Indian J. Plant Physiol., Vol, XXXVI No.2 pp.103-106 (June, 1993)

IMPACT OF ATMOSPHERIC AND SOIL DROUGHT ON THE LEAF WATER POTENTIAL AND MEMBRANE STABILITY IN COCONUT GENOTYPES

V.V.G. K. KURUP, S.R VOLETI AND V. RAJAGOPAL

Central Plantation Crops Research Institute,
Kasaragod-671 124.

Received 4 Aug., 1992

SUMMARY

The seasonal variations in stress parameters like leaf water potential and electrolyte leakage were studied in the popular coconut cultivar namely West Coast Tall (WCT) and the two hybrids WCT x Chowghat Orange Dwarf (COD) and COD X WCT, in relation to weather variables and soil moisture content. There was a significant difference in physiological parameters among the genotypes only during the stress period, characterized by high evaporative demand. The hybrid COD x WCT was found to be most sensitive to moisture stress as indicated by low leaf water potential, and high electrolyte leakage. This implies that the tall genotype and the hybrid with tall female parent (WCT X COD) are relatively more tolerant to moisture stress than the bybrid with dwarf female parent (COD X WCT).

INTRODUCTION

The coconut palm thrives well in warm weather with abundant sunshine, a mean temperature of 27 °C ± 6 °C and rainfall between 1300 and 2300 mm per year (Murray, 1977). A well distributed rainfall favours good growth and nut yield. However, due to disturbances in the rainfall pattern, sufficient soil moisture may not be available to coconut palm and this adversely affects the growth and yield. (Prasada Rao, 1985). Rajagopal *et. al.* 1990b).Only limited reports are available on the physiological and morphological adaptations in plantation. (Balasimha *et. al.* 1985 Rajagopal *et. al.* 1989). The objective of the present investigations was to study the impact of atmospheric and soil drought on some of the physiological processes of coconut palm.

MATERIALS AND METHDOS

The cocount palms (*Cocos nucifera L.*), namely West Coast Tall (WCT), WCT x Chowghat Orange Dwarf (COD) and COD X WCT were planted in 1965 at Institute Farm under rainfed condition with three fertilizer levels, maintained by the Agronomy Division. The present experiments were carried out on palms under only one fertilizer treatment i.e. 1.0 kg N, 1.0 kg P_2O_5 and 2.0 kg. K_2O per plam per year, in split doses. This monocrop experiment was laid out in a randomized block design in red sandy loam soil with three replications of six palms each at a spacing of 7.5 x 7.5m. The experiments were conducted in three different seasons i.e. stages: Post monsoon of 1987 (October - December), Summer of 1988 (January - May) and monsoon of 1988 (June - August). Based on the rainfall and soil moisture data these represented the pre-stress, stress and post-stress stages (I to III), respectively. Soil sampels were collected during three stages from the basins of two plams per genotpye, at a distance of 1M from the bole region, at three depths 0 to 25, 25-50 and 50-100 cm Soil. moisture content was determined gravimetrically. Agroclimatological parameters like light, temperature and relative humidity were measured in the vicinity of experimental palms with the steady state porometer (Li-Cor 1600. USA) as described earlier (Kasturibai *et al* 1988). Data on rainfall and pan-evaporation were collected from the climatological station of the Institute. Leaf water potential 'ψ' was determined in the leaflets from the first and sixth leaf position of three palms from each genotype, using the Scholander pressure chamber (Plant water console model 3000, Soil Moisture Co. USA). according to the method of Milburn and Zimmerman (1977) and Rajagopal *et. al.* (1987).

The rate of injury to cell membranes was estimated through the measurements of electrolyte leakage and potassium content. The leaf discs (0.7 cm diameter) were taken form the first and sixth leaves of three palms per genotype, only during the stress period (i.e. stage II). The leaf discs were kept in a test tube with 10 ml distilled water and the initial conductivity was determined after 10 minutes with Muilard's conductivity bridge. After the initial meaurement the discs were returned to the original solution. The tubes were kept in a boiling water bath for three minutes and the final conductivity of the solution was measured. The electrolyte leakage is expressed as percentage change over the initial conductivity. The potassium conten was measured on a Corning 400 flame photometer before and after boiling the solution. The standard solution was prepared with Analar KCI and the values of potassium leachate have been expressed in terms of ppm. The leakage is expressed in terms of percentage change over the initial value.

RESULTS AND DISCUSSION

During the experimental period from October 1987 to August 1988, there existed three distinct phases namely pre-stress, stress and post-stress as indicated by agroclimatic data (Table I). Of the three stages, the period between January and May (Stress) was characterized by atmospheric drought with high light intensity and temperature, low relative humidity and soil drought as revealed by the pan evaporation rate of 5.5. mm day^{-1}. The response of the three popularly cultivated genotypes WCT, WCT X COD and COD x WCT to the prevailing mositure stress was assessed by studying both the soil moisture extraction pattern and plant stress parameters like leaf water potential and electrolyte leakage.

Table- I. Agroclimatic conditions during the experimental period.

Parameters		Stages		
		I	II	III
Teperature, °C'				
	Max.	30.9	33.1	29.6
	Min.	22.0	22.6	22.8
Relatiive humidity %				
	Max.	66.3	82.6	93.0
	Min.	60.7	51.7	82.0
Light. mE m^{-2}s^{-1}		900 to 1135	1400 to 1650	
Evaporation rate,	mm day^{-1}	3.37	5.50	3.13
Rainfall,	mm	100.5	24.9	553.4

The differential extraction of soil moisture from the root zone of the three genotypes reflect on their rooting pattern (Figure - 1). At stage I (pre-stress conditions) the soil moisture content was relatively high in the sub-soil surface (0 to 25 cm) in WCT (7.43%) as compared to either COD x WCT (6.29%) or WCT X COD (6.02%), while the two

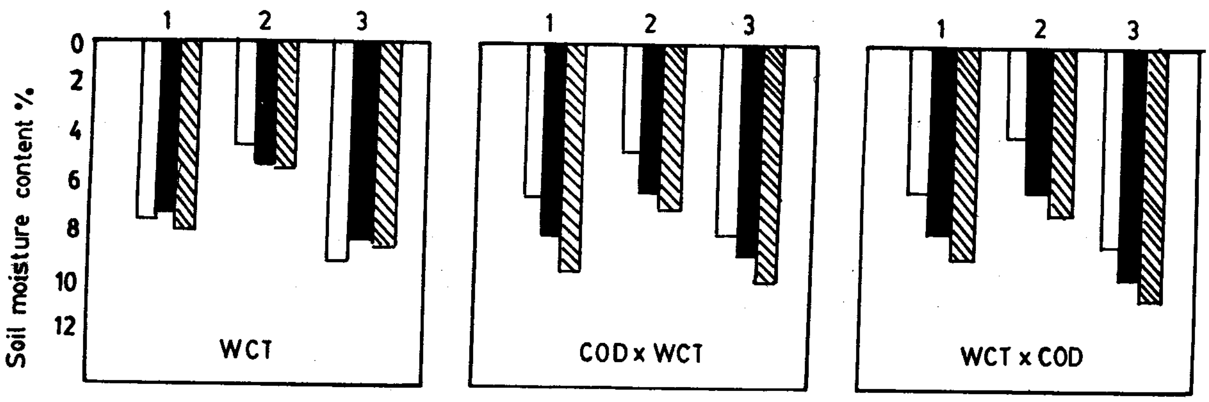

Figure.1 Soil moisture profile at three stages in coconut genotypes

□ 0 -25cm ■ 25- 50cm ▨ 50-100cm

Stage 1. Pre-Stress Stage 2. Stress Stage 3. Post-Stress hybrids had higher moisture content (9.31% and 8.64% respectively) at the lower depth, 50 to 100 cm than WCT. The soil mosture content declined during the next stage (stress period) at all the depths to different degree in the three genotypes. When the total soil profile was considered, the soil moisture decline between stage I and stage II, was found to be more in WCT (34.7%) than in COD x WCT, (27.4%) or in WCT x COD (28.4%). The soil moisture recovered at all depths at stage III (Post-stress) as a result of monsoon rains. This suggests that during stress period WCT had a better capacity to extract soil moisture form the deeper layers than the hybrids. It is interesting to note that COD x WCT tends to extract more water from the sub-soil layers. This perhaps might be the reason for its being sensitive to water deficit under field conditions. as the transpiration rate was also found to be high resulting in an imbalance in water economy. This is in agreement with earlier report on the drought tolerant nature of WCT and susceptibility of COD x WCT (Rajagopal *et al.* 1990a).

The leaf water potential varied among the genotypes and with leaf position (Figure 2). Irrespective of the genotype, the sixth leaf had lower 'ψ' than the first leaf. The 'ψ' decreased with the devlopment of stress in all the genotypes, The decline being less marked in the first leaf than the sixth. With the onset of the monsoon, there was a recovery in the 'ψ'.

The relationship between the changes in soil water potential and plant response has been well established in different crops (Blum 1974) including coconut (Rajagopal *et. al* 1989). Both the first and sixth leaf of WCT had a highter 'ψ' than the hybrid under pre-stress conditons (Figure 2). Even when subjected to moisture stress, WCT maintained higher 'ψ' than the hybrids, when the performance of different leaf positions was compared, it was found from the slope of the curve that the percentage decrease in 'ψ' was high in the sixth leaf of WCT and WCT x COD, while in COD x WCT this occurred in the first leaf. Earlier studies have also indicated that the 'ψ' was lower in COD x WCT than either in WCT or WCT x COD (Rajagopal *et al.* 1990a). The relationship between leaf age and position to changes in 'ψ' was shown in different crops (Aggarwal and Sinha 1984, Lasko *et al.* 1984). The rapid screening test using the changes in 'ψ' during period of dehydration of spindle leaf also indicated that COD x WCT undergoes greater degree of stress than the other two genotypes (Rajagopal *et al.* 1989).

The stability of the membrane was affected to different degrees in the three genotypes. The stress induced damage caused to the tissues is estimated in terms of electrolyte leakage and K+ content. In general, COD x WCT had a higher electrolyte leakage and K^+ content in the sixth leaf than the other two genotypes (Table II). This indicates that COD X WCT tissues experienced more damage than those of either WCT or COD X WCT. Leopold *et al.* (1981). and Blum and Ebercon (1981) reported the degree of membrane stability to stress in different species based on the electrolyte leakage. An increase in membrane stability in drought toler-

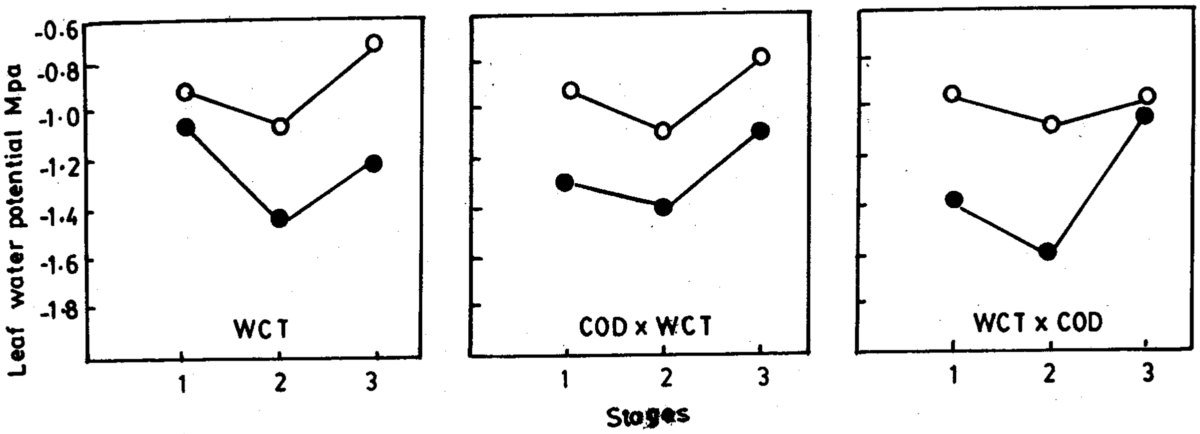

Figure.2. Leaf water potential in coconut genotyes during stress development

o—o 1st Leaf ●—● 6th Leaf

1 Pre-Stress 2. Stress 3. Post -Stress

ant *Ceraterostigma* as against lesser stability in drought sensitive *Spinacia oleracea* was reported by Schwab and Heber (1984).

Table II. Electrolyte leakage and potassium level in coconut under mositure stress. (% increase over initial value.)

Genotypes	Electrolyte leakage		Potassium leakage	
	First leaf	6th leaf	1st leaf	6th Leaf
Wct	245.9	234.1	290.1	272.1
COD x WCT	258.9	414.5	313.3	319.8
WCT x COD	132.3	213.3	2:1.4	225.3

That the membrane stability differs depending on the leaf age is evident form the present study, which is in agreement with the reports on other crops (Martineu *et al.* 1979, Blum and Ebercon 1981).

Form the foregoing account it is evident that coconut genotypes respond differently to the soil and atmospheric drought. The drought tolerant characteristics of WCT and WCT x COD and susceptible nature to COD x WCT are clearly indicated.

ACKNOWLEDGEMENT

We thank Dr. M.K. Nair, Director of the facilities and encouragement and Sri. Jacob Mathew and Sri K.Vijaya Kumar for statistical analysis. Our thanks are also due to Dr. Md. Yusuf, Head of Agronomy for the experimental material.

REFERENCES

Aggarwal, P.K and Sinha, S.K (1984). Difference in water relations and physiological characteristics in leaves of wheat associated with leaf position of the plant. *Plant Physiol.* 74: 1041.

Balasimha, D., Subramanian, N. and Subbaiah, C.C. (1985). Leaf Characteristics in cocoa accessions (*Theobroma Cacao* L.). *Cafe Cacao Tree* 29: 95.

Blum, A. (1974). Genotypic responses in soghum to drought stress II. Leaf tissue water relations. *Crop Sci.* 14: 691.

Blum, A. and Ebercon, A. (1981). Cell membrane stability as a measurement of drought and heat tolerance in wheat. *Crop Sci.* 21: 43.

Kasturi Bai, K.V., Voleti, S.R. and Rajagopal, V. (1988) Water relations of coconut palms as influenced by environmental varaibles, *Agric. Forest Meteorl.* 43: 193.

Lasko, A.N., Geyer, A.S. and Carpentey, S.G. (1984). Seasonal osmotic relations in apple leaves of different ages. *J. Am. Soc. Hort. Sci.* 109: 544

Leopold, A.C., Musgrave, M.E. and Williams, K.M. (1981). Solute leakage resulting form leaf desiccation. *Plant Physiol.* 68: 1222.

Martineau, J.R., Williams, J.H. and Specht, J.E. (1979). Temperature tolerance in soybeans. 11. Evaluation of segregating populations for membrane thermostability. *Crop. Sci.* 19: 79.

Milburn, J.A. and Zimmerman, M.H. (1977). Preliminary studies on sap flow in *Cocos nucifera* L.I. Water relations and xylem transport. *New Phytol.* 19 : 535

Murray, D.B. (1977). Coconut Palm. In: Ecophysiology of tropical crops. (Eds) TA de Alvin and TT Kozlowski Acad. Press, New York. pp 384.

Prasada Rao, G.S.H.V. (1985). Drought and coconut palm. *Indian Coconut J.* 15: 3.

Rajagopal, V., Sumathykuttyamma, B. and Patil, K.D. (1987). Water relations of coconut Palms affected with root (wil) disease. *New Phytol.* 105: 289.

Rajagopal, V., Shivashankar, S. and Kasturi Bai, K.V. (1988). Leaf water potential as an index of drought tolerance in coconut (*Cocos nucifera* L). *Plant Physiol. Bicohem.* 15: 80.

Rajagopal, V., Ramadasan, A., Balasimha, D. and Kasturi Bai, K.V. (1989). Influence of irrigation on leaf water reations and dry matter production in coconut palms. *Irrigation Sci.* 10: 73.

Rajagopal, V., Kasturi Bai, K.V. and Voleti, S.R. (1990a). Screening of coconut genotypes for drought tolerance. *Olegineux*, 45: 215.

Rajagopal, V., Kasturi Bai, K.V., Voleti, S.R. and Shivashankar, S. (1990b). Water stress in coconut (*Cocos nucifera* L). Palms, Proc. Internl. Congr, of Plant physiology (1988) Vol. 1. Eds. SK Sinha PV Sane, SC Bhargana and PK Aagrawal, WCT, IART, New Delhi pp 508-512.

Schwab, K.B. and Heber, U. (1984). Thylakoid membrane stability in drought tolerant and drought sensitive plants. *Planta*, 161: 37