WATER RELATIONS OF COCONUT PALMS AFFECTED WITH ROOT (WILT) DISEASE

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Summary

The water relations of apparently healthy and root (wilt)-diseased coconut palms (*Cocos nucifera* L.) were investigated. Leaves of diseased palms had lower stomatal resistances (with relatively high transpiration rates) and leaf water potentials than apparently healthy palms. Although there was a small reduction of osmotic potential in leaves of diseased palms, there was almost complete loss of turgor potential, and flaccidity resulted.

Key words: *Cocos nucifera* L., Stomatal resistance, root (wilt) disease, water relations, flaccidity.

Introduction

Root (wilt) disease of coconut in Kerala, India, is characterized by irreversible flaccidity of the leaves (Radha & Lal, 1972). In the early stages of the disease symptoms include flattening and bending of leaflets; this is followed by ribbing at later stages. Our earlier studies of diseased palms indicated that dysfunction of stomatal regulation occurred. There was abnormally wide stomatal opening (Rajagopal, Patil & Sumathykuttyamma, 1986) and irrespective of the age of the palm, time of day or season, the transpirational loss of water was significantly higher from leaves of diseased palms than from those of healthy palms. This paper reports an investigation of the water relations of healthy and diseased palms.

Materials and Methods

Coconut palms (*Cocos nucifera* L. var. West Coast Tall), raised at the Institute Farm, were used in the experiments. Eight-year-old palms were maintained as described earlier (Rajagopal *et al.*, 1986).

Stomatal resistance and water relations measurements were determined simultaneously using the opposite leaflets of the same leaf for each parameter. Stomatal resistance and transpiration rate of the first fully opened leaf and the middle leaf (14th from the top) were determined in the field with a Li–Cor 1600 Steady State Porometer (Lamda Instruments, Nebraska, USA) as described earlier (Rajagopal *et al.*, 1986).

Leaf water potential (ψ) was determined on excised leaves using a Scholander pressure chamber (Plant Water Console 3000, Soil Moisture Equipment, USA) according to the method of Milburn & Zimmermann (1977). As suggested by the

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Table 1. *Stomatal resistance, transpiration rate and leaf water potential in root (wilt)-affected coconut palms*

	Apparently healthy palm		Diseased palm	
	First whorl	Middle whorl	First whorl	Middle whorl
Stomatal resistance (cm^{-1} s^{-1})	4·35± 0·52	4·94± 0·39	2·30± 0·18	2·83± 0·26
Transpiration rate (μg cm^{-2} s^{-1})	3·60± 0·33	4·20± 0·29	7·80± 0·68	7·50± 0·81
Leaf water potential (MPa)	−1·51± 0·02	−1·77± 0·01	−1·99± 0·03	−1·99± 0·02

Measurements were made on the leaflets of first- and middle-whorl leaves in the dry season (December, 1983). Values are means of 16 palms ±SE of the mean.

authors, precaution was taken to avoid disruption of xylem continuity during the sample preparation.

To obtain sap for leaf osmotic potential (π) determinations, leaflets were cut into small segments and immediately plunged into liquid nitrogen. After a few minutes of thawing, sap was obtained using a screw-type metal hand press, especially designed on the lines of a hypodermic syringe for hard leaf material, such as coconut (Slavik, 1974). The π of the leaf sap was determined with a vapour pressure osmometer (Wescor, USA). The turgor potential (P) was calculated from the values obtained for ψ and π using the formula $P = \psi - \pi$ (Slavik, 1974).

RESULTS

The first fully opened and middle leaves of diseased palms exhibited lower leaf diffusive resistances and higher transpiration rates than similar leaves from apparently healthy palms (Table 1). The ψ values of apparently healthy palms were −1·51 MPa and −1·77 MPa in the two leaves, whereas both leaves of the diseased palms showed a lower ψ value (−1·99 MPa).

Water potential varied in different leaves, the spindle leaves exhibiting higher potentials than the leaves in other whorls further down, irrespective of the condition of the palms (Table 2). Relationships between the leaflet condition and ψ indicated that generally ψ was reduced in all the leaves of diseased palms compared to apparently healthy ones. For instance, ψ in the middle-whorl leaves, which showed the typical flaccidity with some yellowing and necrosis, was −1·28 MPa compared to −0·79 MPa in the dark-green turgid leaves of apparently healthy palms.

Determinations of ψ at dawn (06·00 h) and in the afternoon (14·00 h) again revealed that the apparently healthy palms always had higher ψ than the diseased leaves (Table 3). Osmotic potential was lower in diseased leaves than in those of apparently healthy palms (Table 4). Turgor potential was only 0·04 MPa in the flaccid leaves of the diseased palms, which was much less than that of the turgid leaves of apparently healthy palms.

Table 2. *Changes in leaf water potential (ψ) with leaf age and leaflet condition in root (wilt)-affected coconut palms*

Position	Apparently healthy palm	ψ (MPa)	Diseased palm	ψ (MPa)
Spindle	Yellow to light green, thick, stiff	−0·37 ± 0·02	White to dull cream, thin, papery, brown spots	−0·72 ± 0·06
First whorl	Green, normal, erect	−0·68 ± 0·06	Light green, slight flattening and bending at the tip	−1·24 ± 0·08
Middle whorl	Dark green, normal, erect	−0·79 ± 0·07	Flaccidity, yellowing, necrosis	−1·28 ± 0·08
Outer whorl	Dull green, senescent but normal	−0·89 ± 0·07	Ribbing, necrosis, abnormal senescence	−1·26 ± 0·09

This experiment was carried out in the 'wet' season (September 1983). Values are means of six palms ±SE of the mean.

Table 3. *Leaf water potential (ψ, MPa) at pre-dawn (06·00 h) and in the afternoon (14·00 h) in root (wilt)-affected coconut palms*

	Palm condition	
Time (h)	Apparently healthy	Diseased
06·00	−0·23 ± 0·01	−0·41 ± 0·03
14·00	−1·27 ± 0·07	−1·67 ± 0·13

ψ was determined on the leaflets of middle-whorl leaves during summer (April 1984). Values are means of eight palms ±SE of the mean.

Table 4. *Water potential (ψ) osmotic potential (π) and turgor potential* (P) *of leaves of root (wilt)-affected coconut palms*

Palm condition	ψ (MPa)	π (MPa)	*P* (MPa)
Apparently healthy	−1·34 ± 0·10	−1·68 ± 0·16	+0·34 ± 0·03
Diseased	−1·79 ± 0·13	−1·83 ± 0·19	+0·04 ± 0·01

Determinations were made on the middle-whorl leaves at noon during the summer (May, 1984). Values are means of eight palms ±SE of the mean.

Discussion

Measurements of the water relations of infected palms showed the consequences of the impairment of stomatal regulation, which resulted in greater loss of water, observed earlier by Rajagopal *et al.* (1986). Leaf ψ of of healthy coconut palms ranged from −1·2 to −1·7 MPa in the daytime depending on leaf position and the season (Tables 1 to 3), while the average pre-dawn ψ was −0·23 MPa (Table 3). Milburn & Zimmermann (1977) and Milburn & Davis (1973) also reported ψ down to −1·5 MPa in coconut. Diseased palms consistently had lower leaf ψ than controls at any given time. The nature of symptoms on the leaflets of different whorls of leaves, i.e. of different ages, reflected the changes in ψ. In the absence of significant effects of disease on π, changes in P closely followed changes in ψ. Although the most perceptible symptom of disease, namely flaccidity, occurred on leaves of the middle whorl, changes in ψ had already begun in the younger spindle leaf and first-whorl leaves. Thus, the appearance of distinct flaccidity on the middle-whorl leaves may not have been a consequence of a sudden event but rather the result of progressive changes beginning at the spindle-leaf stage. Indeed Dwivedi *et al.* (1979) showed that the earliest diagnostic symptom of disease could be located on the spindle leaf.

In the month between the spindle-leaf and the first-leaf stage, the ψ of diseased palms fell from −0·72 MPa to −1·24 MPa (Table 2). The initial change associated with flaccidity, namely flattening and bending of the leaf tip could be seen on the first-whorl leaves, although it might have been initiated much earlier. Once it had started, the later development of symptoms appeared to depend more on histological alterations in the tissues rather than on any significant change in ψ. Thus, there was little difference in ψ between the leaves of middle and outer whorls (−1·28 MPa and −1·26 MPa, respectively). Various changes in the overall cell structure (size, thickness and division) between the healthy and diseased leaves were observed previously by Govindankutty (1981). It was concluded that accelerated transverse division and curtailed longitudinal division of the upper epidermal cells might explain the typical bending of leaflets of diseased palms.

In contrast to other diseases caused by mycoplasma-like organisms (MLOs), in the root (wilt) disease of coconut, with which MLOs are associated (Solomon, Govindankutty & Nienhaus, 1983), there was abnormally wide stomatal opening (Rajagopal *et al.*, 1986). The xylem pressure potential of plants affected by lethal yellowing disease of coconut was higher than that of healthy palms, and this was attributed to early stomatal closure (McDonough & Zimmermann, 1979). Similarly, in American elms showing yellowing caused by MLOs, stomatal resistance and xylem pressure potential were higher than in controls both indicating that infection caused stomatal closure (Matteoni & Sinclair, 1983). In contrast, McDonough & Zimmermann (1979) found reduced xylem pressure potential in the Malayan Dwarf variety of coconut with symptoms of wilt. According to them, this was the result of excessive water loss, a characteristic associated with wilt disease. This is in agreement with the trend observed in the root (wilt) disease of coconut, where infected plants also showed a higher transpiration rate, with lower ψ than controls.

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