Leaf Rot Disease of Coconut

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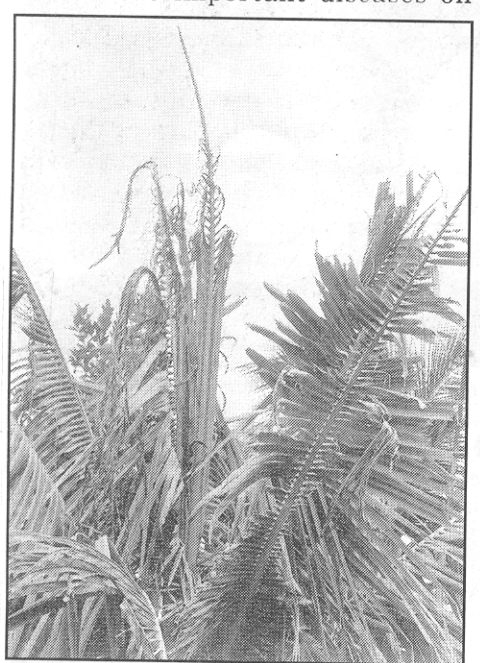
Coconut is the most useful tropical palm grown in India as a traditional plantation crop for the last 3000 years especially along the coasts of India. It is intimately related to the economic, social and cultural life of a vast multitude of small and marginal coconut growers. Every part of the coconut tree is used for some purpose or the other. On account of this, it is called 'Kalpavriksha' or the "Tree of heaven" - the tree that provides all the necessities of life. India ranks first both in terms of production and productivity and third in area among the coconut producing countries of the world (1997). The palm is affected by a number of diseases and pests, some of which are fatal while others, reduce its vigour resulting in economic loss. Eight hundred and thirty insects and mites, 173 fungi and 78 species of nematodes have been found to be associated with coconut (Anon, 1979). Only a few of them cause serious damage to the crop. In India, the root (wilt), tatipaka, thanjavur wilt, stem bleeding and bud rot are the important diseases on coconut. The low productivity of coconut in Kerala is mainly due to the prevalence of root (wilt) disease.



Leaf rot disease affected palm

The occurrence of root (wilt) disease of coconut was first noticed in 1882 in Erattupetta area of Meenachil Taluk in Kottayam District (Butler 1908, Pillai 1911, Menon and Pandalai, 1958). Around 1907 the disease was reported from Kaviyoor and Kalloopara areas of Tiruvalla Taluk and later from Kayangulam of Karthikappally Taluk. The disease which appeared simultaneously in the above foci began to spread to adjoining areas (Varghese, 1934). In later years a number of attempts were made to determine the extent of spread and intensity of the disease (Menon & Nair, 1951, Varghese, 1959; Pillai *et. al.* 1973; George *et. al.*, 1979; Pillai *et. al.*, 1980).

A comprehensive survey was undertaken by the Central Plantation Crops Research Institute in collaboration with the Department of Agriculture, Kerala and other agencies in 1984/85 to estimate the area of spread, intensity of the disease and production loss due to the disease (Anon, 1985a). The survey showed that the disease was prevalent in more or less contiguously in 4,10,000 ha in eight southern districts of Kerala. The intensity of the disease in both bearing and non-bearing palms was highest in Kottayam district (75.6%) followed by Alappuzha (70.7%). In the northern district of Thrissur the incidence was 2.6% and in the southern district of Thiruvananthapuram it was 1.5 percent. The survey also revealed sparse and sporadic occurrence of the disease in the districts of Palakkad, Malappuram, Kozhikode and Kannur. Recently it was reported from Kasaragod district (Solomon. J.J. 1999, Personal Communication). The incidence of the disease was also reported from the adjoining areas of Tamil Nadu such as Shenkotta, Coimbatore, Cumbam, Pollachi and Kulasekharam.

The survey revealed that the annual loss due to the root (wilt) disease was 968 million nuts in Kerala. Loss of husk per nut was 25.8 percent and loss of copra and oil per nut was 9.08 and 11.3 percent respectively. Sixty percent of the leaves were found damaged due to the malady. Mathew *et. al.* (1993) reported decline in yield to the tune of 45 percent in West Coast Tall variety and 60 percent in DxT hybrids and delayed onset of bearing in seedlings that took up the infection.

Information on the loss due to leaf rot disease alone is not available or not possible to estimate since it is always associated with root (wilt). The loss due to leaf rot was computed and estimated to be 461 million nuts annually (Joseph & Rawther, 1991).

Butler (1908) referred to it as "root disease' probably due to the rotting of roots noticed by him in the affected palms. He briefly described the symptoms on unopened spindle, but did not report any pathogen from the affected leaflets. McRae (1916) and Sundararaman (1925) called it the leaf rot disease, Menon (1935) as the coconut leaf disease and Menon and Nair (1948) as the leaf rot disease of coconut. Nagaraj and Menon (1955) felt that the name wilt would be more appropriate taking into account the nature of foliar symptoms. Subsequently the disease came to be known as root (wilt) disease (Shanta *et. al.*, 1960; Mathen *et. al.*, 1983). The non lethal, slow spreading and debilitating nature of the disease, gradual decline in yield, amelioration of symptoms and economic returns with management practices, and total absence of wilt symptoms in the leaves or roots clearly indicate that the name

root (wilt) is a misnomer that gives wrong impression about the symptoms of the disease in the minds of the readers. Keeping these points in view, the name COCONUT DECLINE was suggested by Dr. M. S. Swaminathan in 1976 in his inaugural address of the International Symposium on Coconut Research and Development at CPCRI Kasaragod, Kerala.

Root (wilt) disease minus leaf rot is not a disease of much economic importance, Radha & Lal (1968) reported close relationship between leaf rot and root (wilt) disease in the field as well in inoculation trials. Leaf rot was found to develop on palms without root (wilt) also, probably because these plants had latent infection. They observed that nearly 16-40% of the palms in the root (wilt) affected area developed leaf rot. Varghese (1934) reported that both leaf disease and root disease occurred together on the same palm. Srinivasan (1991) reported that leaf rot disease gets superimposed on 65 percent of root (wilt) affected palms. Menon & Nair (1948) and Menon & Pandalai (1958) observed leaf rot disease on palms of all ages. It does not attack seedlings in the nursery. Almost every root (wilt) affected palm gets leaf rot disease. In certain cases it may occur quickly but in certain palms it may take even 5 or 7 years depending upon the genetic make up, age of the palm, nutritional status of soil, irrigation, etc.

Leaf rot is seen to occur within 10 months of field planting of one year old seedling. The rotting of the spear leaf is always the first symptom to appear in seedlings but this has not been reported as such in the past. Flaccidity, yellowing and necrosis occur later on these seedlings. Normally farmers identify a palm to be root (wilt) affected only when leaf rot sets in. Flaccidity and marginal necrosis of leaflets are not easily recognised by the farmers especially in the early stages.

The coconut palm disease of Travancore is locally known as Kattuveezcha (which means transmitted by wind) spreads along the direction of the wind (Menon & Nair 1951). Spread of the leaf rot disease is aerial. Menon & Nair 1952 collected the spores of the fungus *Helminthosporium halodes (bipolaris halodes)* at a height of 12 m at Kayangulam in aerospore studies.

Symptoms

Fungal spores enveloped in dew-drops or rain water adhere to the cuticle of the tender whitish leaflets and germinate within 24 hrs producing tiny spots of various colours and shapes. These water soaked lesions enlarge, coalesce freely leading to extensive rotting. The rotting may advance into the interior of the spindle. When the spindle grows the rotten portions dry up, turn black, break and get blown off in the wind. The development of the symptoms and rotting is severe at the distal end of the leaf specially 1 to 1.50 m in length. On leaflets also the distal ends are more susceptible. Occurrence of intermittent rotting of leaflets and mid ribs on the same leaf is also seen. In many cases, the rotten distal portions of leaflet adhere to each other from top to bottom on both sides thereby giving a fish bone appearance. On drying these drop off.

Dwivedi *et. al.* (1979) reported whitening and softening of leaflets of the spindle as an important symptom of root (wilt) disease. The leaflets of the spindle of healthy palms are green at the margin and the remaining portion of leaflets is creamy to yellowish or yellowish green whereas in diseased palms the leaflets of spindle are white, devoid of chlorophyll and the margins are pale green. When the leaflets open they are weak and do not have the strength to stand straight. Such white leaflets show large number of orange to brown spots and marginal rotting.

Hardening of the tissues and development of chlorophyll in the maturing leaflets generally slows down the progress of rotting towards the base of the leaflets so that the basal portions of the affected leaflets remain green and normal giving a fan like appearance. Normally the symptoms would appear on each successive spindle thereby showing symptoms on all leaves but the disease is never fatal. In the early stages of the disease some spindles escape rotting during summer months. Severity of leaf rot symptom is more during monsoons and trees of all ages are susceptible and during summer months the leaflets show more of dry rot. The disease causes drastic reduction in photosynthetic area which in turn causes reduction in yield.

In some palms the distal ends of leaves at the 4th or 5th position from the spindle, curl (1-1.5 m below the leaf tip), break, hang down, become yellow, dry and drop off. Such palms show many such leaves in a crown without leaf tip and leaf rot is not very severe on such palms in the early stages. About 15-20 per cent of the most susceptible area for leaf rot at the distal end is broken and dropped off. Later these palms develop typical leaf rot symptoms.

Sudden appearance of bright yellowing of 3-4 leaves in the middle whorl, followed by appearance of large number of brown spots of various shapes with a halo around on all leaflets of yellowed leaves is the first symptom of root (wilt) in certain cases and is known as midwhorl yellowing (Menon, 1935). In the beginning, the yellowing is sometimes restricted from the leaf tips to the middle of the leaf. Shedding of buttons, immature nuts and inflorescence necrosis are the other prominent symptoms in these palms. These yellowed leaves dry up faster and shed when leaves of lower whorls remain green. Yellowing is very bright and conspicuous in the variety Chowghat Orange Dwarf, their segregants and even in their hybrids and more incidence of mid whorl yellowing is seen in this variety. These mid whorl yellowed palms invariably develop rotting of spear leaf subsequently. Incidence of leaf rot can

be prevented by treating these palms against leaf rot immediately after the appearance of yellowing. However, inflorescence necrosis and total button shedding continue to occur for 6-12 months even after treatment. Application of 50g borax along with the fungicide to the crown or 250 g to the basin was found helpful in faster recovery of affected palms (Koshy, personal observation).

Inflorescence necrosis, lack of ability to produce female flowers and pollen sterility render the root (wilt) affected palm unproductive (Varghese, 1934, Varkey and Davis 1960). The extent of decline in yield is 43% in disease early and 74% in disease advanced as compared to disease free palms (Anon, 1985a). Shedding of immature nuts even before the appearance of other visual symptoms or after is another important character.

Rotting of spear leaf (spindle) is the first symptom to appear in seedlings below the age of 5 years and this symptom is expressed in some cases within 10 months, after planting of one year old seedlings in the field.

Etiology

Mc Rae (1916) and Sunderaraman (1925) isolated a *Penicillium* like fungus from diseased leaves in Kochi. *Helminthosporium halodes (Bipolaris halodes) Gleosporium* sp, *Curvularia* sp *Gliocladium roseum, Pestalotia* sp and *Fusarium* sp were isolated from the diseased leaves (Menon and Nair 1948, Anon, 1985). Srinivasan and Gunasekharan (1993) reported isolation and identification by IMI of CAB, UK of the following species viz. *Colletotrichum gleosporioides, Exserohilum rostratum, Gliocladium vermoeseni, Cylindrocladium scoparaium, Fusarium solani, F. moniliformae var. intermedium. Thielaviopsis paradoxa, Rhizoctonia solani, Mortierella elongata, Curvularia* sp, *Acremonium* sp, *Thielavia microspora, T. terricola,* and *Chaetomium brasiliense.*

Studies on the pathogenicity of the fungi were initiated by Menon and Nair (1948, 1951).Inoculating bits of tender leaves and leaflets of mature leaves with spore suspensions of *H. halodes, Gleosporium* sp., *G. roseum* and *Pestalotia* sp. in vitro, they found that *H. halodes* induces infection within 12 hr and the rest in 48 hr. They considered *H. halodes* as the most virulent and the rest only as secondary parasites, aggravating the rotting initiated by *H. halodes.* They confirmed these findings through *in vitro* tests and established the pathogenicity of *H. halodes* using single and mixed inocula. Later Radha and Lal (1968) also confirmed the infectivity of *B. halodes* on coconut. Culture filtrate of *H. halodes* when applied on tender leaves of coconut failed to demonstrate any toxic effect (Anon. 1981). The pathogenicity of *C. gleosporioides, E. rostratum, G. vermoeseni, F. solani, F. moniliformae* var *intermedium, T. paradoxa, R. solani, Mortierella elongata* and *Curvularia* sp was established by Srinivasan and Gunasekharan (1996a).

The leaf rot affected spindle leaf is also colonised by mealy bugs, mites, nematodes, etc. (Nadakkal, 1965). Individual or collective role played by them as aggravators or synergists or as disseminating agents of the disease to the next spindle is to be studied. The leaf rot affected palms are more prone to red palm weevil infestation. Nematodes such as *Aphelenchoides aligarhiensis, Panagrolaimus rigidus* and *Rhabditis* sp. in large numbers are found associated with rotting spindles (Koshy, unpublished). Application of systemic insecticide that has nematicidal property (Phorate-10 G) alongwith fungicide was found to give better protection against leaf rot and other insects pests. (Koshy, Unpublished).

Epidemiology

Leaf rot infection was found to be more severe during the seasons when atmospheric humidity was at its maximum (Menon and Nair, 1951). Severity of leaf infection with *H. halodes, Gleosporium* sp and *G. roseum* was found correlated with high humidity and low temperature prevalent during the monsoon period (Radha *et. al., 1961*). 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). The incidence of *C. gleosporioides* in LRD infected young palms was consistent and significantly higher than *E. rostratum* (Anon, 1996). *C. gleosporioides* is the fungus isolated most commonly during the monsoon and observed on early lesions and is strongly correlated with rainfall, relative humidty and negatively with maximum temperature and hours of sunshine. More of *Fusarium* spp. were isolated during the dry seasons, January to March (Srinivasan and Gunasekharan, 1996c).

Disease Management

It is leaf rot which is responsible for the reduction in photosynthetic area, disfiguration of the palm and reduction in yield. Therefore, an easy, effective and economic control for leaf rot is the most important factor in root (wilt) disease management. Ideally an inflorescence is to be produced from every leaf axil in coconut. The number of female flowers, setting per cent, number and size of nuts, quantity of copra, oil content etc. are directly dependent on the health of the leaf that produced the inflorescence. Hence, the role of the leaf that produced the inflorescence is equivalent to or more than that of the boot leaf of wheat or rice. From the studies conducted earlier it is very clear that a number of fungi are associated with leaf rot but most of them belong to the group Fungi imperfecti. Contact and systemic fungicides are effective against all these fungi rerpoted in association with leaf rot. Earlier field trials using the contact fungicides had given excellent results.

Menon and Nair (1952) conducted spraying in the field using 1.0% and 0.5% bordeaux mixture against leaf rot. Half strength was almost as good as the full strength bordeaux mixture In a fungicidal trial using copper fungicides it was found that bordeaux mixture reduced the intensity by 74.5% followed by Kirti Copper 65.6% and Fytolan 59.6% (Anon, 1963). Gregory (1960) felt that aerial spraying in Vadayar and Malankara estates was useful in controlling leaf rot, but Samaraj *et. al.* (1966) observed that there was no adequate coverage of the spray fluid on the spindle leaf. George and Samraj (1966) reported that coconut palms affected by leaf rot responded favourably to foliar application of boron suggesting boron deficiency as the factor responsible for development of disease. Prophylactic basal application of systemic fungicides (Acitidione, Bavistin, Benlate and MBC) at the rate of 4g per healthy palms twice a year failed to prevent incidence of leaf rot (Anon, 1983). Four sequential spraying of bordeaux mixture 1%, Dithane M 45 0.3% and Fytolan 0.5% on leaf rot affected palms in farmers' gardens resulted in the control of the disease (Anon, 1985b). Srinivasan and Gunasekharan (1996b) reported moderate impact of pouring of calixin and spraying of Indofil M-45 in the control of leaf rot when applied thrice a year, for three years continuously.

In the management of leaf rot the role of the photosynthetic area available in every leaf and its contribution to yield is the most important factor to be considered. The second is the labour requirement for the operation. Difficulty in getting the services of climbers in time of need and the prohibitive cost are the other limiting factors. The fact that the white, soft, achlorophyllus leaflets of spindle alone are susceptible to fungal attack, suggests that the spindle alone is to be protected. The rhinoceros beetle also attacks only the spear leaf. Though the earlier recommendation of sequential spraying of bordeaux mixture 1%, dithane M-45 0.3% and fytolan 0.5% on leaf rot affected palms using rocker sprayer (6 labour) and separate application of BHC 10% or sevidol 8G for the control of rhinoceros beetle three times a year (3 labour) is effective, farmers had not adopted because of the very high requirement of 9 skilled labours (6+3) and the cumbersome spraying involved. Therefore, the need for a simpler, environment-friendly and less labour intensive method combining the application of fungicide and insecticide, without the aid of a sprayer was keenly felt. A series of field trials conducted over a period of three years by the author using various fungicides, bactericides and insecticides having contact and systemic properties led to the development of a very effective, economic, environment friendly and easy method as detailed below.

1. Contaf - 5 EC (Hexaconazole) 2ml per palm	Rs. 1.20
or	
Dithane - M45 or Indofil - M45-3g per palm	Rs. 0.70
2. Phorate - 10G 20 gm/ palm	Rs. 1.10
3. Climbing charges for treatment along with harvest	Rs. 5.00
Total	Rs. 7.30 or 6.80

Frequency : Twice a year in April - May & October - November

Mode of application

1. Cut and remove rotten portions of only the spindle and the adjacent two innermost fully opened leaves.
2. Dissolve either of the fungicides in 300 ml water and pour into the cavity around the base of the spindle leaf.
3. Apply 20g Phorate - 10G - mixed in 200 gm sand around the base of the spindle leaf.
4. Treat all palms in the garden (healthy and diseased).
5. Treatment should not be carried out during rainy days.
6. Palms in the early stages of disease will recover totally (100%) with two or three applications. Palms in the advanced stages (with an index of more than 50%) would take 3 years to recover fully. To prevent the recurrence of the disease the treatment needs to be continued.
7. Residue analysis done for the chemicals, contaf-5EC, Dithane - M45 and Phorate - 10 G in mature and tender nuts shows that the nut water, kernel, coconut oil and coconut cake are free from residues after 45 days of application at the rates suggested above (Koshy, unpublished).

The advantages of the method are:

1. Pouring of fungicides is more effective and target specific since it is applied directly on to the susceptible, white, non-chlorophyllous soft leaflets of spindle resulting in better protection.
2. The cumbersome spraying and the need of a sprayer is avoided.
3. The quantity of spray fluid is reduced from 3000 ml to 300 ml.
4. By removing the rotten portions of spindle and the adjacent two leaves the fungal spore load that would become otherwise available to the next, very tender, susceptible, upcoming spindle gets reduced considerably.
5. All the available chlorophyll area is retained by not cutting and removing the older leaves that had leaf rot infection earlier.
6. The leaf rot affected spindle leaf is also colonised by mealy bugs, mites, nematodes etc. The leaf rot disease affected palms are more prone to red palm weevil infestation. Application of a systemic insecticide that has nematicidal property (Phorate - 10G) along with fungicide was found

to protect from infestation of rhinoceros beetle, red palm weevil, coreid bug, ash weevil, mealy bugs and nematodes.

7. Instead of separate quarterly spraying of fungicide (6 labour) and leaf axil filling of insecticide (3 labour) both can be applied together, two times in a year (April-May and October-November) saving 88 per cent labour cost.

8. The cost of two applications will work out to be Rs. 14.60 when Contaf - 5EC is used and Rs. 13.60 when Dithane - M 45 is used compared to separate quarterly applications of fungicides and insecticides costing Rs. 79 (Rs. 50 + Rs. 29) per palm per year.

9. The combined application of insecticide and fungicide did not affect the effectiveness of each other.

10. Other operations such as harvesting and tying of bunches can be combined with this in May and November to reduce the labour cost.

11. The same treatment may be given to all unaffected healthy palms also twice a year as a prophylactic measure.

12. The mid whorl yellowing affected palm succumbs to leaf rot and inflorescence necrosis within two months of the appearance of initial symptoms of yellowing, immature nut fall and abnormal button shedding. Combined application of fungicides, Contaf - 5 EC - 4 ml or dithane/Indofil - M45 - 3g in 300 ml water and systemic insecticide Phorate - 10G - 20g mixed in 200 g sand per palm immediately after the appearance of the initial yellowing symptoms can protect the palm from the incidence of leaf rot. The treatment needs to be repeated twice a year. Though the inflorescence necrosis disappears with one or two treatment the female flowers produced on subsequent inflorescences are small and shed quickly for another 6-12 months. (Koshy unpublished).

Initial studies have shown that the systemic fungicide, Contaf - 5 EC (Hexaconazole) gets absorbed on feeding through cut ends of functional main roots of palms of all ages. No adverse effect was noticed in 5 palms each treated with 2, 4, 6, 10 and 20ml per palm. The fungicide was also absorbed when fed through the stem @ 5, 10 and 20 ml per palm to five palms each. Another systemic fungicide Tilt-25EC (Propyconazole) was also applied @ 2 and 4 ml per palm to the crown and 5, 10 and 20ml through root feeding and stem infection. The treated palms did not exhibit any phytotoxicity. All palms absorbed the fungicide in 24 - 48 hrs even on rainy days. The leaves of disease control with these treatments are being evaluated. In view of the difficulty in getting climbers for application of fungicides particularly during monsoon, the results of application of fungicides through stem injection and root feeding will be of immense value to coconut farmers. (Koshy, Unpublished)

Antagonistic activity of *Pseudomonas fluorescence* against *C. gleosporioides* and *E. rostratum* is being tested in vitro (Anon, 1999). The bacteria *P. fluorescence* and *Bacillus subtilis* was multiplied on neem and marotti oil cake and applied around the base of the leaf rot affected spindle leaf @ 250gm/palm twice a year did not give encouraging results (Koshy, Unpublished).

Radha (1961) reported high degree of resistance to leaf rot in Andaman Ordinary and New guinea varieties under field conditions. The resistance observed in Kenthali against root (wilt) disease and burrowing nematode which is a very serious problem in root (wilt) prevalent areas should be taken into consideration in future breeding programmes for resistance. Mathai (1988) also reported high degree of resistance to root (wilt) and leaf rot disease by Andaman Ordinary. Even after 40 years no action has been taken to make use of this information. Being an indigenous cultivar seednuts of this could have been introduced in large scale into Kerala for planting in root (wilt) prevalent districts. Because, the cultivar Andaman Ordinary is at par or even slightly better than WCT in terms of yield of nuts, copra and oil content. Even now the situation can be corrected by giving high priority for this. The tolerance to root (wilt) in Chowghat Green Dwarf and its crosses with tolerant WCT of disease endemic areas is also very encouraging. Though a certain percentage of them (maximum of 30%) are susceptible to leaf rot they respond quickly to management practices and recover faster from leaf rot and continue to give good yield. Thus the tolerance observed in Andaman ordinary, New guinea, Kenthali, and CGD cultivars and in individual palms of WCT, COD and CGD of disease endemic areas and their crosses should be made use of at the earliest.

The farmers identify a palm to be diseased only when leaf rot occurs and rotting of spindle is the first symptom to appear in seedlings. Coconut seedlings take up infection early when they are planted in the same pits after uprooting the diseased palms or under planted in gardens affected by leaf rot disease. On treatment of leaf rot affected palms with the new treatment suggested above, yellowing, marginal necrosis of leaflets and inflorescence necrosis disappear. Considerable increase in per cent set and yield also takes place. This gives an impression that yellowing, marginal necrosis of leaflets, inflorescence necrosis and softening and whitening of leaflets of spear leaf are probably the early symptoms of leaf rot. The present trend of investigations by separating root (wilt) disease as a predisposing disease for leaf rot may not be correct and over emphasis of research efforts to find out the cause of root (wilt) disease in the past had only led to many controversies, wrong conclusions and

public criticisms. It is only leaf rot that causes economic damage which can be cured as well as prevented and an effective, simple and cheap method of management for leaf rot is the only answer to the root (wilt) disease. Farmers in root (wilt) prevalent areas of Kerala and Tamil Nadu will stand benefited only by researches on breeding for tolerance/resistance to leaf rot disease and by research on field control of leaf rot which has never been given the due attention that it deserved. As such more research efforts in future should be directed towards management of leaf rot disease by taking into consideration the following:- (1) the unopened, white, soft leaflets of spindle alone are susceptible and they become resistant on development of chlorophyll. (2) Palms in early stages of the disease respond very quickly to treatment (3) the palms in advanced stages (above 70% index) of leaf rot do not respond to treatments quickly. (4) all palms in disease prevalent areas irrespective of their health status need to be treated for curative and prophylactic action continuously (twice a year). (5) difficulty in getting the services of climbers in time and the prohibited cost involved. (6) the cost benefit ratio and (7) environment pollution and residual toxicity in nuts. if any, due to treatment of palms treated with systemic fungicides and insecticides.

I am sure the treatment suggested above for leaf rot will be very effective against spear rot of oil palm and arecanut yellows that exist in Kerala, since the fungi and other organisms associated with leaf rot and spear rot are the same. Here again, more research efforts should be concentrated immediately on field control of spear rot and yellow leaf disease. In a new area, the arecanut yellows always appear first and coconut leaf rot appears later, many times after 10-15 years, which was also mentioned by Butler (1908) in his report.

Future Thrust Areas of Research

1. Popularisation of the simple, effective and cheap integrated management method given above for leaf rot disease and insect pests developed recently, through the Departments of Agriculture, Kerala and Tamil Nadu and mass media like news paper, radio, television and agricultural magazines.
2. Development of easy methods by which systemic fungicides can be administered through root feeding/ stem injection avoiding the employment of climbers.
3. Development of a simple and fast method for determining the susceptible/resistant nature in seedlings to leaf rot disease before planting.
4. Use of tolerance available in certain varieties like Andaman Ordinary, New Guinea, Kenthali, and CGD and individual palms of WCT, CGD and COD of disease endemic areas for production of hybrids because of their early response to management practices in terms of quick recovery and yield. Large scale introduction of seednuts of the tolerant cultivar Andaman Ordinary for planting in the root (wilt) disease prevalent districts of Kerala and Tamil Nadu.
5. Use of modern molecular methods in the investigation of leaf rot disease such as identification of resistance linked markers in seedlings and development of diagnostic PCR tests for the various associated fungi.
6. Studies on the biochemical nature of tolerant/resistant and leaf rot affected palms of the disease endemic areas.
7. Development of serodiagnostic tests for the detection of important fungi such as *Exserohilum rostratum, Colletotrichum gleosporioides, Fusarium solani* and *Fusarium moniliformae* var. *intermedium* in coconut seedlings.
8. Development of environment friendly control methods using bioagents/plant products.
9. Studies on the role of mealy bugs, nematodes, bacteria, mites etc. found associated with the rotting spindle.

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