LETHAL YELLOWING OF PALMS

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History.

Lethal yellowing (LY) is a plant disease that infects and kills coconut palms as well as many other palm species. Known since the 1800's in the western Caribbean Region, LY has long been of concern because of the highly destructive nature of the disease and the economic importance of coconut in the region. LY invaded Key West, Florida, probably as early as the 1930's, but was not diagnosed until the 1950's. It killed about 75% of the coconut palms on Key West before the epidemic subsided about 1965. LY appeared on Key Largo in 1969 and on the Florida mainland in Miami in 1971. By 1973 it had spread northward along the east coast to Palm Beach county. The diversity of ornamental palms was greater in the urban areas of southern Florida than in most Caribbean countries, and it soon became evident that LY affected many palm species additional to coconut. By 1983, the


FIG. 1

epidemic had destroyed an estimated 100, 000 coconut palms and thousands of palms of other species. The epidemic on the southeast coast began to wane in the mid-1980's. However, the disease persists in the area, but attacks only an occasional isolated palm or group of palms. Probably an important factor in today's low incidence of LY is the preponderance of LY- resistant palms in the landscape. In the late 1980's, LY appeared on the southwestern coast of Florida on Estero Island (near Fort Myers) and remains highly active, killing many of the older coconut palms and palms of other species. LY was diagnosed for the first time in Mexico in the 1982 near Cancún on the northeastern tip of the Yucatán Peninsula. Since then it has spread west to the Mexican state of Tabasco and south to Honduras (Figs. 1-2), killing many hundreds of thousands of coconut palms and destroying the locally important coconut industries.

Symptoms. **In coconut tall-type palms, the first symptom of LY is the premature dropping of most or all of the coconuts of all stages of development. The perianth of fallen coconuts is loose, and the area beneath it is dark brown and gives the impression that it was stained by soaking. The next symptom is the darkening of the inflorescence. The male flowers of healthy inflorescences of coconut palm are a clear, yellowish cream to light golden color, while those of palms infected with LY are dark brown to blackish. The inflorescence tends to become dry and gnarled. This symptom is highly diagnostic for LY, but occasionally is manifested atypically, and of course is never present in palms too young to produce inflorescences. In the third stage of disease development, the fronds turn yellow, beginning with the older ones and advancing toward the younger ones near the center of the crown. Sometimes a younger frond will turn yellow early in this sequence. This is commonly called a "flag leaf" (a term borrowed from plant pathology of bananas) and is a significant symptom for diagnosing LY, but is not consistently present. Fronds that have turned yellow desiccate and turn light brown and hang from the tree. The final stage is the death of the bud, causing the youngest unfolded leaf (the "spear" leaf) to collapse. When this stage is reached, the entire bud may rot within days. Sometimes this stage is reached when there are still some green leaves left on the palm, but death of the bud is the equivalent of death of the palm. The entire sequence of symptoms from initial fruit drop to death of the bud usually takes from**


FIG. 2

3-6 months, and the rapidity of these events is in itself a symptom. A disease of coconut palms characterized by frond yellowing and necrosis but that does not kill the palm within 6 months can be suspected to be some disease other than LY. In palms other than coconut, early symptoms are similar. Fruits are shed prematurely and new inflorescences tend to become dark, necrotic, dry and gnarled. Leaf symptoms vary. For example, in *Corypha elata, Pritchardia* spp. *Syagrus schizophylla, Trachycarpus fortunei, Dictyosperma album,* and *Hyophorbe verschafeltii*, the leaves turn yellow beginning with the lowest fronds, and a "flag leaf" may develop. The leaves eventually die and turn brown and may fall or cling to the palm. In *Veitchia merrillii, Borassus flabellifer, Caryota mitis* and *Phoenix* spp., necrosis begins along the leaflet margins as a brownish stain. Within days the entire frond becomes brown and desiccated. Petioles of some fronds may buckle. Within about two months, most of the lower fronds collapse but persist on the palm, while the younger leaves remain green and upright. Eventually the younger leaves also die, the bud rots, and the spear leaf collapses. Because diseases of palms are difficult to diagnose, in critical cases such as are encountered in research, field diagnoses of LY are confirmed by laboratory tests to determine the presence of LY phytoplasmas.

Causal Organism.

Researchers at several institutions, including Rutgers University, Cornell University, the University of the West Indies and the University of Florida, have concurred that the causal agent of LY is a phytoplasma, since they are consistently found colonizing the phloem of palms with symptoms of LY, but are absent from these tissues in healthy palms. The morphology and ultrastructure of phytoplasmas closely resembles those of the true mycoplasmas, a group of culturable prokaryotes that cause diseases in animals, including primates. Phytoplasmas share several other important properties in common with the mycoplasmas, including the fact that they are very small (not much larger than viruses), lack a true cell wall (unlike most bacteria), and are insensitive to penicillin antibiotics (which kill bacteria by interfering with cell wall synthesis), but sensitive to tetracycline antibiotics. Thus, tetracyclines (e. g., oxytetracycline-HCL) are effective against phytoplasmal diseases and, when administered by trunk injection to palms in the early stages of LY, cause a remission of symptoms. Since phytoplasmas have defied all attempts to culture them, thus precluding any detailed laboratory study of these organisms, the precise nature of their relationship to the mycoplasmas has eluded scientists for many years. For this reason, phytoplasmas were previously referred to as "mycoplasmalike organisms", or MLOs. However, new evidence compiled from recent molecular studies has since clarified this relationship, demonstrating MLOs to represent a unique, genetically cohesive group of plant pathogens quite distinct from the mycoplasmas and other genera of wall-less prokaryotes. Thus, in recognition of their unique taxonomic status, MLOs as a group are now known by the generic name of phytoplasma, to which species designations to denote individual pathogens will undoubtedly be added within the next few years.

Mode of Spread. **Research at the FLREC has shown that LY is spread by a planthopper, *Myndus crudus* Van Duzee (Fig. 3). Planthoppers are in the suborder Auchenorrhyncha of the order Hemiptera, that is, they are related to leafhoppers, treehoppers, cicadas, etc. Evidence for *Myndus crudus* as a vector of LY is that (1) extensive field surveys determined that it feeds on susceptible palm, (2) the geographical distribution of high populations of the insect coincided with high LY incidence, (3) suppression of populations of *Myndus crudus* was associated with a reduction in the spread of LY, (4) under laboratory conditions, LY was repeatedly transmitted to palms exposed to *Myndus crudus*, and palms not exposed to *M. crudus* remained free of LY, (5) and DNA-based testing has shown that the *Myndus crudus* acquires the phytoplasmas that cause LY when they feed on palms with this disease. Some insect-borne diseases are known to be transmitted by only one vector species, while other diseases are transmitted by more than one species. In the latter case, the vector species are usually closely related taxonomically. At present, there is no evidence for any vector species of LY in Florida other than *Myndus crudus*.**

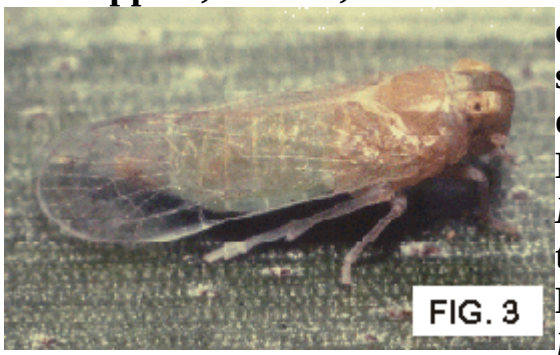
FIG. 3

Susceptible Palm Species. **To date, 34 palm species have been shown to be susceptible to LY (Table 1). *Pandanus utilis* Bory (Pandanaceae) is also susceptible. The list of susceptible species has been accumulated mostly by opportunistic observations on palm species that were common in the landscape in southern Florida, especially during the LY epidemic of the 1970's and early 1980's. Observations on relatively rare palms in Florida were made in Fairchild Tropical Garden, the FLREC and other botanical collections. More data on susceptibility or resistance are available for common than for rare palms. Little or nothing is known concerning the level of susceptibility of species that have not been planted extensively in LY-affected areas. Therefore, the susceptibility ratings of low, moderate and high susceptibility shown in Table 1 are made only for those palms that were common in southeastern Florida or at the FLREC during the LY epidemic, are highly subjective, and should be interpreted only as general guidelines. It has been shown that the susceptibility of coconut palms of different cultivars varies according to site, and this is probably also true of other species of palms. LY susceptibility appears to be concentrated in certain genera, but not in any particular subfamily of palms and does not appear to be related to any obvious botanical feature such as stature, whether the frond is palmate or plumose, time of flowering, etc. The only trends discernable are geographic relationships: Proportionally more species of palms of Eastern Hemisphere origin are susceptible than palms native to the Western Hemisphere. No palms native to the western Greater Antilles, Florida or Mexico are known to be susceptible, although some of these species are extremely ubiquitous and have been exposed for many years to LY. At present, 5 species of American origin compared to 29 species of Eastern**

Hemisphere origin are known to be susceptible. The most highly susceptible palms, i. e., coconut palm and *Pritchardia* spp., are native to the western Pacific Ocean region. Six (17.6.%) susceptible species are native to one island, Madagascar. This may be related to the close taxonomic relationship of these species. No species native to Australia is known to be susceptible, although several species of Australian origin are among the most popular ornamental palms in southern Florida (Table 2). Certain varieties or cultivars of coconut palm are highly susceptible, notably the 'Jamaica tall' (='Atlantic tall'), which was formerly the most common cultivar in southern Florida and throughout the West Indies and the Atlantic Coasts of Tropical America. It remains common throughout this region except in Florida and areas of the West Indies and Mexico where LY has been epidemic in recent decades.

Vector Control.

Although experimental suppression of populations of *Myndus crudus* with insecticides resulted in a reduction in the spread of lethal yellowing in the experimental areas, insecticidal control of vectors on a broad scale would be too costly, environmentally deleterious, unsafe and would eventually result in insecticide-resistant vectors. Limited insecticidal control of vectors would probably not be feasible. Natural enemies of *Myndus crudus* have been identified, , including parasitoids, predators, and fungi. Probably these organisms control the insect for long periods. Perhaps outbreaks of the insect may occur at intervals when the natural controls are disturbed. This is an area in need of investigation.

Cultural Control.

The immature stages of *Myndus crudus* develop on grasses and the adults feed on palms. Thus, ground cover management has been investigated as a method of reducing populations of this insect. All turfgrasses popular in Florida, including St. Augustine, Bahia, Bermuda and Zoyzia grasses are favorable development hosts. Several grass selections tested are poor development hosts but do not have desirable turf grass qualities. Dicotyledonous ground covers that have been tested do not support development of this insect, and can be used in coconut plantations in the tropics, but at present are unlikely to become popular for turf areas in Florida. Research is continuing to discover appropriate ground covers that can be used with palms without encouraging *Myndus crudus* populations. There is interest in this technique as a management tool to be integrated with other methods, principally with the use of LY-resistant palms.

Antibiotic Treatments of Palms.

An effective antibiotic treatment using oxytetracycline-HCL injected into the trunk was developed by researchers at FLREC. This treatment is not curative, and must be repeated every three months to keep the disease in remission. It is not recommended that injection programs be carried out indefinitely, nor are they recommended in the absence of replanting programs, as restricting planting of palms to LY - resistant species and cultivars is the only long term practical solution to this disease problem.

Resistant Palms. **No case of LY has ever been reported in a species of palm native to Florida, Cuba, Jamaica, Hispaniola, or Yucatan, Mexico, areas where LY has been epidemic. Native palms are therefore good choices for landscaping in Florida. Native palms frequently planted as ornamentals include cabbage palmetto (*Sabal palmetto*), royal palm (*Roystonea regia*) , Paurotis palm (*Acoelorraphe wrightii*), Florida thatch palm (*Thrinax radiata*) and Key thatch palm (*T. morrisii*). Exotic palms that have been extensively planted and for which no case of LY has been reported are shown in Table 2. There are many cultivars of coconut palms. These fall into two major groups: talls and dwarfs. Tall cultivars are relatively large and begin bearing coconuts in about seven years. Dwarf cultivars are not true dwarfs, but compared to talls are smaller in frond length, trunk diameter, size of coconuts, etc. and begin bearing coconuts as early as five years of age. Many cultivars have been tested for resistance to LY by the Coconut Industry Board in Jamaica. Cultivars that have shown high resistance in those tests include Malayan green dwarf, Malayan yellow dwarf, Malayan golden (apricot red) dwarf, Fiji dwarf, red spicata dwarf, Chowghat green dwarf, and Ceylon King. The Chowghat green dwarf was selected as a promising cultivar for Florida and is being tested for LY resistance at the FLREC, but so far results are not encouraging. The Malayan dwarf cultivars have been extensively planted in Jamaica since the 1960's. Many were planted in Key West in response to the earlier epidemic there (1950's-1960's). Earlier indications in Jamaica were that of 100 Malayan dwarf palms, 95 could be expected to survive LY (95% resistance). More extensive observations have shown that the resistance of these palms varies with site. On most sites observed in Florida, Jamaica and Mexico, the resistance of Malayan dwarf cultivars under LY epidemic conditions has approached 90% or more, but on occasional sites, losses have been as much as 50%. A tall cultivar that is significantly more resistant to LY than 'Atlantic tall' is the 'Panama tall' (='Pacific tall'), the most common cultivar on the western coasts of tropical America. 'Malayan dwarf' cultivars may be crossed with the 'Pacific tall' to produce 'Maypan" hybrids, so as to combine the higher resistance of the dwarf cultivars with the larger size and adaptability of the tall, with the further advantage of hybrid vigor. Growing pure 'Malayan dwarf' cultivars and producing resistant 'Maypans' is a highly technical art, and at present there are no facilities for producing seednut of either type in Florida. The recommended practice is therefore to obtain seednuts of LY-resistant coconut cultivars and /or hybrids from either of two foreign sources approved by the U. S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), namely, Jamaica and Costa Rica. In Jamaica, the Jamaica Coconut Industry Board is the sole supplier of APHIS-certified seed. In Costa Rica, one seed gardem produces APHIS-certified seed, and possibly more growers will undertake this activity in the future.**

What Can You Do? **Palms should be an important aesthetic component of any beautiful tropical landscape. Although LY persists in southern Florida, the risk of**

palms contracting this disease can be greatly reduced by planting only disease-resistant palm species. Information about palms that are resistant to LY can be obtained from your county Extension Service.

Figure Captions and Credits

Figs. 1 & 2. Effects of LY on coconut palms, Roatán, Honduras. Photo by Richard Illingworth.

Fig. 3. *Myndus crudus*, vector of LY in Florida. Photo by James V. De Filippis.

Tables

Table 1. List of palm species that are susceptible to lethal yellowing disease in Florida.

Scientific name	Common name	Region of origin	Popularity in Florida landscape	Relative LY susceptibility
Aiphanes lindeniana (H. Wendland)		Caribbean	Rare	Unknown
Allagoptera arenaria (Gomes) O. Kuntze	Seashore palm	South America (Brazil)	Rare	Unknown
Arenga engleri Beccari	Miniature sugar palm	Southeast Asia	Rare	Unknown
Borassus flabellifer L.	Palmyra palm	India	Rare	Moderate
Caryota mitis Loureiro	Cluster fishtail palm	Southeast Asia	Common	Moderate to high
Caryota rumphiana Martius	Giant fishtail palm	Southeast Asia	Rare	Unknown
Chelyocarpus chuco (Martius) H. E. Moore		South America	Rare	Unknown
Chrysalidocarpus cabadae H. E. Moore	Cabada palm	Madagascar	Rare	Unknown
Cocos nucifera L.	Coconut palm	Western Pacific (Melanesia)	Common	High to low, depending on cultivar or hybrid.
Corypha elata Roxburgh	Gebang palm	India	Rare	Unknown
Dictyosperma album (Bory) H. Wendland & Drude ex Scheffer	Princess palm	Madagascar	Common	Moderate

Gaussia attenuata **(O. F. Cook) Beccari**	**Palma de lluvia**	**Caribbean (Puerto Rico)**	**Rare**	**Unknown**
Howea belmoreana **(C. Moore & F. J. Mueller) Beccari**	**Belmore sentry palm**	**Western Pacific (Lord Howe Island)**	**Rare**	**Unknown**
Hyophorbe verschaffeltii **H. Wendland**	**Spindle palm**	**Madagascar**	**Common**	**Slight to Moderate**
Latania **spp.**	**Latan palm**	**Madagascar**	**Common**	**Moderate**
Livistona chinensis **(Jacquin) R. Br. ex Martius**	**Chinese fan palm**	**China**	**Common**	**Moderate**
Livistona rotundifolia	**Footstool palm**	**Southeast Asia**	**Rare**	**Unknown**
Nannorrhops ritchiana **(W. Griffith) J. E. T. Aitch.**	**Mazari palm**	**Middle East to India**	**Rare**	**Unknown**
Neodypsis decaryi **Jumelle**	**Triangle palm**	**Madagascar**	**Common**	**Slight**
Phoenix canariensis **Hort. ex Chabaud**	**Canary island date palm**	**Canary Islands**	**Common**	**Moderate**
Phoenix dactylifera **L.**	**Date palm**	**North Africa - Middle East**	**Common, formerly rare**	**Moderate to High**
Phoenix reclinata **Jacquin**	**Senegal date palm**	**Africa**	**Common**	**Low**
Phoenix rupicola	**Cliff date palm**	**India**	**Rare**	**Unknown**
Phoenix sylvestris **(L.) Roxburgh**	**Wild date palm**	**India**	**Rare**	**Unknown**
Pritchardia affinis **Beccari**	**Loulu palm**	**Hawaii**	**Rare**	**Probably high**
Pritchardia pacifica **Seeman & Wendland**	**Fiji fan palm, tonga fan palm**	**Western Pacific (Tonga)**	**Rare; formerly common**	**High**
Pritchardia thurstonii **F. J. Mueller & Drude**	**Thurston palm**	**Western Pacific (Fiji)**	**Rare; formerly common**	**High**
Pritchardia remota **Beccari**		**Hawaiian Islands**	**Rare**	**Probably high**
Ravenea hildebrandtii **H. Wendland ex Bouche**	**-**	**Madagascar**	**Rare**	**Unknown**
Syagrus schizophylla **(Martius)**	**Arikury palm**	**South America (Brazil)**	**Un-common**	**Moderate**
Trachycarpus fortunei **(Hooker) H. Wendland**	**Windmill palm**	**China**	**Un-common**	**Moderate**
Veitchia arecina **Beccari**		**Western Pacific (New Caledonia)**	**Rare**	**Unknown**

Veitchia merrillii **(Beccari) H. E. Moore**	**Manila palm**	**Western Pacific (Philippines)**	**Common**	**Moderate to high**
Veitchia mcdanielsi **H. E. Moore**		**Western Pacific (New Caledonia)**	**Rare**	**Unknown**
Veitchia montgomeryana **H. E. Moore**		**Western Pacific, possibly Vanuatu**	**Rare**	**Low**

Table 2. A partial listing of exotic palms that are common in southern Florida and are not known to contract LY.

Scientific name	Common name	Region of origen
Archontophoenix alexandrae **(F. Mueller) H. Wendland & Drude**	**Alexandra palm**	**Australia**
Carpentaria acuminata **(H. Wendland & Drude) Beccari**	**Carpentaria palm**	**Australia**
Chrysalidocarpus lutescens **Wendland**	**Yellow cane palm**	**Madagascar**
Phoenix roebelenii **O'Brien**	**Miniature date palm**	**Southeast Asia**
Ptychosperma macarthurii **(Wendland) Nicholson**	**MacArthur palm**	**Western Pacific (New Guinea)**
Ptychosperma elegans **Blume**	**Solitaire palm**	**Australia**
Washingtonia robusta **H. Wendland**	**Mexican Washingtonia**	**Northern Mexico**
Wodyetia bifurcata **A. K. Irvine**	**Foxtail palm**	**Australia**
Syagrus romanzoffianum **(Chamisso) Glassman**	**Queen palm**	**South America**