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Water Stress in Coconut (*Cocos nucifera* L.) Palms

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Summary

Effect of soil moisture on morphological, physiological and biochemical responses of coconut genotypes was studied. The genotypes responded to moisture stress to different degrees. The number of drooping leaves was higher in COD x WCT than WCT and WCT x COD. WCT and WCT x COD had higher stomatal resistance, and leaf water potential than COD x WCT. Under stress, there was an increase in epicuticular wax in all the genotypes. The enzymes, acid phosphatase and glutamate - oxaloacetate transaminase, were enhanced during stress conditions. The yield characteristics between rainfed and irrigated palms revealed that there was greater decrease in total nut yield and kernel dry weight in COD x WCT than that in the other two genotypes.

Introduction

As a major oil producing crop, coconut has an important position with tremendous influence on the economy of Kerala state in India, where the crop occupies nearly 65% of the total area of 1.23 m has in the country. The agroclimate at Kasaragod (Northern Kerala) is characterised by high rainfall (360 cm), which is unfavourably distributed with about 84% during southwest monsoon (June to September) and 16% during north east monsoon (October to November). Early cessation or total failure of the monsoons results in long dry months (five to seven months) as in 1982-83 and 1986-87. This atmospheric drought combined with poor retention of water in the sandy or sandy loam soils on which coconut is mostly grown in this region further accentuates the drought situation.

Unlike in majority of cereals and pulses, the effect of drought persists in coconut for nearly two years in view of the long time lag (44 months) between the initiation of inflorescence primordia and ultimate nut yield (Rajagopal, V. & Shivashankar, S. unpublished). Although, the general effects of drought on yield are known, the mechanisms associated with drought tolerance in a perennial crop like coconut are not known. Therefore, the objective of the present study is to understand some of the morphological, physiological and biochemical responses associated with moisture stress in coconut genotypes.

Materials and Methods

Coconut palms (*Cocos nucifera* L.) grown in the Institute farm with the normal cultural and agronomic practices, maintained by Genetics and Agronomy divisions were selected for the studies with details as described earlier (Rajagopal *et al.*, 1989a; Voleti *et al.*, 1989). Different genotypes were used in the present investigation (Tables 1 and 2). Six palms per genotype and 11th leaf were used for the determination of all physiological and biochemical parameters. Agrometeorological parameters were recorded as described earlier (Kasturibai *et al.*, 1988). Soil moisture content at different depths (0-25, 25-50 and 50-100cm) was determined gravimetrically. Stomatal resistance (r_s) and leaf water potential (ψ) were determined using Li-Cor 1600 steady state porometer and

Table. 1. Effect of drought on leaf condition and immature nut fall in coconut genotypes (1982-1983)

Genotypes	Mysore tall	WCT	WCT x COD	COD x WCT
Total no. of leaves	25	27	29	22
No. of functional leaves	10(40)*	23	23(81)	12(54)
No. of drooping leaves	10(40)	3(12)	6(19)	8(38)
No. of broken leaves	5(20)	-	-	2(8)
Total no. of nuts	80	91	140	122
Nuts retained	37	59	104	78
Nuts fallen	43	32	36	44
Percentage fall	54	37	26	36

Precentage values

Scholander pressure chamber respectively (Rajagopal *et al.*, 1986, 1987). Epicuticular wax (ECW) content was determined colorimetrically (Ebercon *et al.*, 1977). The activities of acid phosphatase (APH) and glutamate-oxaloacetate transaminase (GOT) were determined as per the methods of Linhardt & Walter (1963) and Bergmeyer (1963) respectively.

From each palm four nuts were collected every three months to avoid any seasonal variations. The fully matured nuts were harvested and the dry weights of husk, shell and copra were determined after drying in an oven till constant weights were obtained.

Results

Agroclimatic Conditions and Soil Moisture

During the experimental period (February-March) the mean values for light, air temperature, vapour pressure deficit and pan evaporation were 1400 $\mu E\ m^{-2}S^{-1}$, 34.2° C, 29.5 mb and 5,7 mm respectively. The total available soil moisture content in irrigated plots was 43.7 mm as against 9.5 mm under rainfed conditions.

Morphological Effects

It was observed that, depending on the severity of drought, Mysore tall and Chowghat Orange Dwarf x West Coast Tall (COD x WCT) showed 40 and 38% of drooping leaves and 20 and 8% broken leaves respectively, whereas WCT and WCT x COD had higher percentage of functional leaves (Table 1). The percentage of immature nut fall was higher in Mysore tall (54%) whereas the retention was higher in WCT x COD.

Physiological Effects — Irrigated palms of the three genotypes had lower r_s than those under rainfed condition. The r_s ranged from 3.94 sec. Cm^{-1} for WCT x COD to 3.24 sec. cm^{-1} for COD x WCT under irrigated conditions, whereas the rainfed palms of the three genotypes showed resistance to different degrees. Higher r_s was found for WCT followed by WCT x COD and COD x WCT (5.30, 4.54 and 3.51 sec. cm^{-1} respectively). Higher leaf ψ was observed in irrigated palms of WCT and WCT x COD in comparison to COD x WCT. The difference in leaf ψ between rainfed and irrigated palms were 0.37, 0.34 and 0.27 MPa for COD x WCT, WCT x COD and WCT respectively. Similarly, there was about 20 µg more epicuticular wax (ECW) in rainfed palms of COD x WCT when compared to irrigated ones.

Biochemical Effects — Genotypic variations existed in APH and GOT activities. Palms grown under rainfed conditions had higher activities of both the enzymes than irrigated palms. The percentage increase of these enzymes between the treatments ranged from 181-270 in case of GOT and 219-167 in case of APH for WCT and COD x WCT

Table 2. Response of coconut genotypes to moisture stress. Leaf stomatal resistance (r_s), leaf water potential (ψ) epicuticular wax (ECW) and enzymes are determined in the leaves of irrigated (IW/CPE of 0.75) and rainfed palms during Febuary

Parameters	Treatment	WCT	WCT x COD	COD x WCT
LWP, -MPa	A	-0.95	-1.04	-1.13
	B	-1.22	-1.38	-1.50
r_s, sec. cm^{-1}	A	3.50	3.94	3.24
	B	5.30	4.54	3.51
ECW, µg cm^2	A	102.80	97.40	79.10
	B	110.00	103.40	99.00
APH, µmol PNP h^{-1}mg^{-1} protein	A	128.10	201.40	220.20
	B	280.60	413.90	368.10
	C	219.00	205.50	167.10
GOT, µg pyruvate h^{-1}mg^{-1} Protein	A	7.84	7.80	6.83
	B	14.20	15.52	18.72
	C	181.00	198.90	270.10

A = irrigated; B = rainfed; C = % value

respectively (Table 2).

Yield — Nut yield was more in the hybrids than in the WCT under irrigation. However, under rainfed conditions, reduction in nut yield was only 17.5% in WCT as against 24.3% and 22.9% respectively in WCT x COD and COD x WCT as compared to irrigated palms. Similarly, the dry weights of nut (15.6%) and copra (17.8%) were influenced to a greater extent in COD x WCT than in other two genotypes (Table 3).

Discussion

The relationship between the aridity index and visual symptoms of drought in coconut has been reported recently (Rao, 1985). Prolonged drought results in bending and breaking of leaves and high degree

Table 3. Response of coconut genotypes to moisture stress. Nut yield and dry weight are collected for two years and mean values are given

Parameters	Treatment	WCT	WCT x COD	COD x WCT
Nut yield, palm^{-1} year^{-1}	A	120.0	136.0	130.0
	B	99.0	103.0	101.0
	C	82.5	75.7	77.6
Nut dry wt, g nut^{-1}	A	603.4	592.2	575.5
	B	574.4	577.0	485.9
	C	95.2	97.4	84.4
Copra wt g nut^{-1}	A	189.9	175.0	194.0
	B	190.0	159.0	159.6
	C	100.5	90.8	82.2

A = irrigated; B = rainfed; C = % value

of senescence (Table 1). Delay in opening of spindle leaf and spathe (inflorescence) is also commonly observed (Rajagopal, V., unpublished). Besides these morphological effects, closure of stomata occurs which has been reported to increase with stress in coconut as in other species (Turner, 1974). Recently Rajagopal *et al.*, (1989a) have found the relationship between the soil water deficit and stomatal regulation in coconut which revealed the critical soil moisture for stress effects. The effects of weather variables and of soil types on the regulation of stomata have also been reported (Kasturibai *et al.*, 1988; Voleti *et al.*, 1989). The sensitivity of stomata appears to differ in the three genotypes and it is reflected on the leaf ψ between the irrigated and rainfed palms. The hybrid COD x WCT has lower ψ than the other two genotypes. Another indicator of moisture stress is the ECW which aids in checking the water loss from the leaf surface during stress as reported in many species (Ebercon *et al.*, 1977). The WCT palm contains higher ECW than the hybrids. Higher r_s, leaf ψ and ECW play a major role in combating stress (Balasimha *et al.*, 1988: Bengston *et al.*, 1978). Milburn & Zimmermann (1977) have reported that the water balance is achieved through opening and closing of stomata in coconut palm. The present results support the view that the water relation parameters could be useful indicators in identifying drought tolerant characters in coconut also.

Stress-induced increase in the activities of APH and GOT is observed in the genotypes which show differential response. These two enzymes are known to increase with stress in some plants like cotton (Vierra Da Silva, 1970) and the threshold leaf ψ for the enhanced activities of these enzymes has been reported for coconut recently (Shivashankar *et al.*, 1989). Drought tolerant genotypes have less increase in enzyme activity than the susceptible ones (unpublished). Of the three genotypes studied COD x WCT suffers most under stress conditions. This is reflected in the nut yield and dry weight which show greater decrease in rainfed palms of COD x WCT than either WCT or WCT x COD as compared to irrigated palms.

The present study thus highlights the impact of moisture stress in coconut. That some of the sensitive parameters like stomatal resistance, water potential and ECW and other related components can be used for screening large number of genotypes in field conditions has been shown recently by Rajagopal *et al.* (1989b), with major thrust on breeding programme (Rajagopal *et al.*, 1988).

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