

Non-stomatal inhibition of photosynthesis in arecanut palms affected with yellow leaf disease*

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Abstract : Gas exchange rates in the apparently healthy and yellow leaf diseased (YLD) arecanut palms were studied. Net photosynthetic rate (A) was significantly reduced in the leaves of diseased palms compared to apparently healthy palms, while internal CO_2 concentration (C_i) increased. Stomatal conductance (g_s) and transpiration rate (E) decreased significantly in the diseased palms. Significant reductions in A/g_s and A/C_i ratios were also observed in diseased palms. Similar trend was observed at different times of the day (8.00 to 16.00 h). The results indicate that mesophyll factors were more affected than the stomatal factors in the leaves of diseased palms. Hence, A was reduced more than E leading to low A/E ratio.

Keywords : Arecanut palms, yellow leaf disease, inhibition, photosynthesis

Yellow Leaf Disease (YLD) of arecanut (betelnut) caused by mycoplasma like organisms (MLOs) (Nayar and Seliskar, 1978) in Southern India is characterised by 'yellowing' of the leaves of the outer whorl (Rawther, 1976). Earlier studies of diseased palms indicated that impairment of stomatal regulation occurred (Anonymous, 1990). There was abnormal stomatal closure and reduced rates of photosynthesis in the leaves of diseased palms than from those apparently healthy palms (Anonymous, 1990). Since photosynthesis is regulated by stomatal and mesophyll factors, it is imperative to find out their relative roles in limiting photosynthesis under a given biotic stress conditions. Hence, the present study was undertaken to find out the role of these factors in regulating photosynthesis in YLD affected palms as the information is not available in 'yellows' diseases caused by MLOs.

MATERIALS AND METHODS

Eighteen to twenty year old arecanut palms (*Areca catechu* Lin.) var. South Kanara affected with yellow leaf disease (disease index score 20-23 which was calculated according to method of George *et al.*, 1980) as well as apparently healthy palms grown in a farmers field at Sullia, Karnataka were used for the experiments. The palms were planted at a spacing of 2.7×2.7 m and each was applied fertilizer annually with 100:40:140 g NPK. The palms received weekly irrigation during summer months.

Net photosynthetic rate (A), stomatal conductance (g_s) intercellular CO_2 (C_i) and transpiration rate (E) were measured on the detached outer leaf (which exhibits typical yellowing symptoms) using a Licor-6200 portable photosynthesis system (Licor, Nebraska, USA) with one litre chamber enclosing upto 20 cm^2 leaf area as per procedure described by Balasimha *et al.* (1991). The measurements were made between 10.00 and 12.00 h except diurnal patterns.

During measurements, the photosynthetically active radiation (PAR) ranged between 1000 and 12000 $\mu\text{mol m}^{-2}$, leaf temperature between 30 and 33°C and vapour pressure deficit (VPD) between 1.84 and 2.34 Pa. The ratios of A to g_s , A to C_i and A to E were then calculated. Diurnal variations in A, g_s , C_i , PAR, leaf temperature and VPD were studied between 8.00 and 16.00 h.

RESULTS AND DISCUSSION

A, g_s , C_i , E and ratios of A/ g_s , A/ C_i and A/E are presented in Table 1. The diseased palms showed lower A and higher C_i with significant reduction in g_s and E, compared to apparently healthy palms. When determination on A were made at different times of the day, i.e., from 8 to 16 h, the leaves of apparently healthy palms clearly showed an increase in A with increase in PAR, temperature and VPD up to 12 h and then declined (Fig. 1). On the other hand, the diseased palms exhibited decrease in A throughout the day. The g_s decreased more in the diseased palms than apparently healthy palms at any given

Table 1 : Net CO_2 assimilation rate (A), stomatal conductance (g_s), intercellular carbon-dioxide (C_i), transpiration rate (E) in the leaves of apparently healthy and yellow leaf diseased (YLD) arecanut palms

Parameters	Apparently healthy	Diseased	t-test
A ($\mu\text{mol m}^{-2}\text{s}^{-1}$)	5.9*	1.2 (79.2) ^b	16.1**
g_s ($\text{mol m}^{-2}\text{s}^{-1}$)	0.5	0.2 (-55.8)	2.9**
C_i (ppm)	266.4	289.1 (+7.8)	2.2*
E ($\text{mmol m}^{-2}\text{s}^{-1}$)	4.5	2.5 (-44.5)	3.2**
A/ g_s	15.8	6.6 (-58.1)	3.4**
A/ C_i	0.02	0.0038 (-83.5)	15.0**
A/E	1.6	0.6 (-60.5)	4.4**

Determinations were made on the outer-whorl leaves in the 'wet' season (October 1989) between 10 h and 12 h.

* Mean of 15 palms.

^b Values in parentheses show percentage increase (+) and decrease (-) over apparently healthy palms. Significant at $P = 0.01$ (**) or $P = 0.05$ (*).

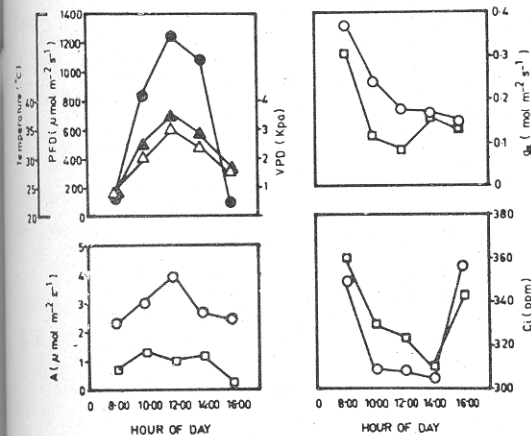


Fig. 1 : Day time fluctuations in environmental variables recorded in the vicinity of the palms: photon flux density (●), temperature (Δ) and VPD (▲), and A, g_s and C_i in the leaves of apparently healthy palms (○) and YLD affected palms (□).

time. The diseased palms had higher levels of C_i irrespective of hour of the day as compared to apparently healthy palms.

The ratio of A to g_s was significantly lower in the diseased palms (Table 1). This decrease was obviously due to more reduction in A (79.3%) than g_s (55.8%). Since A is function of both stomatal and mesophyll factors, it is evident that observed decrease in A/ g_s ratio was due to mesophyll factors being affected more than stomatal factors. Similarly, Jacob *et al.* (1990) reported the decreased A/ g_s ratio in sorghum and amaranthus grown under low levels of nitrogen fertilizer, thus suggesting non-stomatal inhibition of A.

Non-stomatal inhibition of photosynthesis by abscisic acid (ABA) in addition to its effect on stomata has been reported earlier (Cornic and Migniac 1983; Raschke and Hedrich, 1985; Bunce, 1987; Wård and Bunce, 1987). In these experiments, a decrease in both g_s and A have been observed with higher levels of C_i , suggesting a decline in biochemical capacity to fix carbon in response to ABA. Accumulation of ABA in leaves following mechanical girdling in grape and its involvement in source-sink relationships was documented (Loveys and Kriedmann, 1974). It is presumed that obstruction of phloem translocation in YLD affected palms (Nayar, 1976) could have caused accumulation of ABA in the leaves. This increased levels of ABA might have directly affected the photosynthetic apparatus in diseased palms leading to reductions in A (Table 1 and Fig. 1). Hormonal imbalance, particularly accumulation of ABA has been reported in the MLOs caused lethal yellowing affected coconut palms in Mexico (Leon *et al.*, 1991), in which the stomatal regulation is similar to the one observed in YLD of arecanut.

That the carboxylation efficiency was also affected in the diseased palms was indicated by 83.47% reduction in A/C_i ratio of diseased palms compared to apparently healthy palms (Table 1). Indeed, ABA induced decrease in Rubisco activity linked to a decrease in A has been reported in *Pennisetum typhoides* (Sankhla and Huber, 1974). The observed reduction in the A/E ratio (measure of instantaneous water use efficiency) in diseased palms (Table 1) may be attributed to the significant reductions in the A/C_i ratio, probably coupled with the lack of strong feed back control of g_s by g_m leading to the impairment of stomatal regulation.

Thus, the results suggest that there is mesophyll limitation of A in the leaves of diseased palms, thereby increasing the C_i . This is the first report showing non-stomatal

limitation of A in 'yellows' diseases caused by MLOs.

Acknowledgements

We thank Dr. M.K. Nair, Director, Central Plantation Crops Research Institute, Kasaragod and Dr. K.B. Abdul Khader, Joint Director In-charge, CPCRI Regional Station, Vittal for facilities and encouragement. We also thank Dr. K.K.N. Nambiar, Head, Division of Crop Protection, CPCRI, Kasaragod and Dr. V. Rajagopal, Head, Division of Physiology & Biochemistry, CPCRI, Kasaragod for reading the manuscript and helpful comments.

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