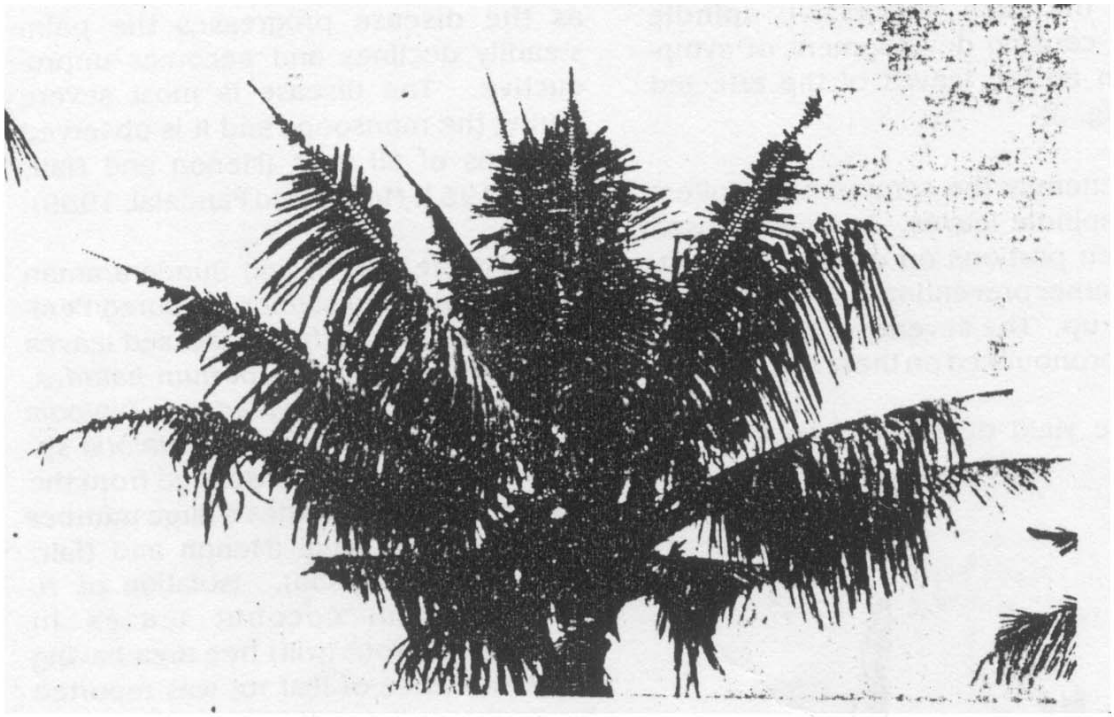

Fig. 3 Symptoms on all the leaves of an affected adult palm. Typical fan-like appearance of the leaves due to rotting, drying and severing away of the distal ends of the leaflets is evident.

Kayangulam (Anon, 1983). Largest number of spores was present in the atmosphere during May-August (Menon and Nair, 1952; Anon, 1985a).

Studies on the pathogenicity of the fungi were initiated by Menon and Nair (1948, 1951). Inoculating bits of tender leaves and leaflets of matured leaves with spore suspensions of *H. halodes*, *Gloeosporium* sp., *G. roseum* and *Pestalotia* sp. *in vitro*, they found that *H. halodes* induced infection within 12 hours and the rest in 48 hours. Infection was least with *Pestalotia*. They considered *H. halodes* as the most virulent and the rest only as secondary parasites aggravating the rotting initiated by *H. halodes*. Test *in vivo* confirmed these findlings, and established pathogenecity using single and mixed inocula. Among the single culture inocula *H. halodes* incited 84 per cent infection which was the highest, while it was 93 per cent with the combined cultures of *H. halodes*, *Gloeosporium* sp. and *Gliocladium* sp. (Tables 1 and 2). Radha and Lal (1968) confirmed the infectivity of *B. halodes* on coconut. Comparative infectivity of four new isolates of *B. halodes* from Kayangulam did not show any difference in their virulence (Anon., 1979).

Leaf rot infection was found to be

Table 1. Results of inoculation experiments on palms (After Menon and Nair, 1951).

Inoculum	No. of trees inoculated	No. of trees infected	% of infection
Helminthosporium sp.	260	218	83.8
Controls	260	-	-
Gloeosporium sp.	155	87	56.1
Controls	155	-	-
Gliocladium sp.	174	91	52.3
Controls	174	-	-
Pestalotia sp.	44	11	25.0
Controls	44	-	-
Fusarium sp.	40	-	-
Controls	40	-	-

Table 2. Results of inoculation experiments on trees using spores of the three fungi in combination (After Menon and Nair, 1951).

Inoculum	No. of trees inoculated	No. of trees infected	% of infection
Helminthosporium sp. and *Gloeosporium* sp.	58	46	79.3
Controls	58	0	0
Helminthosporium sp. and *Gliocladium* sp.	63	51	81.0
Controls	63	0	0
Gloeosporium sp. and *Gliocladium* sp.	48	13	27.1
Controls	48	0	0
Helminthosporium sp., *Gliocladium* sp. and *Gloeosporium* sp.	45	41	91.1
Controls	45	0	0

the most severe during the seasons when atmospheric humidity was at its maximum (Menon and Nair, 1951). Severity of leaf infection with *H. halodes*, *Gloeosporium* sp. and *G. roseum* was found correlated with high humidity and low temperatures prevalent during the monsoon period (Radha, Sukumaran and Prasannakumari, 1961). It was observed that low night temperature and moisture on leaf surface either due to dew or precipitation also favoured fungal infection. Monthly records of observations for three years revealed that period of high

atmospheric humidity and low temperature are favourable for natural development of leaf rot disease (Radha and Lal, 1968).

Examination of tender leaves of healthy and leaf rot diseased palms showed no significant difference in the contents of amino nitrogen, ascorbic acid, total phenols and total sugars (Table 3). Silica content was higher in the diseased leaves (Anon. 1976). There was no qualitative difference among the sugars (Anon, 1983). Lily (1963) recorded higher contents of moisture, N, P, K, Ca, Mg and non-protein N in the tender leaves and suggested that the same supported infection by *H. halodes*.

Culture filtrate of *H. halodes* when tested on tender leaves of coconut failed to demonstrate any toxic effect (Anon. 1981). Maximum growth of *H. halodes* was observed in Oat-meal agar and *Gloeosporium* sp. in Brown's agar. Optimum growth of the fungi was at pH 7. *H. halodes* tolerated copper sulphate upto 0.3%, *Gloeosporium* sp. to 0.35% and *G. roseum* to 0.2% concentration. Mercuric chloride and phenol were lethal at all levels. Thermal death point of *H. halodes* was 60°C and for *Gloeosporium* sp. and *for G. roseum* it was 55°C (Menon and Nair, 1951). Culture filtrate of *Bacillus subtillis* at 2% concentration inhibited growth of *H. halodes* in pure culture (Lily, Radha and Menon, 1955).

Attempts at controlling leaf rot disease were started as early as in 1951 by Menon and Nair. Among the fungicides tested, Bordeaux mixture was the most effective.

A manuring-cum-spraying trial conducted at Kayangulam during 1951-'56 demonstrated the beneficial effect of regular application of organics and inorganics and quarterly application of Bordeaux mixture every year (Nair and Radha, 1959).

In vitro studies on the effect of different copper fungicides on the mycelial growth and spore germination of *H. halodes* (Prasannakumari, Radha and Kurian, 1960) showed that Bordeaux mixture completely inhibited mycelial growth at 0.3% level.

Menon and Nair (1952) conducted spraying trials in the field using 1.0% and 0.5% of Bordeaux mixture against leaf rot. Half strength of Bordeaux mixture was almost as good as the full strength. Bordeaux mixture, Shell copper, Kirti copper and Fytolan were sprayed on the foliage to study their effect on leaf rot

Table 3. Contents of certain biochemical components in the tender leaves of healthy and leaf rot diseased palms.

Biochemical component	Healthy	Diseased	Reference
Amino nitrogen	270-610 µg	315-590 µg	Anon., 1984
Ascorbic acid	172-280mg	143-281 mg	Anon., 1982
Total phenol	66-105 mg	124-216 mg	Anon., 1982
Total sugars	0.31-0.63%	0.41-0.83%	Anon., 1981.

(Anon. 1963). Bordeaux mixture reduced the intensity of the disease to the extent of 74.5%, Kirti copper 65.6% and Fytolan 59.6%. Diseased palms in alluvial, laterite and sandy loam were treated with Bordeaux mixture 1%, Dithane M45, 0.2% and Cuman. 0.4% with and without manuring (Anon. 1970). Although application of manure alone increased the nut yield by 4, there was hardly any reduction of the disease. Bordeaux mixture application coupled with manuring gave the highest control (50%). By regular spraying, intensity of leaf rot could be brought down from 40.2 to 7.8% during the period from 1976 to 1981.

Basal application of the systemic fungicides (Actidione, Bavistin, Benlate and MBC) at the rate of 4 g per healthy palm twice a year failed to prevent incidence of leaf rot (Anon. 1983). Complete control of leaf rot was not noticed by spraying 10 diseased palms each thrice an year for three years with Bavistin, 0.1%, Bordeaux mixture 1%, Difolatan, 0.3% and 0.5%; FM spray, 0.3%; FM spray formula 55, 0.3%; Fytolan (acidic), 0.3%, Fytolan (neutral), 0.3% and Kitazin, 0.3% (Anon, 1982). However, application of Bordeaux mixture, Fytolan (acidic) and Fytolan (neutral) reduced the intensity to 76.6%, 68% and 66% respectively.

Four sequential sprayings of Bordeaux mixture, 1% Dithane M45, 0.3% and Fytolan, 0.5% on 1610 leaf rot diseased palms in farmers' gardens during 1982-'84 in the order given, resulted in 87.8 per cent control of the disease. Sequential spraying of Bordeaux mixture 1%; Fytolan, 0.3% and Dithane M45, 0.3%, on 5701 leaf rot affected palms once an year for four years in farmers' gardens under Operational Research Project, resulted in the control on 2774 (48.7%) palms.

George and Samraj (1966) reported that coconut palms affected by leaf rot responded favourably to application of boric acid, suggesting boron deficiency as the factor responsible for development of the disease. Foliar application of boron (575 ppm), manganese (783 ppm), zinc (1136 ppm), copper (127 ppm), iron (1000 ppm) and molybdenum (540 ppm) was done four times annually. All the treatments except boron reduced leaf rot infection (Radha, 1965).

Gregory (1960) felt that aerial spraying of oil based copper fungicide in Vadayar and Malankara Estates was useful in controlling leaf rot. It provided good coverage to the foliage. However, Samraj, Pally and Cheeran (1966) observed that the spray fluid did not adequately protect the spindle leaf. Two other aerial spraying trials were carried out in January and August 1968 in Vypeen island, using oil based copper fungicides viz. Oleocopper and Fycol-8 (Anon. 1970). The spraying in January was effective in decreasing the disease incidence considerably while the one in August did not give positive result.

Studying resistance of palms to leaf rot, Radha (1961) observed that Andaman Ordinary and New Guinea were more resistant than others tested.

Leaf rot disease of coconut with a history of over a century manifests superimposed on about 16-40 per cent of the root (wilt) disease affected palms, chiefly in the eight southern districts of Kerala. A fungal etiology for the syndrome has well been established. This is

also in the face of unsuccessful attempts at ameliorating the damage through exclusive manurial, especially micronutrient application. Yet there are vistas demanding emergent attention. Present practice of controlling leaf rot through manual application of contact fungicides at the susceptible site is exorbitantly expensive. Knowledge of systemic fungicides inhibitory to the pathogen and developing means to introduce them harmlessly are needs of the time. Exploring resistance or tolerance against the disease is yet another gap to be bridged.

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