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Questions and Answers about Lethal Yellowing Disease

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Lethal yellowing (LY) disease is one of the most serious threats to palms worldwide because it is fast-spreading, kills palms rapidly once they are infected, incurable at present, and affects many species of palms. Thanks partly to some members of the International Palm Society, a research program with a multidisciplinary team of six scientists representing the fields of plant pathology, entomology and horticulture was established by the State of Florida in the 1970's at the University of Florida's Fort Lauderdale Research and Education Center to try to find solutions to this problem. The Fort Lauderdale group soon formed a close working relationship with a similar LY research group which had been organized in the Research Department of the Coconut Industry Board of Jamaica by the British Oversees Development Ministry.

By the early 1980's, due to changes in budgetary priorities and other administrative considerations, both LY research programs were phased out by their respective governments. This was unfortunate. Together, the two groups had developed more knowledge of the basic nature of the disease, as well as practical ways to manage it, than had been accumulated in the 100 years or more since LY had been known in the Caribbean Region. Lethal yellowing is still with us, and in fact, has spread into new localities in the last few years, but the momentum of these research programs has been lost and research on the disease is comparatively limited at present.

The careers of most of the members of the original Florida and Jamaica "LY research teams" have taken them separate ways. Having been associated with the original LY research teams, the authors continue to conduct research on LY as a part of the Ft. Lauderdale Center's long-term interest in tropical ornamental horticulture and the Coconut Industry Board's mission to serve the coconut industry of Jamaica.

Over the years, we have received many questions on LY from growers, horticulturists, and others interested in palms. The most frequent and some of the most interesting questions are presented here.

Q. Which palm species are most susceptible to LY?

A. The coconut palm (*Cocos nucifera*) and species of *Pritchardia* are the most susceptible species (Howard et al. 1979). However, there are different degrees of susceptibility among the many varieties of coconut palm. The 'Jamaica Tall' variety, which is the most common coconut palm seen throughout the Caribbean Region and formerly in southeastern Florida and the Keys, is one of the varieties that is highly susceptible to LY (Harries 1971, 1974). In Jamaica, where this was once the prin-

1. A plantation in Jamaica of 'Jamaica Tall' coconut palms destroyed by lethal yellowing disease.

cipal variety grown, entire plantations were lost to LY within periods of a year or two (Fig. 1). There are more than 30 species known to be susceptible to LY (Table 1).

Q. What causes LY?

A. Scientific studies have indicated that LY is caused by mycoplasmalike organisms (MLOs). Mycoplasmas are microorganisms that are intermediate between viruses and bacteria. They have been known for some time as pathogens that cause certain diseases of animals. In the last two decades, similar organisms have been found to be associated with certain plant diseases. Since it has not been definitely established that they are mycoplasmas, they are called mycoplasma*like* organisms.

Q. How do palms "catch" LY disease?

A. The mycoplasmalike organisms which cause LY are transmitted by the American palm cixiid, *Myndus crudus*. (A cixiid is a planthopper of the family Cixiidae.) This information is based on field evidence (e.g., Howard 1980) and on experiments in which American palm cixiids were collected from palms in areas where the disease was active

and introduced into cages containing palms previously unexposed to the disease. Palms in cages into which the insects were introduced contracted LY. Palms in similar cages kept free of these insects remained healthy (Howard et al. 1983). Further testing was done with younger palms and palms of different species with similar results (Howard et al. 1984).

Q. Are there insects other than the American palm cixiid that could spread LY?

A. Our studies indicate that the American palm cixiid is the principal and possibly the only vector of LY in the Americas. If there were other insect species capable of transmitting the disease, they would be limited to localized areas. In most cases in which diseases are spread by more than one species of insect, all of the species are taxonomically closely related. Thus, if there is a vector of LY additional to the American palm cixiid, we would expect it to be another species of cixiid. Except for the American palm cixiid, species of this group are quite rare on palms in the Caribbean Region. In conclusion, if we could control the American palm cixiid, we could control LY in most (if not all) places in the Americas where the disease is present.

Q. Where did LY come from?

A. Lethal yellowing may have originated in the Western Caribbean area, as there were reports of what appears to have been this disease in coconut palms in the Cayman Islands as early as 1832, and in Cuba, Jamaica and Haiti in the late 1800's. Palm species native to the Americas, particularly to the Caribbean Region, are almost never affected by this disease, suggesting that perhaps in past ages the disease spread repeatedly through this region, thus selecting out resistant strains of these palms (reviewed by Howard 1983). There are also reasons to suspect that LY may have evolved in Asia (Harries 1979).

Table 1. List of palm taxa susceptible to lethal yellowing in Florida, and relative susceptibility, June 1989.

Palm	Relative Susceptibility[1]
Aiphanes lindeniana	unknown
Allagoptera arenaria	unknown
Arenga engleri	3
Borassus flabellifer	2
Caryota mitis	2
Chrysalidocarpus cabadae	1
Cocos nucifera	3
Corypha elata	3
Dictyosperma album	2
Gaussia attenuata	unknown
Howea belmoreana	unknown
Hyophorbe verschaffeltii	2
Latania spp.	2
Livistona chinensis	1
Nannorrhops ritchiana	unknown
Neodypsis decaryi	unknown
Phoenix canariensis	2
P. dactylifera	3
P. reclinata	1
P. rupicola	unknown
P. sylvestris	unknown
Pritchardia spp.	3
Ravenea hildebrandtii	unknown
Syagrus schizophylla	2
Trachycarpus fortunei	2
Veitchia arecina	unknown
V. merrillii	2
V. montgomeryana	2
Veitchia sp. (Sunshine palm)	2

[1] Susceptibility ratings based on combined observations of Fort Lauderdale Research and Education Center personnel. 1 = slightly susceptible, 2 = moderately susceptible, 3 = highly susceptible.

Q. In which countries has LY been reported?

A. In the Western Caribbean Region: Cuba, Jamaica, the Cayman Islands, Hispaniola (Haiti and the Dominican Republic), New Providence (Bahamas), Yucatan and Quintana Roo (Mexico); in the United States: Florida and Texas. In Tropical West Africa, a similar or perhaps identical disease has been reported in Ghana, Togo, Cameroon and Nigeria. Also, in Tanzania (East Africa) an LY-like disease is being studied. Since

no major differences have been detected between the diseases of Africa and the Americas, they are all referred to as LY (reviewed by Howard 1983).

Q. What is the current distribution of LY in Florida (June of 1989)?

A. Key West was where LY was first discovered in Florida, possibly as early as 1937. Between 1955 and 1960, an epidemic of LY eliminated about 15,000 (75%) of the coconut palms in Key West (Martinez and Roberts 1967). Today, a visitor travelling the Overseas Highway to Key West will pass over many islands with abundant stands of healthy coconut palms (the 'Malayan Dwarf' and 'Jamaica Tall' varieties and hybrids between these are represented) but may occasionally spot a palm or perhaps a cluster of palms with LY symptoms. Coconut palms are still common on Key West, and some of the old 'Jamaica Tall' palms (e.g., near the beach on the south side of the island) survived the earlier LY epidemics. Some islands, e.g., Conch Key and Pigeon Key, have remained virtually free of LY.

The epidemic of the 1970's and early 1980's on the east coast from Miami to the Palm Beaches (Howard 1980) has subsided because few palms of susceptible species are left. LY continues to spread among these widely separated susceptible palms. (The extensive plantings of coconut palms along beaches are notable exceptions.) During the 1970's there were relatively few cases of LY on the west coast of Florida or on the east coast north of Jupiter Inlet (Howard 1980). However, within the last few years there has been a serious outbreak of LY in Stuart, which is the northernmost city on the east coast of Florida with extensive plantings of coconut palms. And within the past two years, the disease killed more than three hundred coconut palms on Estero and Sanibel Islands and Ft. Myers on the west coast of Florida.

Q. What is the current situation regarding LY in Jamaica?

A. In Jamaica there were formerly an estimated 5 million 'Jamaica Tall' coconut palms (Harries 1974). LY destroyed most of these by the 1980's, and they were replaced by 'Malayan Dwarf' palms. There are still some 'Jamaica Tall' coconut palms throughout the island, and they continue to be eliminated by LY.

Q. Since LY is spread by an insect, can the disease be controlled by spraying the palms with an insecticide?

A. Although the American palm cixiid can be controlled by insecticides on a limited basis (Reinert 1977), insecticidal control of the vector is not promising as a long-range strategy to control this disease. We were able to suppress populations of this insect and bring about a reduction of 50 to 75% in the rate of spread of LY in large experimental blocks by spraying palms biweekly for 14 months. A 50% reduction in the spread means that it would take twice as long for all of the palms to die. Perhaps the rate of spread could be slowed further by more frequent applications of more toxic and more persistent insecticides to even larger blocks of palms, but large scale use of insecticides to control this disease would entail unacceptable costs and environmental hazards (Howard and McCoy 1980; Howard, unpublished data).

Q. How was it determined that LY is caused by MLOs?

A. Researchers have observed mycoplasmalike organisms consistently in tissue samples from palms with LY symptoms, but have never observed these organisms in healthy palms (Beakbane et al. 1972; Heinze et al. 1972; Plavsic-Banjac et al. 1972; Thomas 1974, 1979; Thomas and Norris 1981). In one experiment, tissue samples of palms with LY symptoms and

of healthy palms grown under identical conditions were compared. Only the palms with LY symptoms had MLOs (Howard et al. 1983). In addition, researchers injected various materials into palms with LY, and found that only tetracycline antibiotics, which are known to be active against MLOs, suppressed the disease. Penicillin, which is effective against bacteria, did not suppress LY symptoms (McCoy 1972, McCoy and Gwin 1977, Hunt et al. 1974, Steiner 1976).

Q. Can tetracycline injections be used to control LY?

A. The tetracycline treatment developed by Dr. R. E. McCoy and co-workers (McCoy 1972, McCoy et al. 1976) is very effective, but involves regular injections every 4 months for the life of the tree. It suppresses the symptoms of the disease so that a palm infected with lethal yellowing stays alive and healthy. But if the injections are stopped, the infection will break out again and kill the palm. Therefore, this treatment was never recommended by the University of Florida as a permanent cure for LY, but as a means of saving infected or immediately threatened palms while resistant palms were planted and grown to take their place. The method is generally considered impractical for use in commercial coconut plantations because of the cost and other factors.

Q. Someone told me that St. Augustine grass is an alternate host of LY disease. Is this true?

A. It is plausible, but remains to be proven. It is known that St. Augustine grass (*Stenotaphrum secundatum*), as well as many other species of grasses, serves as a host to the immature stages of the American palm cixiid (Eden-Green 1978, Zener de Polania and Lopez 1977). When this insect becomes an adult, it flies to palms, returning to grasses to lay eggs and begin the cycle again. This raises the question whether the insects can transmit the MLO to the grasses. If so, grasses could serve as a reservoir of the pathogen. We have attempted to investigate this point, but our results were inconclusive because adequate experimental techniques have not yet been developed.

Q. Given present technology, what is the best method for controlling LY in coconut plantations?

A. Coconut plantations affected by lethal yellowing should be replanted to certified seednut of either 'Malayan Dwarf' or the 'Maypan' coconut palms, which are highly resistant to lethal yellowing disease (Harries 1970, Harries and Romney 1974). The 'Maypan' is a hybrid obtained by crossing the 'Malayan Dwarf' with a 'Panama Tall,' the latter which is significantly more resistant to LY than the 'Jamaica Tall' (Harries and Romney 1974). We have investigated several sites in both countries where there were unusually high losses of 'Malayan Dwarf' or 'Maypan' coconut palms to LY. We have not conclusively determined why these losses were so high at these sites (Howard et al. 1987). However, since millions of these palms in Jamaica and many thousands of them in Florida have survived LY epidemics, they are thus far the most recommendable coconut palms for LY-affected areas.

Q. Are there additional resistant varieties of coconut palm?

A. The 'Fiji Dwarf,' 'Ceylon King' (a semi-dwarf), 'Cuban Dwarf,' 'Ceylon Yellow Dwarf,' 'Indian Green Dwarf' and 'Red Spicata Dwarf' are varieties of coconut palm that appear to be resistant, based on limited trials in Jamaica. These are undergoing further field tests in Jamaica, and some of them are being tested in Florida with the cooperation of the Coconut Industry Board.

Q. For landscaping use, which lethal yellowing-resistant palms can be recommended?

A. In addition to the resistant coconut palm varieties already mentioned, there are many species of palms that are suitable as ornamentals and which are resistant to lethal yellowing disease. More than 30 species of palms are known to be susceptible to LY (Table 1). But in Florida, at least 386 species of palms can be grown. This is the number of palm species identified in Fairchild Tropical Garden, Miami (Howard et al. 1979). On the other hand, many of the palm species in the Garden cannot be said to have been adequately tested for LY susceptibility. For example, during the peak of the LY epidemic in the Garden (1973–1977), LY had not affected *Bactris ottostapfeana*, a species which was represented in the Garden by one palm. This palm is still there, leading one to suspect that this species is not susceptible to LY. However, this does not constitute a conclusive test of the effect of LY on this species. By contrast, in 1977, *Coccothrinax argentea* was represented in the Garden by 40 palms, none of which was lost to LY. The higher the number of palms exposed to LY, the more confident are we of its resistance or susceptibility to the disease. We can be quite confident about palms that are popular in southern Florida, because by now they have had ample exposure to LY without succumbing to it. *Acoelorrhaphe wrightii*, *Chrysalidocarpus lutescens*, *Phoenix roebelenii*, *Ptychosperma elegans*, *Roystonea regia*, *Sabal palmetto*, *Syagrus romanzoffiana*, and *Washingtonia robusta* are very common in southern Florida cities and we can say with a great deal of certainty that there has never been a case of LY in these palms in Florida. Notice that five of these eight species are native to the Americas. In Florida we found that most of the susceptible species are native to Asia, Oceania and Africa. Only four species native to the Americas are known to be susceptible to LY (*Aiphanes lindeniana*, *Allagoptera arenaria*, *Gaussia attenuata* and *Syagrus schizophylla*).

A booklet listing the numbers of palms of different species in Fairchild Tropical Garden, their geographic origins and the numbers lost to lethal yellowing from 1971–1977 is available from the Ft. Lauderdale Center.

Q. Are the date industries of Arizona and California threatened by LY?

A. It was once believed that LY was exclusively a disease of coconut palms. When it invaded Florida, where many species of ornamental palms are common, it was discovered that it had a broader host range. Even then, it was suspected that coconut palm was a primary host, and that the disease would not spread outside of tropical and semi-tropical areas where coconuts grow. The appearance of LY in the Rio Grande Valley of Texas, where it spread rapidly and devastated plantings of Canary Island date palm (*Phoenix canariensis*), was a grim lesson (McCoy et al. 1980). Arizona and California have imposed quarantine regulations to try to prevent LY from invading those states and affecting the date industries and also the Canary Island date palms which are an essential part of the distinctive landscape of cities of the American Southwest. Methods of preventing and controlling LY in coconuts and other tropical palms developed through research in Florida and the Caribbean would usually be applicable to date-growing regions. In addition, some research in Florida emphasizes management of LY in date groves. A preliminary evaluation of susceptibility of different date palm varieties has been completed (Howard et al. 1985), and an apparently resistant variety, the 'Halawy,' is being tested further. Also, Canary Island date palms grown from seed of different provenances are being tested

for LY resistance, with some early promising results.

Q. Is LY a threat to Hawaii?

A. In spite of its isolated geographic position and strict quarantine measures practiced by agricultural officials, Hawaii has more than its fair share of plant pests and diseases inadvertently introduced from sometimes very distant lands. If LY were introduced into Hawaii, it would have a devastating effect. To evaluate the susceptibility of Hawaiian coconut palms, a field trial was conducted at the Ft. Lauderdale Center, in which 18 palms of a tall variety common in Hawaii and 13 of a dwarf variety referred to in Hawaii as 'Samoan Dwarf' were grown from seednut obtained from Hawaii. For comparison, 18 'Jamaica Tall' coconut palms were grown from seednut obtained locally. The seednuts were held in a seedbed until two years after sprouting and then were planted in a field in April 1983. The palms were examined frequently for disease symptoms, and diagnoses by symptoms were substantiated by taking bud tissue samples from one symptomatic palm of each of the three varieties and examining them under the electron microscope for MLOs.

MLOs were observed in tissue samples from all three varieties, confirming that our diagnoses by symptoms were correct. After four years of field exposure to LY (April 1987), losses of the three varieties to the disease were as follows: 'Jamaica Tall'—88.8%; tall variety from Hawaii—83.3%; 'Samoan Dwarf'—92.3%. In addition to coconut palms, other palms in Hawaii would be affected by LY. We have found *Pritchardia affinis*, a native of Hawaii, to be highly susceptible to LY, as are other species of this genus when grown in Florida.

Q. Can LY be carried in the seed of palms?

A. There is no evidence that MLOs can be tranmitted *via* the seed of plants, and experts doubt that this occurs. For one thing, palms infected with LY shed their seeds. However, the possibility of seed transmission of MLOs has not been disproven.

Q. Under what conditions are palms most susceptible to LY?

A. We lack conclusive experimental data to answer this question, but based on field observations by a number of scientists, palms are apparently most likely to contract LY when grown under the following conditions: (1) in full sun, (2) on a site with grasses that serve as hosts to immature stages of the American palm cixiid, and (3) when given plenty of water and fertilizer. Also, in our experience (4), LY spreads faster and destroys more palms if susceptible species are planted in blocks or monocultures, rather than mixed with non-susceptible palms or other trees.

Q. Under what conditions do palms of susceptible species escape LY infection?

A. Palms of susceptible species grown in the shade (e.g., of a large, spreading live oak or similar tree) often escape the disease. In southeastern Florida extensive plantings of 'Jamaica Tall' coconut palms on the ocean beaches survived the severe LY epidemic of the 1970's and early 1980's and are still standing. The disease appeared to spread relatively slowly in palms surrounded by large paved areas, e.g., parking lots, and some 'Jamaica Tall' coconut palms have continued to survive in such areas, while in nearby areas with lawns the palms died from LY. In general, the disease appears to spread more slowly in areas where palms are presumably "stressed" due to lack of maintenance or otherwise inhospitable environmental factors than in areas where they are given ample water and fertilizer, especially high rates of nitrogen. For example, in Florida LY spreads particularly fast on golf courses as opposed to areas of the cities where the

lawns and trees are neglected by the residents. This relationship needs further investigation.

Q. What is the current status of research on lethal yellowing disease?

A. At the Ft. Lauderdale Center, methods of controlling the vector are being investigated. A key to control of this insect is that the immature stages develop on grasses, and the adults fly to palms. There is considerable interest throughout the humid tropics in the conversion of ground-covers of coconut plantations to improved forage grasses. Use of grasses that do not support the American palm cixiid could prevent or help control the spread of LY. Recently, the authors completed a three-year cooperative project funded by the U.S. Agency for International Development. This project resulted in the identification of grasses that are poor hosts of the American palm cixiid and that are valuable tropical forage grasses well-adapted for use as ground-cover in coconut plantations. This work continues at Ft. Lauderdale, with increased emphasis on finding turfgrasses and other ornamental ground-covers that do not support the vector of LY. Research on varieties of coconut that are resistant to LY continues to receive high priority in Jamaica and Florida. Testing of date palms and other species continue at Ft. Lauderdale.

Dr. Nigel Harrison, a plant pathologist at the Ft. Lauderdale Center, is currently attempting to develop a biochemical test to diagnose LY in its pre-symptom stage. Pre-symptom diagnosis of LY has been a goal of a number of researchers for many years because of the importance of such a technique to many research problems directed towards developing practical methods of managing and preventing the disease.

Research on LY is also being conducted by the Mexican Secretaria de Agricultura y Recursos Hidraulicos by personnel stationed in Veracruz and at the experiment station in Chetumal, Quintana Roo (Villanueva et al. 1987).

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