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STOMATAL RESPONSES IN ARECANUT PALMS AFFECTED WITH YELLOW LEAF DISEASE*

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ABSTRACT

The stomatal responses of apparently healthy and yellow leaf diseased (YLD) arecanut palms were studied in two different seasons; (a) before symptom expression during May ('dry' season) and (b) after appearance of visible symptoms during October ('wet' season); and at different times of the day at two diseased areas such as Sullia and Palode. During 'wet' season the leaves of diseased palms had higher stomatal resistance and water potential than apparently healthy palms while the transpiration rate was significantly reduced. The stomata of the diseased palms remain closed through most of the day in the 'wet' season. During 'dry' season these changes between the apparently healthy palms and diseased palms were not discernible.

INTRODUCTION

Yellow Leaf Disease (YLD) of arecanut (*Areca catechu* L.) a disease of mycoplasmal (MLOs) etiology (Nayar and Seliskar, 1978) is prevalent in Southern India. The disease is characterised by interveinal foliar yellowing (Rawther, 1976). The diseased palms start exhibiting the characteristic yellowing symptom from the tip of leaflets of the outer whorl during South-West monsoon. This is followed by necrosis at later stages and symptoms are discernible during the entire wet season (June-October). In majority of the diseased palms, the symptoms begin disappearing well before the onset of 'dry' season and remain symptomless during 'dry' season (December-May). Stomatal closure as distinctive feature of plant 'yellows' disease caused by MLOs was reported earlier (Matteoni and Sinclair, 1983). Though irregular shaped stomata with shrunken stomatal pore was reported in the diseased palms (Nair, 1976), an insight into aspects associated with stomatal regulation had not been studied. The main objective of the present study was to investigate the change in water relations in YLD affected palms in two locations during seasons and through the day.

MATERIALS AND METHODS

Arecanut palms (*Areca catechu* L. Var. South Kanara) planted at different locations viz., a)in the institute farm at Vittal ('disease free area'), (b) in the Institute farm at Palode (disease affected area) and (c) in a farmer's field at Sullia (disease affected area) were used in the present experiment. 18-20 year old palms were maintained adopting the recommended package of practices, spacing (2.7 X 2.7 m), fertilizer application (100:40:140 g of NPK per palm per year) and summer irrigation at weekly intervals.

Stomatal resistance (r_s), and transpiration rate (E) were determined using the opposite leaflets of the same leaf for each parameter. The measurements were made on the excised leaflets of first fully opened, middle and outer leaves in the field during the months of May (dry season) and during the month of October (wet season) with a Licor-6200 portable photosynthesis system with one litre chamber enclosing upto

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20 cm^2 leaf area according to the method of Rajagopal *et. al* (1986). Environmental variables like light, temperature and VPD near the palms were also recorded at both places.

Leaf water potential (ψ) was determined on excised leaves using a Scholander pressure chamber (Soil moisture equipment, USA) according to the method of Milburn and Zimmermann (1977). This work was done only at Sullia and Vittal.

RESULTS

The mean environmental variables recorded during the season are presented in Table I. PAR, temperature and VPD were higher in 'dry' season than in 'wet' season. The data on r_s, ψ and E for 'wet' and 'dry' seasons are given in the Tables II and III. The outer and middle leaves of diseased palms had higher r_s and low E than similar leaves from apparently healthy palms in the 'wet' season. The trend was similar in both the locations (Table II and III). There was

Table I. ***Mean microclimatic variables recorded in the vicinity of palms.***

Location	Season	PAR ($\mu mol\ m^{-2}s^{-1}$)	Tair (O^oC)	VPD (kPa)	Visual symptoms
Sullia	Dry	1651	39.19	3.72	Absent
	Wet	1168	33.11	2.69	Present
Palode	Dry	1550	34.80	3.37	Absent
	Wet	1180	29.20	1.86	Present
Vittal	Dry	1609	37.09	3.24	Absent
	Wet	1228	32.67	2.85	Absent

Table II. ***Stomatal resistance, transpiration rate and leaf water potential in the leaves of healthy, apparently healthy and YLD diseased areca palms during the 'dry' (May) and 'wet' (October) seasons at Sullia and Vittal.***

Parameter/ Category	Dry season (May)			Wet season (October)			LSD			
	First leaf	Middle leaf	Outer leaf	First leaf	Middle leaf	Outer leaf	Category May	Category October	Leaf position May	Leaf position October
1. Stomatal resistance rs (scm^{-1})										
a) Healthy	3.13	3.24	3.06	1.78	1.44	2.14				
b) Apparently healthy	3.02	3.05	3.40	1.75	1.71	3.15	NS	0.524**	NS	0.524**
c) Diseased	3.06	3.31	2.97	1.77	2.13	5.84				
2. Transpiration rate, E($mmol\ m^{-2}s^{-1}$)										
a) Healthy	4.00	4.15	4.18	6.60	7.58	5.92				
b) Apparently healthy	3.56	3.64	3.40	5.81	5.51	4.04	0.320*	0.570**	NS	0.570**
c) Diseased	3.29	3.81	3.20	6.68	5.32	2.70				
3. Water potential (Mpa)										
a) Healthy	-1.26	-1.35	-1.32	-1.26	-1.21	-1.14				
b) Apparently healthy	-1.10	-1.11	-1.11	-1.21	-1.20	-1.13	0.064	0.068**	NS	0.068**
c) Diseased	-1.06	-1.06	-1.06	-1.15	-0.95					

Values are means of twenty palms; Determinations were made on the detached leaflets of first, middle and outer whorl leaves.
**denotes significant at P=0.01, NS = Not Significant

Table III. ***Stomatal resistance (rs) and transpiration rate (E) in the leaves of apparently healthy and YLD affected palms during dry and wet seasons at Palode (mean of 13 palms± SE)***

Parameter/ Category	Dry season		Wet season	
	Middle	Outer	Middle	Outer
Stomatal resistane ($s\ cm^{-1}$)				
Apparently healthy	3.20±0.39	3.52±0.21	4.88±0.49	6.20±0.32
Diseased	3.89±0.45	3.92±0.57	7.69±0.57	8.32±0.27
Transpiration rate ($mmol\ m^{-2}\ s^{-1}$)				
Apparently healthy	3.66±0.35	4.01±0.11	3.81±0.12	3.50±0.58
Diseased	3.72±0.14	3.88±0.15	3.20±0.26	3.00±0.01

a significant linear relationship between E and r_s. The trend was similar irrespective of the palm condition and season. Pooled data is presented in Fig. 2. The ψ values of apparently healthy palms were -1.13 Mpa and -1.20 Mpa in the two leaves, whereas both the leaves of the diseased palms showed higher values (-0.95 and -0.81). When the determinations on the r_s were made at different times of the day i.e., from 8 h to 16 h, the leaves of apparently healthy palms showed an increase in r_s with increase in light, temperature and VPD (Fig.1). Even though the diseased palms followed similar diurnal patterns, the stomata of diseased palms closed through the most of the day and thus result in accumulation of water (Fig.1). E was reduced in the leaves of diseased palms irrespective of hour of the day as compared to apparently healthy palms. The differences in water relation components between apparently healthy palms and diseased palms were not observed during the 'dry' season (Table II).

DISCUSSION

The two seasons ('dry' and 'wet') in which the experiment was conducted differed not only in environmental variables, but also in the expression of disease symptoms in both the locations (Table I). A high evaporative demand in the atmosphere existed during 'dry' period as indicated by high PAR, temperature and VPD and masked the diseased symptoms, while during 'wet' season the weather parameters showed differences and the palms exhibited clear symptoms of the disease. There was no soil moisture stress during both the periods as the palms were under irrigation, although atmospheric drought occurred during May. From the foregoing, it could be inferred that environmental variables may be playing an important role in manifestation of visible symptoms in the diseased palms. Similarly, the controlling influence of environmental variables, particularly temperature on the growth of *Spiroplasma citri in vitro* is well documented (Chen and Davis, 1979). According to them, the optimal temperature for growth of *S. citri* ranged from 28° to 33°C and practically no growth occurred at 37°C. This optimal temperature was found to be favourable for the expression of a stubborn disease symptoms in citrus (Bove and Saillard, 1979). Probably the higher temperature recorded in both locations during dry season may have a detrimental effect on the organism thereby resulting in a temporary remission of symptoms.

The apparently healthy palms showed lower r_s (Table II and III) with decrease in radiation, temperature and VPD (Table I) during the 'wet' season while reverse trend occurred in the 'dry' season irrespective of location. There was no difference between the two seasons (Table II). It was obvious that environmental variables such as temperature, light and VPD differences

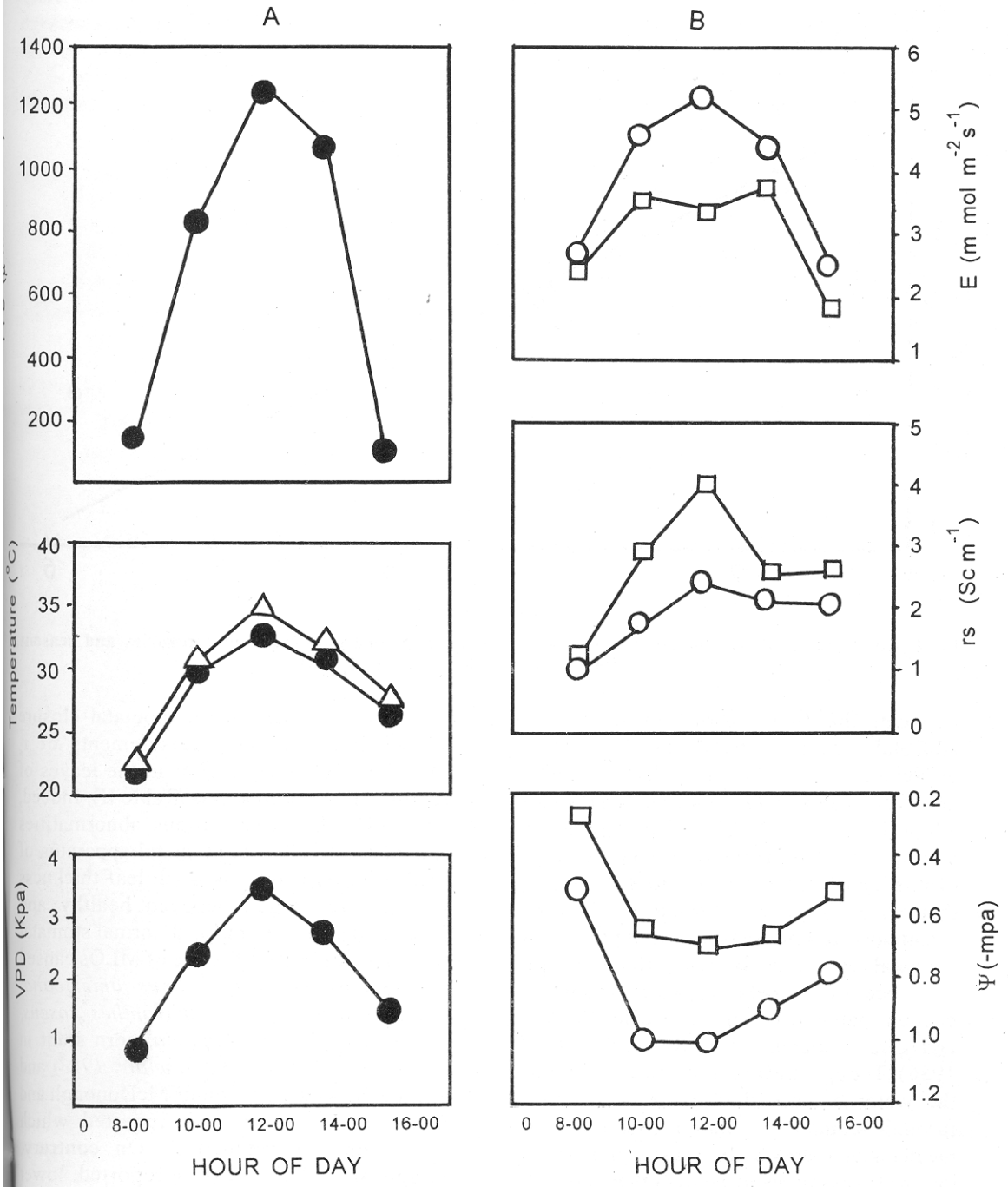

Fig. 1. A Day time fluctuations in environmental variables, (0-0) recorded in the vicinity of palms during the 'wet' season.

B. Day time fluctuations in water potential, stomatal resistance and transpiration rate in the leaves of outer whorl in the 'wet' season (0-0 apparently healthy palms Diseased palms)

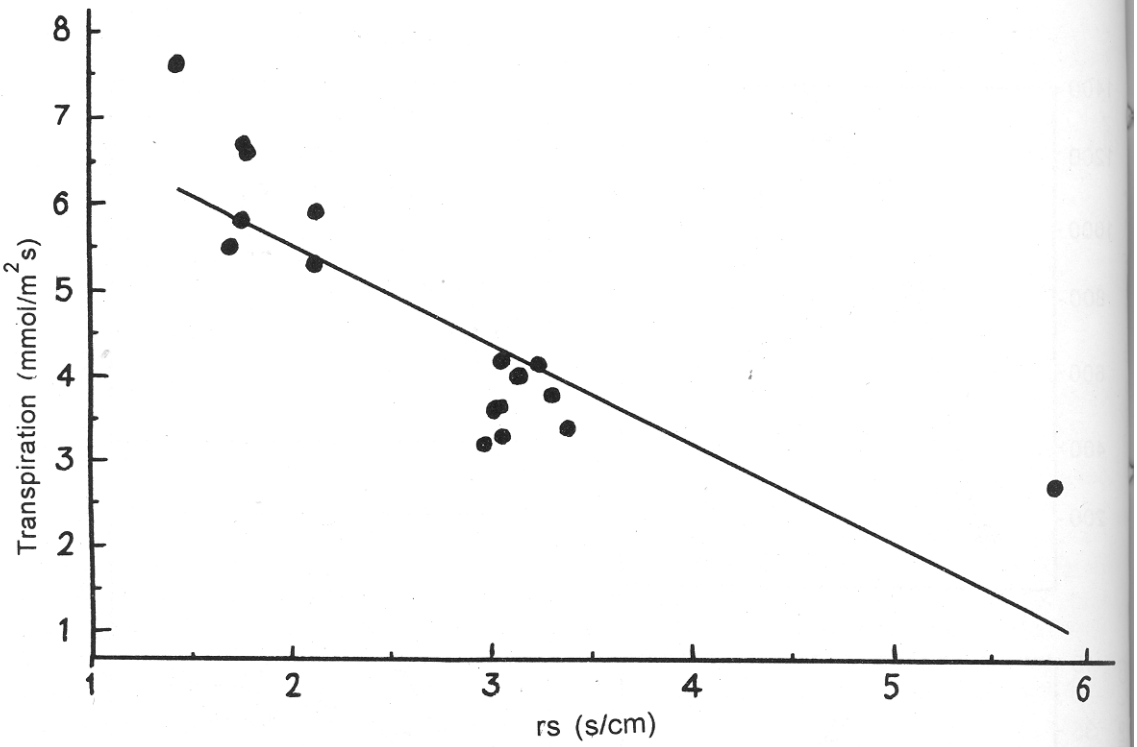

Fig.2. Relationship of transpiration to stomatal resistance; pooled data from all categories and seasons, y = 7.849 - 1.159 X, R^2= - 0.695, P<0.01.

between the two seasons influenced the stomatal regulation greatly as also reported by Schulze *et. al.* (1974). In diseased palms, however, r_s and ψwere higher in 'wet' season while in the 'dry' season, the trend was similar to the apparently healthy palms (Table II). From these observations, it appears that water balance of healthy palms was maintained in both seasons through effective stomatal regulation. Similarly, the controlling influence of stomata on water balance of coconut palms was reported earlier (Milburn and Zimmermann, 1977; Rajagopal *et. al.*, 1986). Though the diseased palms maintained the water balance during the 'dry' season through stomatal regulation, the regulatory mechanism seems to be greatly impaired in the 'wet' season resulting in higher leaf water potential and stomatal resistance (Table II), thus indicating that the diseased palms could be identified from healthy plants only in the 'wet' season.

The evidence for the stomatal closure was obtained through measurements of r_s which was relatively higher in the leaves of yellow leaf diseased palms (Table II). Indeed, Nair (1976) reported various abnormalities in epidermal cells and stomatal apparatus of YLD affected palms although leaf thickness did not vary much between healthy and diseased palms. Similarly, abnormal stomatal closure as distinctive feature of MLOs caused yellows diseases of *Ulmus americana, Fraxinus americana, Catharanthes roseus,* x disease in *Prunus virgiana,* corn stunt in *Zea mays (Metteoni and Sinclair, 1983)* and lethal yellowing of coconut (McDonough and Zimmermann, 1979) was reported which reflect on the reduced E. On contrary, Rajagopal *et. al.*, (1987) reported lower stomatal resistance and water potential in the root (wilt) disease of coconut caused by MLO. According to them, there was excessive water loss, a characteristic feature associated

with the wilt disease. In conclusion, the present study indicates there is an imbalance in the water economy of diseased palms. This might be due to impaired stomatal functions.

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