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Effect of Lethal Yellowing on Xylem Pressure in Coconut Palms

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Abstract

Pressures in the xylem of leaflets of healthy coconut palms vary from ca. –1 bar at night to ca. –10 bars at midday in sunshine. There is little diurnal pressure variation in palms showing lethal yellowing symptoms; midday pressures do not drop below ca. –4 bars. This seems to indicate stomatal closure. High pressures were also found in an apparently healthy tree which began to show symptoms two weeks later. Unusually high midday xylem pressures may therefore be the earliest recognizable symptom of lethal yellowing.

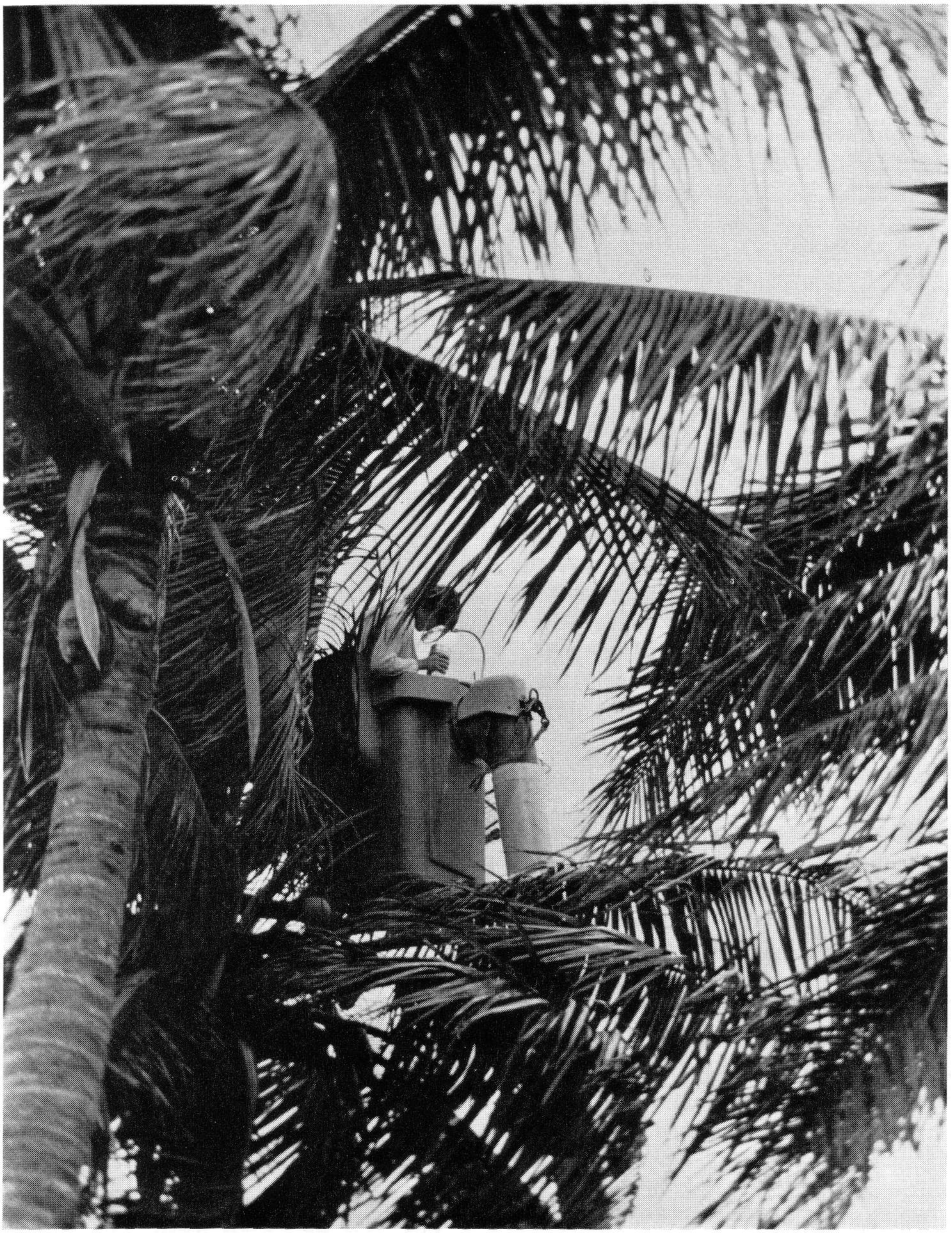
Lethal yellowing (LY) of coconut palms was first recognized in Jamaica in 1891. Over the years Jamaican economy has been greatly affected by the essentially complete elimination of the 'Jamaican Tall' cultivar from the cultivated fields (Romney, 1972). The disease arrived on the Florida mainland in 1971 and is now found in seven counties of South Florida. In Florida the palm is largely valued as an ornamental, so its rapid death has caused devastating changes in the state's landscape (Fisher, 1975).

Research into the disease implicates a mycoplasmalike organism (MLO) as the causal agent. Large numbers of MLO have been found in sieve tubes in sink areas (young developing or storage areas) of infected trees (Beakbane *et al.*, 1972; Parthasarathy, 1974; Plavsic-Banjac *et al.*, 1972).

Disease symptom remission has been observed after oxytetracycline injection (McCoy, 1975). Furthermore, symptom development has been prevented in oxytetracycline-treated healthy trees (McCoy, 1976b). Based on studies of disease spread (McCoy, 1976a), evidence suggests that a phloem-feeding insect vector introduces the MLO into the sieve tubes.

Most often the MLO have been observed in sieve tubes from areas of rapid growth (phloem sinks). Young inflorescences are wrapped in a very substantial bract; their phloem is thus inaccessible to phloem-feeding insects. The leaves are obvious sites for insect feeding. This would indicate long distance movement of the pathogen from the site of the original infection (most likely the leaves) to the sink areas (young inflorescences) via the sieve tubes. Studies of translocation are therefore very desirable in order to learn more about the nature of the disease. Few such studies have been published (Milburn & Davis, 1973; Milburn & Zimmermann, 1977; Zimmermann, 1973).

There is a close relationship between the movement of food in the phloem and the flow of water in the adjacent xylem (Zimmermann, 1969). Both translocation compartments need further investigation. Measurement of the parameters of phloem movement, particularly in intact plants, is difficult (Milburn & Zimmermann, 1977), while a few techniques have been developed that have made xylem measurements possible (Boyer, 1969; Kanemasu *et al.*, 1969; Talbot *et al.*, 1975).



1. The senior author measuring xylem pressure in the crown of a coconut from a bucket truck.

This paper describes an investigation of water pressures in the xylem before and after infection. It is a very brief extract from the thesis of the first author (McDonough, 1977).

Methods

The diurnal variation in xylem water tension in leaflets of coconut palm has been examined with the Scholander pressure chamber (Scholander *et al.*, 1965).

Before measurement, the basal 2.5 cm portion of the lamina of the leaflet to be measured was trimmed from both sides of the midvein at the point of its insertion on the leaf rachis. The leaflet midvein was then cut cleanly with a razor blade. The leaflet was rolled and inserted into the pressure chamber with the midvein protruding slightly. The crowns of tall palms were reached with a bucket truck (Fig. 1). The results given in Figures 2 and 3 are based on well over a thousand measurements, each taken in triplicate.

Results and Discussion

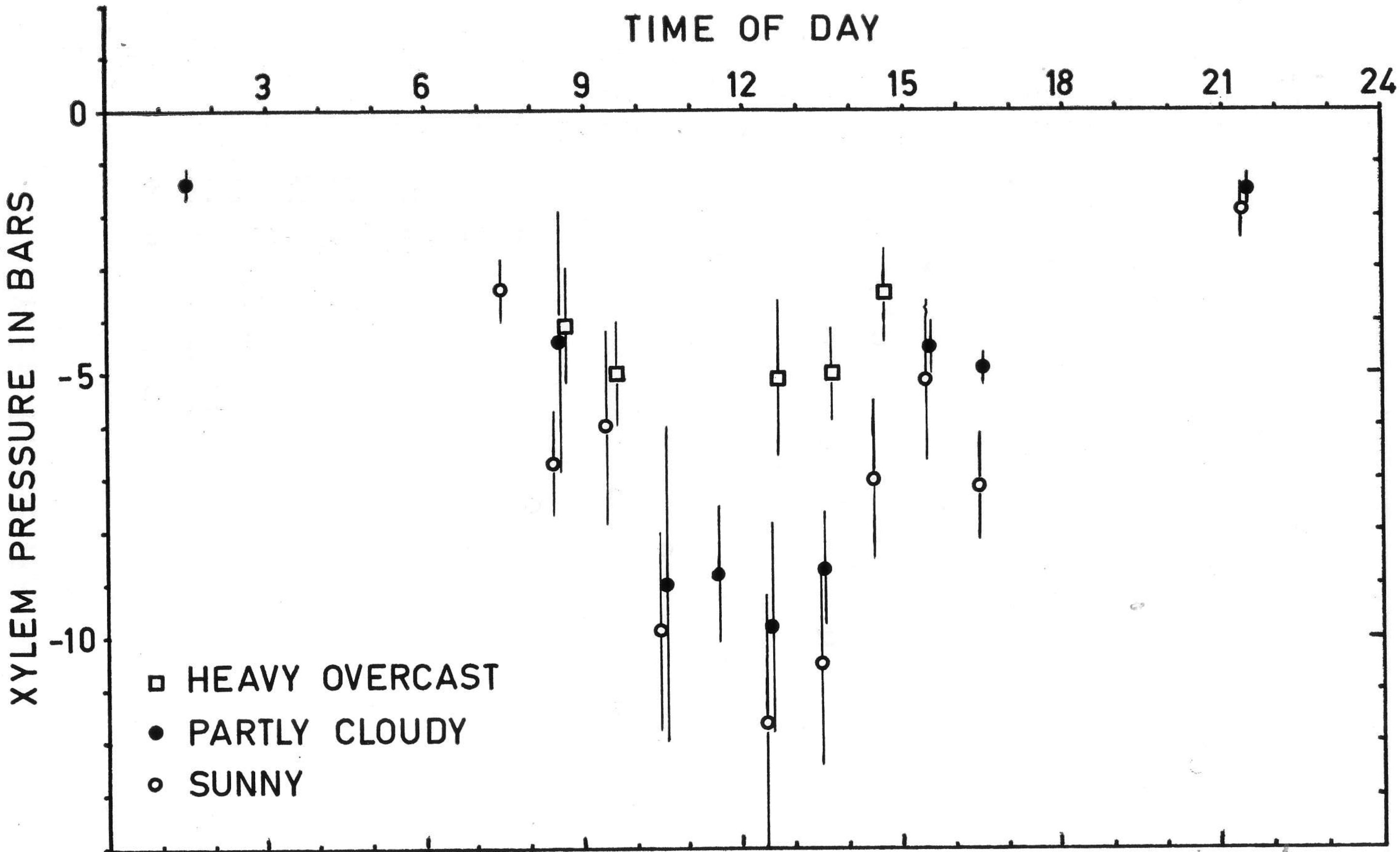
Initial xylem presssure measurements were obtained from healthy, young (3 m tall) trees in an area where LY had not been reported. Typical diurnal patterns are shown in Figure 2. Pressures were high at night, they dropped after sunrise, reaching their lowest point between 10:00 and 14:00 hours. The lowest pressure obtained during any one day was dependent on environmental conditions. Figure 2 shows that lowest pressures were reached on warm, sunny days; pressures were slightly higher on warm, cloudy days, while under heavily overcast to rainlike conditions, lowest pressures were significantly raised.

In the next phase of the study, readings were taken on mature trees (6–7.5 m tall) in an area of high LY infection, where trees in various stages of disease development were available. All readings were taken on warm, sunny or partly cloudy days in order to observe the maximum daily changes in water pressure. Xylem pressures in all diseased (symptom-showing) trees measured remained high throughout the day (Fig. 3 □) as compared to healthy trees. This seems to indicate water conduction from roots to leaves, but blockage of water loss from the leaf surface. This is best explained by stomatal closure.

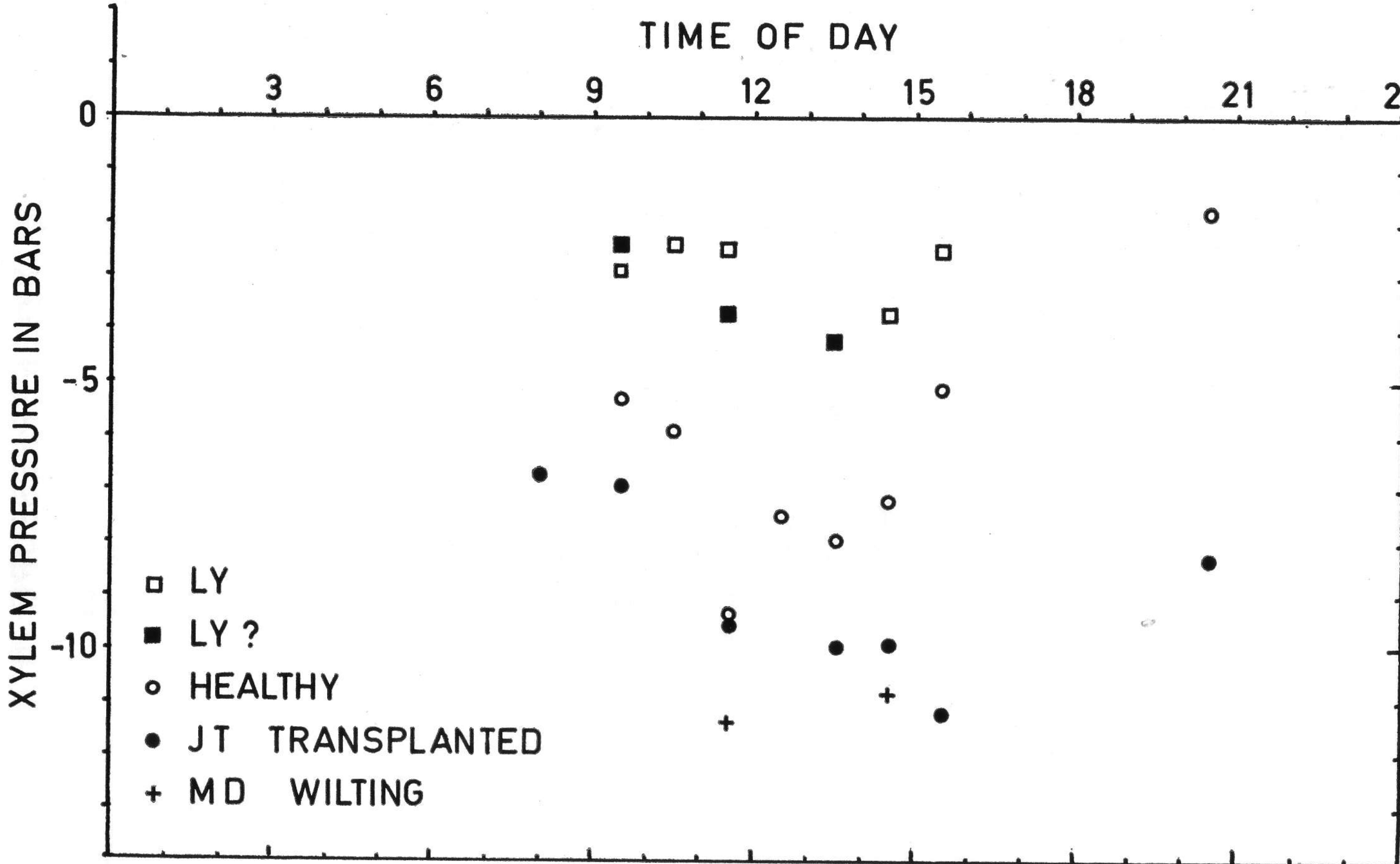
In the same area two apparently healthy trees were selected. One of these (Fig. 3 ■) followed the diurnal pattern associated with diseased trees. Two weeks after these measurements typical LY symptoms began to develop. In another tree (not shown) tensions were slightly reduced (pressures raised) at the time of first measurement. A January frost, approximately one month after measurements were begun on this tree, may have affected subsequent observations. However, over a period of about three months, midday measurements remained high (as compared to values of non-diseased trees). Finally, after three months the first symptom of LY development (premature nut fall) was observed. Unfortunately, the tree's removal prevented confirmation of LY.

A final aspect of this study was the measurement of a coconut palm of the 'Malayan Dwarf' cultivar whose foliage appeared very wilted (Fig. 3 +). This variety is considered highly resistant to LY and is often used to replace the 'Jamaican Tall' cultivar. In contrast to LY-diseased trees, xylem pressures of this tree remained low even during the evening hours (e.g. –8.3 bars at 20:30 h) when transpiration normally ceases and pressures increase. High xylem tension (low pressure readings) can be explained by excessive water loss or dessication, a disruption of water transport commonly associated with the wilt syndrome. A recently transplanted 'Jamaican Tall' showed similar low pressures (Fig. 3 ●).

These observations are interesting for two reasons. First, they indicate that LY is the opposite of a wilt disease. The pathogen seems to produce a metabolite that ascends in the xylem and causes stomata to close. Second, xylem pressure measurements seem to permit disease recognition at least two weeks ear-



2. Comparison of diurnal pressure variations in the xylem of leaflets of young (3 m tall), healthy coconut palms on sunny (○), cloudy (●), and and heavily overcast (□) days. Lowest pressures are reached in bright sunshine. Cloudy weather raises the low midday pressures. Vertical lines indicate standard deviations.



3. Xylem pressures in leaflets of mature coconut palms (6–7.5 m tall), measured on sunny days. Palms showing symptoms of lethal yellowing, had unusually high pressures (□ LY). Xylem pressures in an apparently healthy tree nearby were also high (■ LY?); this tree showed nut fall two weeks later, and typical LY symptoms continued to appear over the next few months. An unhealthy-looking coconut palm planted on a golf course a few years after LY-diseased 'Jamaican Tall' coconut palms had been removed, showed very low xylem pressures, typical of wilting (+ MD). A recently transplanted 'Jamaican Tall' coconut palm (● JT) also showed excessive tensions in the xylem, particularly notable late in the day. The diurnal pressure variations of two healthy, mature coconut palms from a noninfected area are indicated for comparison (○ Healthy). Scatter of results was similar to that shown in Figure 1; vertical lines are omitted for the sake of clarity.

lier than the previously recognized first symptom (nut fall). This is of practical importance because early oxytetracycline treatment raised the percentage of trees that responded favorably to treatment to 90% (McCoy, 1976b).

The severe frost of 20 January 1977 interfered with the continuation of these measurements. Most coconut palms lost many leaves, and measurements of xylem pressure on palms with greatly reduced crown size are not very meaningful. It is hoped that future studies will confirm our findings and that pressure measurements can be correlated with other observations such as stomatal opening. It would also be interesting to see if other yellows diseases cause stomatal closure and to examine possible relationships between leaf yellowing and stomatal closure.

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