

OSMOTIC ADJUSTMENT AS A MECHANISM FOR DROUGHT TOLERANCE IN COCONUT (*COCOS NUCIFERA* L.)

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SUMMARY

Coconut plants accumulated organic solutes such as sugars and amino acids during stress period as compared to non-stress period. Cultivar differences were not found significant in sugar accumulation during non-stress and stress periods. However, 6.2% to 16.3% increase in sugar accumulation was observed during stress period compared to non-stress period. Similarly free amino acid accumulation increased by 38% during stress period as compared to non-stress period. Drought tolerant types accumulated more of these solutes than the susceptible types during severe stress condition. Association of these solutes in the osmotic adjustment of the crop is discussed by working out correlations. The results indicated that osmotic adjustment plays an important role in the drought tolerance mechanism in coconut.

Key words : Amino acid, coconut, osmotic potential, sugar.

INTRODUCTION

Plants accumulate osmotically active organic solutes such as sugars and amino acids in the free or combined form when exposed to environmental stresses and genotypic difference are observed in the accumulation of solutes (Munns and Weir, 1981). These are used either for growth or for osmotic adjustment (Morgan *et al.*, 1986). However, no reports are available with respect to perennial tropical tree crop like coconut which is grown mainly under rainfed or limited water availability conditions. At Kasaragod where the work was carried out summer period extends upto four to five months in an year starting from January to May.

Genotypic differences in the leaf water potential during non-stress and stress periods have been reported by Rajagopal *et al.*, (1990). However, reports are not available on the solute accumulation capacity of the coconut genotypes in response to water deficit conditions or association of these solutes in the osmotic adjustment. Hence the present work was undertaken to estimate the accumulation of sugars and amino acids during non-

stress and stress periods in the leaves of cocount palms and to assess the association of these solutes in the osmotic adjustment of this crop.

MATERIALS AND METHODS

Eighteen year old palms of cocount tall cultivars (viz., West Coast Tall (WCT), Philippines Ordinary (PO) and Andaman Ordinary (AO), Two dwarf cultivars (viz., Malayan Yellow Dwarf (MYD) and Gangabondam (GB) and three hybrids (WCT x WCT, WCT x Chowghat orange Dwarf (COD) and COD x WCT) grown in red sandy loam soil under rainfed condition were the material for the studies. Six palms were selected from each genotype for recording observations. Each palm was taken as a single replication. Sampling was carried out between 10.00 hrs. and 11.30 hrs. during non-stress (September), stress (February) and severe stress periods (April). The parameters were determined consequently for two years and mean of these two years observations were used for statistical analysis. Significance was worked out by analysis of variance and correlation coefficient was worked

out as per the standard methods (Panse and Sukhatme, 1967).

Leaf water Potential (ψ_w) was measured in the detached leaf-lets from the sixth leaf from the spindle, using Scholander's Pressure Chamber (Plant Water Console-3000, Soil moisture Co. USA). The osmotic potential (ψ_s) of the expressed sap was determined by Vapour Pressure Osmometer (5130-Wescor Inc.). Turgor Potential (ψ_p) was calculated as the difference between water potential and osmotic potential. Total sugar content and free amino acids (FAA) were estimated following the methods of Dubois *et al.*, (1956) by phenol sulfuric acid method and Lee and Takahashi, (1966) by using the ninhydrin glycerol buffer mixture respectively.

Micrometeorological variables in the experimental plots were recorded using portable photosynthesis system (Li-6200, Li Cor Inc, USA) and soil moisture content was determined gravimetrically.

RESULTS AND DISCUSSION

The non-stress period was characterised by low Vapour pressure deficit (VPD) (2.2 KPa) with an air temperature of 33.3°C whereas the stress period by high VPD (3.1 KPa) and high air temperature (34.7°C). During severe stress period the air temperature increased further by 7.5% and VPD by 16% as compared to the stress period

Table I. Micrometeorological variables during the experimental periods.

Parameter	Non-stress	Stress	Severe stress
Radiation (Wm^2)	141.7	314.1	351.0
VPD (KPa)	2.2	3.1	3.6
Temperature (°C)	33.3	34.7	36.1
Pan evaporation (mm day ⁻¹)	3.3	5.2	5.5

(Table I.) The soil water content during severe stress period ranged from 3% to 4% which accounted for 54% reduction as compared to the non-stress period.

Coconut palms accumulated osmotically active organic solutes such as sugar and free amino acid during stress period as compared to non stress period. Total soluble sugar content did not vary significantly among the cultivars during non-stress or stress periods (Table II). However, significant increase in sugar accumulation was observed during stress period and the increase was in the range of 6.2% and 16.3%. The increase in sugar accumulation was less in the Dwarfs (MYD and GB) and the hybrid COD x WCT (6.2% to 5.4%) than the others (9.9% to 16.3%). In an earlier study Kasturi Bai and Ramadasan (1983) observed higher accumulation of non reducing sugar content during summer months and reducing sugar content during monsoon period in coconut leaves. This has indicated the inherent mechanism of the palms to combat water deficit conditions during summer months.

Table II. Total sugar content and FAA in coconut cultivars/ hybrids during non-stress and stress periods (mg g⁻¹ DW)

Cultivar Hybrid	Total sugar		Free amino acid	
	Non-Stress	Stress	Non-Stress	Stress
WCT	15.37	17.03 (10.80)	0.52	0.69(32.7)
PO	14.10	15.50 (9.93)	0.38	0.52(36.8)
AO	13.63	15.00 (10.05)	0.45	0.51(13.3)
MYD	15.63	16.60 (6.21)	0.44	0.56(27.3)
GB	14.50	15.43 (6.41)	0.42	0.55(31.0)
WCT x WCT	13.33	15.03 (12.75)	0.41	0.68(65.9)
WCT x COD	12.73	14.80 (16.26)	0.37	0.66(78.4)
COD x WCT	14.07	14.97 (6.40)	0.38	0.50(31.6)

CD (P = 0.05)

Genotype n.s 0.074

Stress treatment 0.972 0.037

Percentage increase over non-stress period in parenthesis

Free amino acid (FAA) content (Table II) showed significant genotypic differences ranging between 0.37 mg. g⁻¹ dry weight and 0.52 mg. g⁻¹ dry weight during non-stress period. During stress period the FAA accumulation increased to a range of 13.3% to 78.4% over non-stress period. Highest accumulation in the FAA content was observed in the two hybrids WCT x WCT and WCT x

COD than in COD x WCT. This supports the ranking of coconut cultivars/hybrids as drought tolerant and susceptible types based on physiological and biochemical parameters by Rajagopal *et al.*, (1990). They ranked WCT x WCT and WCT x COD as relatively tolerant types and COD x WCT as drought susceptible. The accumulation of FAA as an immediate source of energy and nitrogen during recovery of plants from stress has been reported by Thomas (1991).

In coconut higher increase in the stomatal resistance in the drought tolerant types than the susceptible types with the development of water deficit conditions, thus maintaining the turgor was observed (Rajagopal *et al.*, 1990). Except ψ_w both ψ_s and ψ_p showed significant differences between the drought tolerant and susceptible types with higher maintenance of turgor in WCT x WCT

Table III. Water relation components (MPa) and solute accumulation (mg g⁻¹ DW) in coconut hybrids during severe stress condition

Hybrids	ψ_w	ψ_s	ψ_p	Sugar	FAA
WCT x WCT	-0.93	-1.16	0.23	17.42	0.98
COD x WCT	-0.95	-1.03	0.08	14.5	0.67
CD (P=0.05)	---	0.059	0.082	2.34	0.267

than COD x WCT (Table III).

As compared to the susceptible types, drought tolerant types accumulated significantly more sugar and free amino acids. Association of solutes in the osmotic adjustment of coconut was understood by working out correlation (Table IV.) High correlation was observed between total sugar content and ψ_s (-0.716 P=0.05). ψ_p also was negatively correlated with ψ_s . However, no correlation was observed between ψ_w and ψ_p . The relation between sugar and FAA accumulation was also significant. This implies that under severe stress condition coconut palms maintain the ψ_p by accumulation of solutes thus reducing the ψ_s .

In sorghum, Jones *et al.*, (1981) observed the contribution of solutes in the osmotic adjustment during moderate stress levels than severe stress levels. This

Table IV. Correlation between leaf water potential components and solute accumulation

Parameter	ψ_w	ψ_s	ψ_p	Sugar
ψ_s	0.0535	--	--	--
ψ_p	0.5678	-0.7916*	--	--
Sugar	0.2337	-0.7163#	0.7335#	--
FAA	0.411	-0.5594	0.5474	0.7725*

*Significant at 1%, # Significant at 5% levels

implies that the increased accumulation of total sugar and amino acids during stress condition can be an indicator of the adaptive nature of the coconut palms to cope up with the adverse conditions during summer months. The fact that the genotype which is able to accumulate more solutes withstand drought better than those genotypes which can not accumulate the solutes. This clearly indicated that the osmotic adjustment plays an important role in the stress tolerance mechanism in coconut.

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