

# BRIEF REVIEW OF COCONUT LETHAL YELLOWING

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## Abstract

Coconut lethal yellowing occurs in W. Caribbean islands, Florida and Yucatan. Similar diseases are found in W. and E. Africa. Some 60% of coconut palms in the world are susceptible.

The symptoms are described, including presence of MLO in the phloem. Chemotherapy against MLO is effective. *Myndus crudus* is considered to be the vector in Florida. The incubation period ranges from 3-6 months in young palms to 7-15 months in mature palms. Artificial transmission has not yet been achieved.

Resistant coconut cultivars and hybrids, notably 'Malayan Dwarf' and Maypan, respectively, developed in Jamaica have been planted in large numbers. Selection and breeding of resistant strains continues so as to broaden the genetic base of resistance as a defence against lethal yellowing mutants. Resistance testing is now being done in Africa.

Large scale tetracycline therapy has been used in Florida as a temporary control.

A MLO-associated lethal decline, similar to Lethal yellowing, affects 22 other palm species, including *Phoenix* spp.

Quarantine and field sanitation are of doubtful efficacy but cannot be neglected.

## Introduction

This review is mainly based upon the author's 21 years' experience with lethal yellowing (LY) on Caribbean islands and Florida. However, references are also made to diseases with similar symptoms in W. and E. Africa.

## Distribution and Importance

The disease was first reported by the Marquis of Sligo in 1834 in Grand Cayman (Johnston, 1912). In Cayman Is, Jamaica (Romney and Harries, 1978), Haiti (Leach, 1946) and Florida (Ennis, 1980) LY has destroyed

most of the tall variety of coconut palm, with correspondingly large economic losses and replanting costs. Of the 6 million susceptible palms in Jamaica in 1961, 90% were lost by 1981. Some 400,000 valuable decorative coconut palms died in Florida between 1971 and 1981.

The disease is less serious but spreading in Bahamas (Leach, 1946) and Dominican Republic (Romney, 1970). In eastern Cuba most susceptible palms have died and been replaced by resistant strains (Romney and Harries 1978A). A serious recent development has been the confirmation of LY in Yucatan (Mc Coy, 1982). Harries (1978) estimated that 62% of world coconut palms are vulnerable to LY in future. It should be mentioned that lethal decline with symptoms resembling LY affects some 22 other palm species in areas of Florida where LY occurs [Thomas, 1980] and large numbers of *Phoenix* palms in Texas [Mc Coy et al, 1980].

### Symptoms

Lethal yellowing palms can be distinguished fairly reliably from healthy palms. Symptoms comprise progressive leaf yellowing, commencing with the oldest leaf premature nut-fall (sometimes unilaterally,) necrotic young inflorescences (both open and unopen) and necrosis of the distal portion of the spear leaf. These aerial symptoms are accompanied by root rot (Eden-Green, 1982). Shortly before the first visual symptoms, growth increases then declines to zero (Eden - Green and Dabek, 1975).

With the aid of an electron microscope, symptoms can include the distribution of mycoplasma-like organisms (MLO) in LY-affected palms, concentrations being found in the phloem of roots, spear leaves and young inflorescence rachillae, i. e. sinks, also in the flag leaf when it occurs (Waters 1978). MLO have been found in LY coconut palms

in Cuba (Waters, et al, 1980). More recently, rapid detection of MLO in diseased palms in Tanzania has been effected using a UV fluorescent microscope and DAPI stain (Neinhaus et al, 1982). The older leaves on LY-affected palms of the *Niu vai* type (most pacific and Asian cultivars) become brown as opposed to the yellow colour for the *Niu kafa* type (Jamaica and W. Africa Talls, for example). Visual symptoms alone are not sufficient however, to distinguish LY from Cedros wilt of coconut palms in Trinidad (Waters 1978 A) and Hart Rot in Surinam (Parthasarathy, 1978,) the two latter being associated with a protozoan, *Phytomonas staheli*.

### Diseases Probably Related to LY

Coconut diseases with symptoms similar to LY occur in Africa, viz. Cape St. Paul wilt in Ghana, Kaincope in Togo, Kribi disease in Cameroon, Akwa wilt in Nigeria and lethal disease in Tanzania. In addition, lethal bole rot in Kenya (Bock et al, 1970) and a yellow leaf disease in Mocambique (Carvalho and Mendes, 1958) have great similarity to LY.

### Cause and Vector

Very considerable research has been done over a number of years by many workers, mainly in Jamaica (Romney, 1972) and more recently in Florida (ICLY Meetings). The disease spreads unrestricted by soil boundaries, intercrops, fertilizer practices, etc. Studies on fungi, bacteria, insects, nematodes and viruses failed to incriminate any cause.

Epidemiological studies demonstrated that a pathogen is involved. Work by Heinze et al

(1972) strongly indicated an air-borne vector. The slower spread of Kaincope compared with LY in Florida and Jamaica suggests different vectors, possibly soil-borne in Togo [Mc Coy, 1976]. In Jamaica, the rate of infection in regularly planted coconut groves varies from 1% to 15% per month [Johnson, 1975].

Heinze et al [1972] in Jamaica found the incubation period to be three to six months for non-bearing palms with highest vector activity from February to August inclusive. Four to six months elapsed in Florida before secondary disease appeared near isolated LY palms (Mc Coy, 1976). Working in Jamaica on new LY outbreaks, Romney [1971] found the incubation period in mature palms to be not less than 7-15 months.

MLO were discovered in the phloem of LY-diseased palms by Plavsic - Banjac et al [1972] and Beakbane et al [1972], and their large size and varied shapes demonstrated by Waters and Hunt [1980]. The directions of research were consequently modified. In addition to concentrating the vector search in the Auchenorrhyncha, where most vectors of MLO-associated plant diseases occur, the involvement of MLO with LY was soon supported by symptom remission specifically by tetracycline (Mc Coy, 1973), an antibiotic to which only mycoplasmas and plant pathogenic bacteria are sensitive.

Since the implication of MLO in LY, many man-years were spent on testing leaf-hoppers as vectors, including acquisition feeding, injection of coconut sap

and monitoring the presence of MLO in insects using indicator plants and in test plants by electron microscopy (Tsai, 1980) (Dabek and Waters, 1980). In view of the much greater incidence of phloem-feeding *Myndus crudus* in LY areas [Howard, 1980] and its wide LY-susceptible palm host range, Howard [1980A] used large numbers of *Myndus* [some 20,000 per test cage] to induce LY symptoms [confirmed by electron microscopy] in Manila palms [*Veitchia merillii*], and subsequently in coconut palms. The large numbers of insects used to effect transmission are consistent with the natural incidence of insects in palm groves calculated from insect trap catches [Johnson, 1975]. Evidently only a small percentage of vector insects carry MLO, or there is some barrier to inoculation. Selection of insect species for test as potential vectors was aided by numerous insect surveys in Jamaica and Florida. Waters [1975] demonstrated that labial imprints on leaf surfaces could be seen by light microscopy to locate feeding leaf hopper stylet tracks.

#### Related Diseases

Symptomologically similar diseases in Africa show other resemblances to LY. MLO are associated with Cape St. Paul wilt in Ghana and Kaincope in Togo [Dabek et al, 1976] with Kribi disease in Cameroon [Doltet et al, 1977] and with the lethal disease in Tanzania [Schuiling et al, 1981]. Steiner [1976] effectively treated Kaincope with tetracycline. Resistance to these diseases and LY is considered later.

#### Artificial Transmission

Although the association of MLO with diseased palms, the effectiveness of tetracycline therapy and the apparent absence of any other pathogen strongly implicate MLO as the cause of coconut LY, artificial transmission was a major line of work in Jamaica, not only to satisfy Koch's postulates but also optimistically to arrive at a technique for testing coconut cultivars for resistance. In Florida, Mc Coy and Chani-dattan (1975) demonstrated a disease-specific antigen in phloem sap from coconut and *V. itchia*, which could not be related to any known MLO, spiroplasma or other 'yellows' disease extract. The lack of a method of transmission, even by an artificial vector, and of an infective extract or culture mutually limit research on each other, and artificial transmission has not been effected so far.

#### Resistance to LY

With LY, for which no inoculation technique exists, survival after many years of field exposure in an area where Jamaica Tall (JT) eventually succumbs 100% is presumed to be due to resistance.

Resistance to LY by Malayan Dwarf (MD) was first noted in Jamaica by Nutman and Roberts (1955). In a number of replicated field trials planted 1962-65, the three colour forms of MD achieved 96% survival [Been, 1981]. Selection of MD mother palms and nursery roguing raised the resistance in later plantings to 99.8% [Romney, 1979].

Many coconut cultivars have been introduced into Jamaica,

mainly by Whitehead [1966, 1968], and distinguished by different fruit composition, fruit shape and germination speed. They were found to vary widely in resistance (Been, 1981), none being sufficiently resistant to be used directly by farmers. The 'Ceylon Dwarf' 'Indian Dwarf' and 'King Coconut' appear to have resistance equal to MD, but only small numbers are on trial and hence they are being multiplied by selfing. The 'King Coconut', if resistant, would be a useful female parent in a seed garden by virtue of its red colour.

Also of possible value are two palms introduced into Jamaica, in 1951 from Cuba and ca 100 open-pollinated progeny from them. Parents and most progeny resemble the disease-resistant 'Cafe con Leche' type in Cuba (Harries, 1978 A).

An introduction was made into Jamaica in 1933 of seeds from MD x 'Niu leka' F1 hybrid palms in Fiji. Several generations of open-pollinated multiplication has led to segregation of visible characters, but 95% show LY resistance [Been, 1981]. However, poor yields and high susceptibility to *Aceria* mites render this open-pollinated hybrid swarm unsuitable for farmers' use.

Although MD is more productive per acre than JT under good conditions (Romney, 1971A) it yields poorly under poor conditions. Many F1 hybrids were therefore produced and tested in Jamaica in the hope of combining LY resistance with tolerance to poor environment, leading to the Maypan [MD x 'Panama Tall'] F1 hybrid for commercial use [Harries and Romney, 1974]. The survivors of the 'more resistant'

cultivars introduced into Jamaica in 1966-68 were sibbed [for multiplication purposes recently and a number of crosses made and put in the field for test [Been, 1979].

Most hybrids with MD as one parent have resistance levels between those of the parents but generally closer to that of the more resistant [Been, 1981]. Hybrids between 'Panama Tall' [PT] and certain other tall have resistance the same as or even higher than that of the more resistant parent. Although MD has never been seen recovering wholly or partly from LY, natural partial remission of symptoms for 1-4 years was noted by Harries [1972] in PT, MDxJT and PTxJT. Romney (1972 A) suggested that PT may have a form of resistance different to that in MD, and this may also be true for other cultivars.

In Florida, MD and Maypan are used extensively for replanting, mainly imported from Jamaica. The MD x *Niu leka* crosses can also be useful since coconuts in Florida are for beautification rather than production.

### Resistance to African Diseases

Resistance has not yet been proven against the diseases in Africa, although two resistance trials were planted in 1979-81 in the Kaincope area, and one trial in 1977 in an area of Krib disease (Ollagnier, 1980): no infection had occurred by the end of 1982 (Wuidart, personal communication). Red 'Cameroon Dwarf' [CD] is susceptible to Krib disease and Kaincope [Dollet et al, 1977]. In Ghana, CD and green and yellow MD from Ivory

Coast were planted in 1966 together with red, green and yellow MD from Jamaica: symptoms of Cape St. Paul wilt began in 1971 and losses in every cultivar exceeded 89% by 1975 [Johnson and Harries, 1975]. 'Ceylon Tall' also succumbed to Cape St. Paul wilt like 'West African Tall'. Since F1 hybrids between MD, JT or PT mother palms and CD pollen are showing high resistance in Jamaica (Been, 1981), it would appear that the West African diseases are a different strain of MLO from LY.

The only report available on Akwa disease (Agwu and Okoye, 1978) lists losses which suggest that the disease had not completed its activity in the area i.e. 75% of 285 'West African Tall', 22% of 18 yellow MD and 0% of 25 green MD.

In Tanzania, at Kange where lethal disease kills only a few per cent of 'East African Tall' annually, the author has observed that ca 200 F1 hybrid palms ['East African Tall' x 'Pemba Dwarf'] planted in 1974/5, are also suffering light losses. Resistance trials with a number of cultivars and their hybrids were planted in Tanzania in 1981 and 1982 [Schuiling, M. personal communication].

### Resistance Trials

Field testing is the best practical method of resistance assessment, but Harries [1978B] showed that coconut cultivars of the *Niu vai* type [thin husk, round fruits, early germination] are usually much more resistant to LY than *Niu kafa* type [triangular fruits]. Although the diseases in Africa may have a dif-

ferent host range from LY, efforts should be made to include *Niu vai* type in African resistance trials. Harries also reasons that some LY-resistant individuals might be found in even highly susceptible cultivars: germ plasm collections by Whitehead [1966, 1968] consisted of one seed per tree in an attempt to gather any resistance that might exist—a method which is to be recommended. To produce resistant dwarf x tall F1 hybrids, the pollen source should be those individuals of tall cultivar which survive the disease. Thus losses of Maypan to LY declined from a mean of 10% in those first tested to almost zero in later plantings as LY eliminated susceptible PT.

Howard et al [1979] found that most of the palm species susceptible in Florida to lethal decline are of Old World origin and none are native to the W. Caribbean or Florida. They attributed the relatively small losses in the botanical gardens which they studied to the plant diversity there. However, MD x JT in five resistance trials in Jamaica, showed a mean resistance of only 77%, yet survived 95% and 98% in two mono-hybrid plantings of 1,000 and 400 palms respectively [Romney, 1972]. Resistance to a cultivar varies from one resistance trial to another, presumably depending upon variability of LY intensity but also upon the extent to which some survivors are escaped which may die later: the 77% resistance cited for MD x JT is the mean of figures ranging from 66% to 95% at different sites. To identify a cultivar with a resistance level high enough for commercial farming several resistance trials should

be operated, and a cultivar selected for farmers only if it has adequate resistance at all sites. It follows that the disease should be at, or spreading into, each site planted as a resistance trial, and adequate numbers of the known susceptible cultivar should be planted at the same time as "controls". Regular inspections (ca monthly) of each test plant are necessary to distinguish LY losses from other causes: bud rot, leaf spot, fire, drought, grazing animals, etc. can cause extensive losses.

### Practical Measures Versus LY

Quarantine measures in Jamaica and Florida comprise legislation against movement of living coconut plant material out of LY areas, although there is no evidence that this contains the disease. In fact, some 600 JT seedlings raised from seeds collected from parents with LY symptoms, and planted in two disease free areas, showed no case of LY over seven years of observation. Nevertheless, MD seeds sent to Ghana in 1965 were harvested in disease-free areas of Jamaica because of the possible existence of different strains of LY. Movement of living plants from LY to healthy areas should be avoided because of the additional risk of transferring infective vectors.

Field sanitation by felling affected palms was not convincingly effective in Jamaica, perhaps because LY was so widespread, and was abandoned partly because of the cost. Even the method used by Romney (1971) — trunk injection of systemic insecticides into apparently healthy palms in 1.5 ha and arsenical poisoning of palms in 0.5 ha around single palms outbreaks — was ineffective.

Chemotherapy is used on a large scale for decorative coconut palms in Florida as a partly successful temporary LY control whilst resistant palms are grown [Ennis, 1980]. In Jamaica, with commercial coconut palms, chemotherapy was rejected due mainly to the cost but also to the hazards of tetracycline residues particularly in endosperm.

Resistant cultivars and hybrids have been used extensively. Some four million MD and 0.15 million Maypan F1 hybrids were established in Jamaica between 1962 and 1979 (Romney, 1980), mainly where LY continued to be active in mature JT. Such underplanting was dictated by farmers' needs to re-establish their groves, but also served to demonstrate the very high LY resistance of MD and Maypan. However, if there is no reservoir of LY in alternative hosts, this lengthy exposure may

increase the opportunity for any LY mutant to attack resistant cultivars. Over the years, occasional MD have died of the disease. With LY and Tanzanian lethal disease, plants begin to die at age three years or less, hence some can be replanted, but this is hardly possible with Kaincpe and Kribi disease which usually do not affect palms younger than seven years old (Ollagnier, 1980). Some 15 palms, mainly MD, near Montego Bay, Jamaica, were recently observed by the author to be dying with symptoms resembling LY: over 100 palms with LY are reported to have been cut down since early 1982. Several affected MD were found to contain MLO (Waters, H, personal communication). It is understood (Barrant, C. I., personal communication), that the Coconut Industry Board is monitoring symptoms and spread to determine whether these losses are due to a LY mutant attacking cultivars previously resistant, and hence whether quarantine, field sanitation, chemotherapy and further testing for resistance need to be instituted.

### Acknowledgement

This review is published with the permission of the German Agency for Technical Cooperation, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

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