

DISEASES OF ARECANUT IN INDIA— A REVIEW AND FURTHER CONSIDERATIONS*

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ABSTRACT

The major diseases affecting arecanut in India are: koleroga or mahali, anabe, yellow leaf disease, inflorescence die-back, and button shedding. Among the less serious diseases, the bud-rot, bacterial leaf stripe, stem breaking, seedling diseases, and infection of processed arecanuts, occurs at times in serious proportions in some places and cause considerable damage. Over 40 pathogenic and non-pathogenic forms have been recorded in India. The work done on them except the storage infections is reviewed here with suggestions for future lines of work.

INTRODUCTION

Arecanut or betelnut palm (*Areca catechu* L.) is affected by a number of diseases during different stages of its growth and development. About 20 diseases, reportedly associated with 40 pathogenic and non-pathogenic forms, have been recorded in India in different degrees of intensity. However, based on the extent of damage and nature of disease, the koleroga, anabe, yellow leaf disease, inflorescence die-back, and button shedding are considered to be the major diseases. Among the less serious ones, the bud rot, bacterial leaf stripe, stem breaking, seedling diseases, and infection of processed arecanuts are important. Some of these at times occur epiphytotically in localised places and cause heavy losses.

The literature on arecanut diseases is widely scattered. No attempt has been made so far to bring together and update the know-

ledge on these diseases. The present review is an attempt to bridge this gap and suggest future lines of work to tackle the diseases more effectively.

1. Koleroga, Mahali, or Fruit rot caused by *Phytophthora arecae* (Coleman) Pethybridge

It was first recorded by Butler (1906). It occurs in severe form in heavy rainfall areas (Coleman, 1910; Anstead, 1924; Kamat, 1953; Dorasami, 1956; Mundkur, 1967; Seshadri and Rawther, 1968; Singh, 1973). Detailed surveys have not been made to estimate the loss due to this disease. However, an annual loss of 10-75% in parts of Karnataka and Kerala States, or total destruction of crop in individual gardens (Coleman, 1910; Thomas, 1937; Nambiar, 1956; Anonymous, 1960a), have been recorded. Coleman and Venkata Rao (1918)

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estimated an annual loss of Rs. 4 lakhs in Malnad region (Karnataka) alone.

Symptoms appear as water-soaked lesions on the surface of affected nuts and extend to give dark appearance to fruits. They then drop down from the bunches. A felt of white mycelial mass develops on the fallen nuts (Coleman, 1910; Shaw, 1913; Venkata Rao, 1915, 1919; Gokhale et al., 1955; Patel and Nagaraja Rao, 1958; Sannegowda, 1961; Anonymous, 1969 a, b; Nambiar, 1971; Rangaswami, 1972). As the disease advances, the fruit stalks and axis of inflorescence are also affected (Sundaraman and Ramakrishnan, 1924). Affected nuts are lighter in weight and possess large vacuoles and dark brown radial strands internally. Late infections occurring from August result in drying up of nuts which stick to bunches (Marudarajan, 1950a). These nuts are often affected by saprophytes like *Gloeosporium* sp. and are locally called "dry Mahali" in central Kerala. The decreased susceptibility of nuts to disease with increased maturity (Anonymous, 1962a, 1963a) may be probably due to prevalence of unfavourable weather factors at the time of maturity.

In general, the disease occurs during the south-west Monsoon period (June-September) in Karnataka and Kerala. While heavy rainfall with constant high humid conditions (Narasimhan, 1922, Venkata Rao, 1925) and an alternation of sunshine and rain (Coleman, 1910) are conducive to disease development, the heavy rain and wind (Nambiar, 1956), and to a certain extent, insects and small birds (Coleman, 1910) facilitate its spread. It is pertinent to note that this period is also marked by low temperature (20-23°C).

The pathogen was first named as *Phytophthora omnivora* de Bary by Sydow and Butler (1907). Later, Coleman (1910) called it as *P. omnivora* var. *arecae*, and Butler (1918) considered it as *P. arecae* (Coleman) Pethybridge. Mycelial characters (Coleman, 1910), growth media (Leonian, 1925; Tucker,

1931), and spore dimensions (Rosenbaun, 1917; Gadd, 1927; Leonian and Geer, 1929; Thomas et al., 1947) of this fungus have been extensively studied. Some investigators (Narasimhan, 1932; Ramakrishnan, 1954; Ramakrishnan and Seethalakshmi, 1956a) have reported that the fungus was homothallic, others such as Ashby (1929), Narasimhan (1930, 1931a), Venkatarayan (1932), Uppal and Desai (1939), and Marudarajan (1941) claimed that it was heterothallic. The fungus produces oospores on inoculated arecanuts and on *Cereus formosus* and *Clarkia elegans* (Coleman, 1910). It is antagonised by *Trichoderma lignorum* (Thomas, 1939).

Various bushes and trees, notably coconut (McRae, 1924), *Bryophyllum calycinum* (Narasimhan, 1926, 1927), *Colocasia*, *Ficus*, citrus, jack, sandal wood, mango, rubber (Ramakrishnan and Seethalakshmi, 1956b) and *Agave* (Peregrine, 1969) can harbour the pathogen. The fungus can also infect brinjal seedlings (Coleman, 1910), potato tubers (Rosenbaun, 1914), apple fruits, and very young tomato (Tucker, 1931).

The practice of covering areca bunches with areca leaf sheath (*kotte* or *karada* in the local language) neither prevent nor eradicate the disease (Anonymous, 1954, 1956a; Krishnamurthy, 1955; Nagaraja Rao, 1960). Coleman (1910) was the first to recommend spraying of 1% Bordeaux mixture with resin washing soda as an adhesive to control the disease. Various workers have tested the efficacy of different adhesives and spreaders with Bordeaux mixture with good results. Casein (Narasimhan, 1923, 1924; Venkata Rao, 1926, 1927), potash alum (Narasimhan, 1928a, b, 1931b; Venkata Rao, 1929), and vegetable oils (Narasimhan, 1934b, 1935; Thomas, 1938; Thomas and Marudarajan, 1938, 1952; Patel and Nagaraja Rao, 1958) added to Bordeaux mixture protect the arecanut palms against mahali. However, Bordeaux mixture, without any adhesive, has

also been reported to be equally effective in controlling the disease (Venkatarayan, 1943; Marudarajan and Kalyana Subramaniam, 1948, 1952; Marudarajan, 1950*a, b*, 1952), and therefore, prophylactic sprayings with Bordeaux mixture alone, two-three times a year, has been recommended and is now being practised extensively (Nambiar, 1956; Anonymous, 1956*a*, 1967).

A number of other chemicals have also been tested against the pathogen. Among them, the mercurised copper oxychloride and blitane inhibited fungal growth in nutrient media (Rawther, 1969) whereas nickel chloride had no effect (Anonymous, 1964*a*). Though successful control of koleroga with copper oxychlorides was achieved by some workers (Anonymous, 1956*b*, 1960*b*, 1962*b*), others got contradictory results with the same treatment (Thomas, 1938; Uppal, 1942).

Phytosanitary measures are to be adopted by removing and destroying the fallen nuts, diseased bunches, tree tops, etc. (Coleman, 1915; Anonymous, 1926). Alternate hosts of *P. arecae* such as colocasia and other bushy plants and trees must be eliminated from the vicinity of the gardens. Above all, it is worthwhile to develop efficient forecasting systems for different agroclimatic conditions in all attempts to curb the disease.

Radha Menon (Nayar) (1959*a*) reported that besides *P. arecae*, organisms such as *Dimerosporina arecae*, *Erwinia* sp., *Stemcnites* sp., and *Glomerella cingulata* infect the arecanuts and cause soft rots to different degrees. She recommended spraying of 1-2% Bordeaux mixture to control them.

2. Bud rot caused by *Phytophthora arecae* (Coleman) Pethybridge.

Bud rot was first reported from heavy rainfall tracts of Karnataka (Nambiar, 1949; Anonymous, 1951, 1960*c*, 1962*d*; Lingaraj, 1969) and Assam (Sen, 1930; Nambiar, 1952). An annual loss of 1% or more was

recorded by Coleman (1910). However, heavy crop losses (Dorasami, 1956) in endemic areas are not uncommon.

In the affected palms, the colour of the spindle changes from the natural light green to yellow and then to brownish. It later slumps. Infection spreads to successive whorls of undeveloped leaves, which rot rapidly. As the disease spreads inside the bud, the growing point of the stem also rots resulting in the death of the palm. The outer whorl of leaves then becomes yellow, droops, down, and drop off one by one leaving the stem bare. Secondary organisms enter the rotting bud and make it into a slimy mass which would emit a fetid odour (Coleman, 1910; Anonymous, 1954).

Rawther and Nambiar (1970) and Sarma and Murthy (1971) in their studies on crown rot in Assam observed *Thielaviopsis paradoxa*, whereas Rai (unpublished) recorded *Phytophthora* sp. Naidu (1960) reported falsely that a bacterium caused drying of heart leaf in young palms (also Anonymous, 1960*d*).

Plantations in low-lying areas or those sheltered by thick belts of trees or covered heavily with intercrops resulting in high humid conditions are more severely affected. Though, it generally occurs during monsoon season, the infection taking place during November onwards, becomes severe in succeeding dry months (Marudarajan, 1950*b*).

Control measures included prophylactic drenching of the crown with 1% Bordeaux mixture (Anonymous, 1969*a*; Lingaraj, 1969), or 0.1% Ceresan wet or lytosol. Infected tissues of bud may be scooped off and treated with Bordeaux paste. Overcrowding of palms, which may create high humidity in the gardens, should be avoided. Removal and destruction of dead palms and also arecanut bunches affected by mahali, and spraying the surrounding healthy palms will go a long way in minimising the incidence of the disease.

3. **Anabe roga** or **Foot rot** caused by *Ganoderma lucidum* (Leys) Karst.

This was first recorded by Watt (1909). It occurs chiefly in the *maidan*, and semi-*malnad* areas of Karnataka (Coleman, 1911; Venkata Rao, 1917; Venkatarayan, 1935, 1937, 1952; Anonymous, 1961*a, b*; Naidu et al., 1966), in parts of Tamil Nadu, Kerala, and Assam (Anonymous, 1960*b*), Bengal (Sharples, 1928), and in Nicobar Islands (Sangal et al., 1961). In the Mettupalayam area of Tamil Nadu, the annual disease incidence has been estimated to be 0.05-5.10% [Radhakrishnan(Nair) et al., 1971]. The death rate in Karnataka has been estimated to be 1-8% (Naidu et al., 1966) to 12-15% (Venkatarayan, 1936). Butler (1906) recorded 94% mortality in a neglected garden.

The first symptom to appear is discoloration of leaflets of outer whorl of leaves which gradually spread from there. The crown gradually assumes a dull yellow colour as it would appear under drought conditions. It then dries up, and leaves fall off leaving the trunk bare. The base of the stem shows brown discoloration and oozing of a dark fluid. The roots are brittle, discoloured, and dry. Sporophores of the fungus develop at the base of stem in an advanced stage or on stumps left in the field after cutting the diseased palm (Venkatarayan, 1929, 1949).

The disease is severe in neglected, ill-drained, and over-crowded gardens (Venkatarayan, 1952), in hard, black loamy, and acid soils, and in soils of higher iron and lower calcium contents (Lalitha Kumari, 1969). Palms of over 5-10 years age are more prone to infection (Coleman and Venkata Rao, 1918; Nambiar, 1956). The disease is primarily soil-borne and spreads secondarily through air-borne spores.

The fungus grows well on a number of synthetic and non-synthetic media [Radha Menon(Nayar), 1963*a*; Nambiar et al.,

1971; Nambiar and Radhakrishnan (Nair), 1972, 1973]. It can grow at a pH range of 2-9 with the best growth occurring between 4.5-6.5 (Venkatarayan, 1952; Lalitha Kumari, 1969). The fungus secretes a number of hydrolytic enzymes into the culture medium (Schmitz, 1919-20; Venkatarayan, 1936). It is heterothallic and tetrapolar (Banerjee and Sarkar, 1958).

The fungus has wide host range. The sporophores have been recorded on mango (Bose, 1930,1931), stem pieces of arecanut (Venkatarayan, 1936), casuarina (Banerjee and Sarkar, 1956), cassia and tamarind [Nambiar and Radhakrishnan (Nair), 1971], and in PDA with biotin (Anonymous, 1963*b*), saw dust with 10% malt extract [Radhakrishnan (Nair), and Saraswathy, 1973], and Waksman's liquid medium [Nambiar and Radhakrishnan (Nair), 1973]. Sporophores contain three types of spores (Banerjee and Sarkar, 1959). These spores germinate on a number of media (Sen Gupta, 1943; Sarkar, 1959). Rao (1957) has recorded insecticidal property in kerosine oil extracts of the sporophores.

Inoculation of areca palms with *G. lucidum* does not always induce the disease (Narasimhan, 1934*a*). The fungus has been observed to be infective on *Phyllanthus* sp. and *Acanthospermum* sp. (Radhakrishnan Nair and Saraswathy, 1974).

Since the disease is primarily soil-borne, its prevention is better than cure. Fresh planting of arecanut should be avoided in cleared jungle containing dead stumps. Also, fruiting bodies of the fungus and dead stumps of diseased palms should be removed along with major portion of roots (Venkatarayan, 1935; Venkatakrishnan, 1956) and destroyed by burning. The drainage should be improved, overcrowding avoided, and clean cultivation of gardens adopted (Venkatarayan, 1952). Planting of susceptible trees such as *Delonix regia*, *Pongamia glabra*, *Cassia siamea* etc. in the

vicinity of gardens should be discouraged.

When once the disease appears, its spread to neighbouring palms should be prevented by digging deep trenches all round the affected palm (Anonymous, 1956a) and growing *Euphorbia* sp. around it (Naidu et al., 1966).

A large number of chemicals have been tried against the fungus/disease with varied results. Though sulphur was reported to be effective in controlling the disease by some workers (Narasimhan, 1940; Nambiar, 1956), other investigators found it to be ineffective [Nair and Rao, 1965; Nambiar and Radhakrishnan (Nair), 1972]. The important chemicals reported to be effective are mercurised copper oxychloride (Nair and Rao, 1965), cycloheximide (Lalitha Kumari, 1969), difolatan, vitavax, and aureofungin sol [Nambiar and Radhakrishnan (Nair), 1973; Koti Reddy et al., 1976; Koti Reddy and Saraswathy, 1976].

It is also known that *Trichoderma* sp., *Bacillus coagulans*, *Streptomyces* sp., and *Mucor* sp. are antagonistic towards *G. lucidum* [Anonymous, 1963b, 1967; Radha Menon (Nayar), 1963a]. A thorough investigation on soil microflora of healthy and various stages of diseased palms will give additional information on potential antagonists. Efforts should then be diverted to enhance their activity in the root zone and explore the possibility of biological control of the pathogen. Inoculation of dead plant stumps with fast growing organisms such as *Peniophora gigantea*, *Ascocaryne sarcooides* may help in preventing the spread of disease to nearby healthy palms. However, investigations on these lines are lacking. Above all, biochemical and serological tests may be developed for rapid detection of the disease in its early stages of development.

4. Inflorescence die-back and button shedding caused by *Colletotrichum gloeosporioides* Penz. (Stonem) Spauld and Schrenk.

This malady occurs widely (Saraswathy,

et al. 1977). Symptoms appear as yellowing of rachille which turn dark brown, and is followed by shedding of female flowers (buttons). Fructifications of the fungus develop on the rachis and shed buttons (Anonymous, 1961e).

Many agents/factors have been reported to be associated with this malady. However, *Gloeosporium* was being constantly isolated from the fallen buttons as well as rachis (Thomas, 1938; Anonymous, 1961c; Nagaraja Rao, 1965; Murthy et al., 1971; Radhakrishnan Nair and Nambiar, 1971). Saraswathy, Reddy and Nair (1977) found *Colletotrichum gloeosporioides* was pathogenic to the rachis and that over 70% of shed buttons had the fungus. Murthy et al. (1971) suggested that lack of pollination, association of insects and fungi, moisture stress, and imbalanced nutrition were the probable causes of the malady.

Assisted pollination (Raghavan and Baruah, 1956; Shama Bhat, 1963), spraying growth regulators (Anonymous, 1964a; Bavappa, 1969) and application of wood ash (Saidalikutty, 1951) or heavy doses of NPK (100:40:150 kg/ha) to soil (Radhakrishnan Nair, unpublished) reduce button shedding to a certain extent. Copper fungicides like shell copper, coppesan, and Bordeaux mixture, either individually or in combination with an insecticide endrex (Anonymous, 1964c) as well as zineb, DMOC, and aureofungin sol (Saraswathy et al. 1975) have been reported to be effective in reducing shedding. Besides the above, timely and judicious irrigation will be essential to reduce water stress if any in the host plant.

5. Yellow leaf disease

Its aetiology is unknown. This malady was first reported from Moovattupuzha and Meenachal taluks of Kerala state in 1914 (Nambiar, 1949). Since then, it has been recorded in a serious form from many parts of Kerala, coastal regions of Bombay,

parts of Karnataka, and Tamil Nadu [Nāmbiar and Srinivasan, 1951; Radha Menon (Nayar), 1962a, 1963b; Srinivasan et al., 1970; Yadava, Mathai, and Vellaichamy, 1973]. The loss due to the disease has been estimated at 20% in parts of Karnataka (Dastagir, 1963). Mohapatra, Bhat, and Devaraju (1975) recorded the disease in 5% of plantations in south Kerala and Chickmagalore district of Karnataka. A survey in 1959-60 revealed wide-spread occurrence of disease in Kerala (Anonymous, 1960b). The CPCRI has just concluded a comprehensive survey of Kerala and Karnataka to study the extent and severity of the malady (Annual Report, CPCRI, 1976, pp. 283). Its results will be reported shortly. A comprehensive review of this malady has been recently published in *Arecanut & Spices Bulletin* (Vol. 8, No. 2, 1976).

The malady is characterised primarily by yellowing of leaves of affected palms. In advanced stages, leaves become smaller and closely bunched. Production of roots is reduced, and the tips and absorbing portions of young roots become dark and gradually rot. Nuts become reduced in size and fall prematurely (Anonymous, 1971; Abraham, et al., 1971; Rawther, 1976). A number of indigenous and exotic collections of arecanut were susceptible to the disease at Palode (Rawther, 1976). Extensive degeneration of phloem [Radha Menon (Nayar), 1968; Radha Nayar (Menon), 1971, 1976] and tyloses in xylem vessels of older leaves (Nair and Aravindakshan, 1970) are the other manifestations of this malady.

The etiology of the disease is yet to be established. Water logging, acidity, and nutritional disorders have been reported to be probable causes of the malady (Anonymous, 1961d; Dastagir, 1963; Velappan, 1969; Rawther et al., 1976). Fungi isolated from leaves [Radha Menon (Nayar), 1959b; Radha Menon (Nayar) and Kalyanikutty, 1961; Anonymous, 1963b], and roots (Anony-

mous, 1969a), bacterio (Srivastava et al., 1970; Anonymous, 1975), as well as nematodes (Koshy et al., 1976) obtained from the root region, when inoculated, have not so far reproduced the symptoms. The mean population of fungi, bacteria, and actinomycetes in the root zone was higher than in healthy palms (Anonymous, 1964b). Radha Menon (Nayar) (1960, 1961) recorded an active ribonucleoprotein from the leaves of diseased plants. The same author (1963b) also reported sap transmission of the disease, but the symptoms produced were not typical of yellow leaf disease. Other investigators could not transmit the disease by sap (Anonymous, 1967) or by spindle bug, mealy bug, or mites [Radha Menon (Nayar), 1963b; Anonymous, 1969a]. Recently, Radha Nayar (Menon) (1976) reported culturing of mycoplasma-like organisms (MLO) from diseased leaves but could not confirm that MLO were responsible for the yellow leaf disease.

Various workers have suggested different measures to reduce the intensity of malady and increase the yields. They include manuring the garden adequately with NPK and lime, improving the drainage, and other cultural operations and adopting proper plant protection measures (Dastagir, 1963; Anonymous, 1975).

Even though there is no effective curative measure at present for the malady, yields of diseased gardens can be increased considerably by adopting proper management practices by monitoring the diseased palms. It will be better to remove and destroy palms in advanced stages of disease. Inter or mixed cropping with crops like legumes, forage grasses, cacao, etc., and also mixed farming in areca gardens will at least give additional income to the farmers in these affected gardens.

6. Band or Hidimundige

Its aetiology is also uncertain. This was first recorded during 1889-1890 (Joshi and

Joshi, 1952). It occurs in parts of south Maharashtra and North Kanara, Karnataka.

Diseased palms produce smaller, dark green, and crinkled leaves. Their crowns exhibit cabbage-like appearance in the later stages. Their stems become tapered, inflorescence small, and malformed, and roots poorly developed (Kibe et al., 1957; Patel and Nagaraja Rao, 1958).

The disease is prevalent in water-logged, soils. Environmental factors (Coleman, 1910), poor drainage, and low soil fertility (Gokhale et al., 1916; Daji, 1948; Nambiar, 1951) have been reported as possible causes of the disease.

The attribution of the disease to *Aphelenchus coccophilus* infestation (Thirumalachar, 1946) was rebutted in later studies (Venkatarayan, 1946). No fungus, virus or insect is now considered to be responsible for the malady (Anonymous, 1951).

Improving the drainage (Kibe et al., 1957), removing hard pan formation in the soil, foliar application of micronutrients (Patel and Nagaraja Rao, 1958), soil application of NPK manures (Anonymous, 1962a), correction of soil acidity and also incorporation of mixture of CuSO₄ and lime or ZnSO₄ (Nagaraja Rao, 1960; Anonymous, 1961c) have been reported to check the disease intensity.

Since etiology of this malady is still elusive, further detailed studies are warranted.

7. Stem breaking

This is more an abnormality than a disease. It is generally seen in palms bordering the southern and western sides of the gardens.

Yellow patches, turning to dark brown with longitudinal cracks, develop on the stem (Venkatarayan, 1955). Subsequent infection by saprophytic fungi (Narasimhan, 1933; Anonymous, 1957) weakens the stem and can easily break even in small winds.

This malady is said to be primarily due to

sun scorching (Anonymous, 1953b, 1962c, 1963c, 1964d).

Stem breaking can be reduced by trailing plants along the stem, raising rapidly growing trees on the outskirts of garden (Govindankutty Kurup, 1955) and by protecting the trunk with a cover of dry leaves (Shama Bhat et al., 1956). Reinforcing the cracked portion with split areca stem is partially successful in preventing stem breaking due to wind (Anonymous, 1957). A suitable alignment of the plantings to get a filtered shade in the garden (Ishwara Bhat, 1965) will also minimise the incidence of this malady (Shama Bhat et al., 1969, 1970; Somaiah and Khader, 1971).

8. Nut splitting

This is mentioned as *anduodakka roga* in Karnataka and *achikeeral* in Kerala (Nambiar, 1949). Its causes are also uncertain.

Symptoms appear as premature yellowing followed by splitting of nuts at the ends longitudinally and exposing the kernel (Bavappa and Sahadevan, 1952).

Sudden flush of water/sap after a period of drought (loc. cit), and deficiency of potassium (Ishwara Bhat, 1961) have been suggested as probable causes of this malady.

Splitting can be reduced by making longitudinal side slits at the base of inflorescence (Bavappa and Sahadevan, 1952), improving drainage, application of potash fertilizer (Ishwara Bhat, 1961), and also by spraying borax on the nuts.

Since no reliable data are available on the efficacy of the above suggested remedial measures, this problem has to be studied afresh.

9. Stem bleeding caused by *Thielaviopsis paradoxa* Von Hohn (*Ceratostomella paradoxa*)

This is a minor disease. Discoloured regions appear on the stem with disintegration of fibrous tissues and oozing out of dark brown liquid (Sundaraman et al., 1928).

The disease is severe in areas of high water table and poor drainage (Varadarajan, 1958) and in palms infested by stem borers like *Xyleborus* sp. etc. (Nambiar, Unpublished data).

The fungus also infects coconut, date palm, sugarcane, pineapple etc. (Sundaraman et al., 1928; Anonymous, 1953c).

The disease can be controlled by applying hot coal tar, Bordeaux paste, or santar A (Nambiar, 1949; Patel and Nagaraja Rao, 1958). Control stem borers, if any, using insecticides. Reducing the water table by providing deep drains may also help in the long run.

10. **Shoot rot** caused by *Gloeosporium* sp.

This is also a minor disease. Inner whorl of leaves exhibit yellowing followed by appearance of necrotic reddish-brown spots on the lamina. Infected portions rot and the palms are killed in a few days (Nagaraja Rao, 1962a).

Fungi such as *Helminthosporium*, *Gloeosporium*, *Pestalotia* sp. (Lily et al., 1965) and *Exosporium arecae* (Subramaniam, 1956) often infect the foliage and cause leaf spots in different intensities. These can be controlled by spraying Bordeaux mixture.

11. **Bacterial leaf stripe** caused by *Xanthomonas arecae* Rao and Mohan.

This was first reported from the CPCRI farm at Hirehalli (Rao and Mohan, 1970). It is at present a minor disease confined to Tumkur and adjoining areas in Karnataka.

Water soaked areas which develop to necrotic dark brown to black lesions appear on the lamina. They cause profuse exudation. In severe infections, the crown may be killed, particularly in seedlings (Rao and Mohan, 1970; Sampath Kumar, 1977). The fungus, *Nigrospora sphaerica* (Naidu and Sampath Kumar, 1964) appears secondarily on the bacterial infected foliage (Nambiar, unpublished).

The disease spreads rapidly during August-November, when the maximum temperature ranges 19-26°C and the minimum 12-16°C (Sampath Kumar, 1977). The bacterium on artificial inoculation could infect coconut and sugarcane leaves (Rao and Mohan, 1976).

Antibiotics such as streptomycin, tetracycline, chlortetracycline, demeclocycline, and streptomycin inhibited the bacterium *in vitro* (Sampath Kumar 1977). Field control trials are now in progress at Hirehalli.

Nursery Diseases

12. **Yellow leaf spot** caused by *Curvularia* sp.

This usually appears in severe form during February-March and continue until the onset of rains. Lesions with yellow hollow develop on the foliage. Severe infections lead to stunted growth and death of seedlings (Anonymous, 1953a).

Seedlings exposed to sun and ill-manured ones are more prone to the disease (Nagaraja Rao, 1962b).

Spraying Bordeaux mixture, ziram, or copper oxychloride preparations (Anonymous, 1962a) or duter (Anonymous, 1964a) check the disease. Providing good shade to seedlings and applying heavy manurial dose [Anonymous, 1961e; Radha Menon (Nayar) 1962b] make the seedlings strong to withstand the fungal attack.

Fungi such as *Colletotrichum*, *Phyllosticta*, *Helminthosporium* (Nagaraja Rao and Bavappa, 1961) and *Alternaria tenuis* (Agnihotri, 1963) may also cause leaf spots which cause stunted growth of seedlings.

13. **Leaf blight** caused by *Pestalotia palmarum* Cooke.

The disease usually occurs during February-June. The symptoms consist of reddish-brown discoloured spots that blight the lamina. Poor soil fertility favours the

disease. Radha Menon (Nayar) et al. (1962) suggested application of N and K₂O to the plants followed by spraying with dithane to check the disease.

14. **Leaf blight** caused by *Phomopsis palmicola* (Wint) Sacc. f. *arecae*.

Seedlings at transplanting stage exhibit round, brown, zonated spots that wither the lamina. Severe infection leads to stunted growth of plants (Ray, 1965).

Radha Menon (Nayar) (1959c) reported a seedling blight by a pycnidial fungus and suggested providing shade, applying proper manures, and spraying Kriticopper to control the disease.

15. **Root/Collar rot** caused by *Fusarium* sp. and *Rhizoctonia* sp.

This is common in nurseries where ill-drainage prevails. The fungi infect roots and cause wilting of seedlings. Sometimes, bacteria enter the stem through collar and cause rotting of bud and spindle leaf.

The severity of the disease can be minimised by providing good drainage in the nursery and drenching the soil with ceresan wet, Bordeaux mixture or cheshunt compound (Anonymous, 1964e; Nagaraja Rao and Bavappa, 1961).

16. **Red rust** caused by *Cephaleuros* sp.

This algal parasite infects the stem and foliage. Circular spots with sunken centres and yellow hollows appear on the foliage. The lesions are irregular on the stem. Infection destroys the epidermis [Pailey and Radha Menon (Nayar), 1960].

This alga can be controlled by providing good shade to plants and spraying with Bordeaux mixture at frequent intervals (Westcott, 1960).

DISCUSSION AND CONCLUSION

Though more than 40 pathogenic and non-pathogenic forms have been recorded on

arecanut in India causing different maladies only four diseases are considered to be major ones based on the nature and extent of damage. Also among the less serious ones, the bud rot, bacterial leaf stripe, stem breaking, and seedling diseases have been found to inflict severe damage in certain places and in some years.

In view of the heavy economic losses caused by the diseases, concerted efforts must be made to popularise plant protection measures in arecanut. Though farmers generally know that diseases like koleroga can be prevented only by spraying Bordeaux mixture at the correct time, most of them still do not adopt this. Further, many do not know how to prepare the mixture correctly, and hence, the desired results are not achieved by spraying the chemical thrice or even more. Researchers should make concerted efforts to obtain systemic chemicals of longer persistence (40 days or more) to combat the disease(s), particularly in the heavy rainfall areas. Besides chemical control, wherever useful, it is essential to adopt phytosanitary measures to reduce the inoculum potential in the gardens. In addition, a thorough knowledge of the ecological factors that govern the seasonal abundance of pathogens in different areas and the factors responsible for sporadic outbreaks of certain diseases in some localised tracts, are an essential prerequisite for evolving suitable integrated control schedules against them. For diseases such as yellow leaf and band, where the etiology of the maladies are not clearly established, it is useful to adopt proper management practices to get additional income even from affected gardens. Research on these lines has to be intensified.

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