

Relationship between Leaf Water Potential and Peroxidation of Cell Wall Lipids in Coconut

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Coconut seedlings of four tall, West Coast Tall (WCT), Laccadive Ordinary (LCT), Philippines Ordinary (PHOT), Andaman Ordinary (AOT), one dwarf Chowghat Green Dwarf (CGD) and the reciprocal cross combinations (T × D's and D × T's) were evaluated by using leaf water potential and lipid peroxidation for understanding the variation in the stress-sensitive parameters under water stress and during recovery. An attempt also has been made to find out the relation, if any, between the two parameters. The observations were carried out in the seedlings under normal irrigation (non-stress), imposing stress by withholding irrigation for 23 days (stress) and re-irrigating the seedlings continuously for seven days (recovery). Leaf water potential decreased to an extent of 62.7% during stress period compared to non-stress period. Recovery potential of the seedlings indicated 24% increase in water potential compared to stress period. However, a reverse trend was observed in the peroxidation of lipids. The lipid peroxidation values showed an increase of about 20.7% during stress period compared to non-stress period and showed a reduction of 21.8% during recovery. Relationship worked out between the two parameters indicated negative correlation. The studies clearly indicated that recovery potential of the seedlings after relief of stress is indicative on the seedling adaptability to water stress conditions.

Keywords: Coconut, leaf water potential, lipid peroxidation.

Introduction

Water stress affects the physiology and biochemistry of crop plants, but they have a remarkable ability to resume normal function once the stress is relieved (Miah *et al.*, 1988). In coconut lot of work has been carried out to understand the drought-tolerance mechanism and traits for drought tolerance have been established from these studies (Rajagopal *et al.*, 1990). Leaf water potential has been extensively used for screening for drought tolerance in crop plants and in coconut a method for rapid screening for drought tolerance has been developed based on this trait (Rajagopal *et al.*, 1988). Peroxidation of cell wall lipid has been established to be one of the most damaging reactions for membranes and cellular constituents (Dhindsa *et al.*, 1982). In adult coconut palms, Chempakam *et al.* (1993) have reported the relationship between peroxidation of lipids and activity of drought-sensitive enzymes and established lipid peroxidation as an important biochemical trait for screening for drought tolerance. However, information is lacking in coconut on the changes in the

patterns of the above traits after relief of stress or the relationship between these two important traits. In the present paper an attempt has been made to understand (a) the variation in leaf water potential and peroxidation of lipids among the coconut seedlings of different cross combinations under water stress condition and during recovery from stress, and (b) the relationship between the two parameters. The observation may help in understanding the drought tolerance mechanism at the seedling level and selection of simple trait for large scale screening of seedlings for drought tolerance at the nursery level.

Materials and methods

Eighteen-month-old seedlings belonging to 13 coconut combinations which include tall, dwarfs, and hybrids (listed in Tables 1 and 2) growing in the field condition were used. The plants were watered daily. The sample size consisted of six seedlings per combination. Seedlings were exposed to water stress during March by withholding water supply from an initial time until the end of stress period. They were watered for a week after a specified period, i.e. about 23 days of stress. This period was arrived by monitoring the leaf water potential of the seedlings.

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Table 1. Leaf water potential (–MPa) in coconut seedlings during non-stress, stress and recovery periods.

Cultivar/hybrid	Non-stress	Stress	Recovery	Mean
WCT	0.64	0.92	0.81	0.79
LCT	0.63	0.79	0.57	0.66
PHOT	0.64	1.19	0.69	0.84
AOT	0.51	0.97	0.76	0.75
CGD	0.63	0.95	0.67	0.76
WCT × CGD	0.61	0.95	0.74	0.77
CGD × WCT	0.51	0.89	0.79	0.73
LCT × CGD	0.57	0.93	0.70	0.73
CGD × LCT	0.58	0.96	0.76	0.77
PHOT × CGD	0.68	1.10	0.88	0.89
CGD × PHOT	0.55	0.95	0.57	0.69
AOT × CGD	0.66	1.14	0.89	0.90
CGD × AOT	0.44	0.76	0.63	0.61
Mean	0.59	0.96	0.73	

CD: $P = 0.05$; Genotype, 0.075; Treatment, 0.030; Interaction, 0.107.

Table 2. Lipid peroxidation (MDA content $\mu\text{mol g}^{-1}$ fr wt) in coconut seedlings during non-stress, stress and recovery periods.

Cultivar/hybrid	Non-stress	Stress	Recovery	Mean
WCT	7.22	9.16	7.22	7.89
LCT	6.58	6.84	5.03	6.15
PHOT	8.65	9.29	8.26	8.73
AOT	6.45	10.97	7.61	8.34
CGD	7.99	8.39	7.61	8.00
WCT × CGD	8.26	9.68	6.32	8.09
CGD × WCT	8.26	9.56	8.64	8.82
LCT × CGD	6.71	7.74	6.06	6.84
CGD × LCT	8.51	9.68	7.89	8.69
PHOT × CGD	5.42	7.74	5.29	6.15
CGD × PHOT	7.48	9.29	6.45	7.74
AOT × CGD	7.10	8.13	6.19	7.14
CGD × AOT	6.97	8.90	7.61	7.83
Mean	7.35	8.88	6.94	

CD: $P = 0.05$; Genotype, 1.174; Treatment, 0.423; Interaction, 1.548.

Leaf water potential (ψ_L) was measured following the method of Scholander *et al.* (1964). From each replication the leaflet from the third leaf was excised and immediately placed in the pressure chamber to avoid transpirational water loss. ψ_L was determined between 10.00 and 11.30 hr. For lipid peroxidation (LP) estimation, leaflets opposite to that sampled for ψ_L determination were used. The LP was estimated by measuring the content of 2-thiobarbituric acid reactive substances in leaf homogenates according to

the method of Heath and Packer (1968). The observations were carried out before the start of stress treatment, i.e. under irrigated conditions (non-stress), by withholding irrigation (stress) and after relief of stress by re-irrigating the seedlings (recovery). Significance was worked out by the analysis of variance and the relationship between the two traits was estimated. The soil moisture content during stress period ranged between 3 and 4% (75 cm depth). The micrometeorological parameters, viz. photosynthetically active radiation (PAR), temperature and vapour pressure deficit (VPD) during the time of observation were around $1300 \mu\text{E m}^{-2} \text{s}^{-1}$, 34°C and 2.8 KPa respectively.

Results

Leaf water potential (ψ_L) showed significant genotypic differences during the three treatments (Table 1). Higher potential was observed in Laccadive Ordinary (LCT), Chowghat Green Dwarf (CGD) × Philippines Ordinary (PHOT) and CGD × Andaman Ordinary (AOT) than the others. Treatment differences as well as interaction between variety and treatment were also found to be significant. In the unstressed seedlings, ψ_L ranged between -0.68 MPa (PHOT × CGD) and -0.44 MPa (CGD × AOT). Withholding irrigation decreased ψ_L to different degrees ranging from -1.19 MPa (PHOT) to -0.76 MPa (CGD × AOT). Compared to non-stress period about 25.4% (LCT) to 90% (AOT) decrease was observed in ψ_L during this period. After re-irrigation the seedlings recovered to different degrees. During this period, ψ_L ranged between -0.57 MPa (LCT and CGD × PHOT) and -0.89 MPa (AOT × CGD) among the genotypes. One important aspect to be noticed here is that the highly stressed seedlings recovered better than the others. In general, compared to non-stress period the ψ_L decreased by 62.7% during stress period and the recovery after relief of stress was only 24%. Even the interaction between variety and treatment was also found to be significant. However during re-hydration, ψ_L did not reach the original level.

Similarly, malondialdehyde (MDA), product of LP, also showed significant genotypic differences during the three treatments. During non-stress period the MDA content ($\mu\text{mol g}^{-1}$ fr wt) ranged between 5.42 (PHOT × CGD) and 8.65 (PHOT) while during

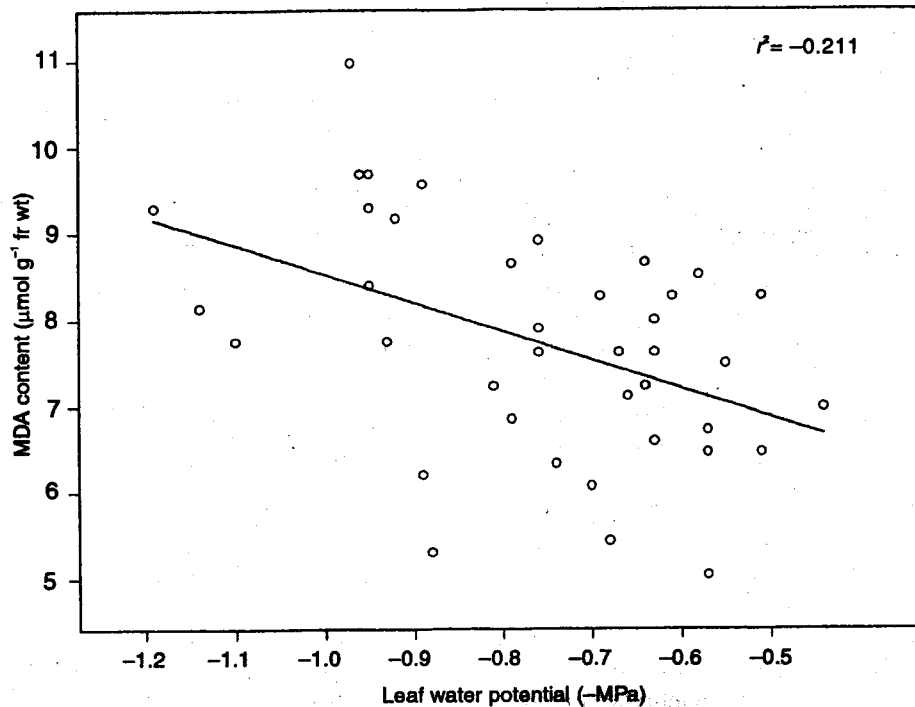


Figure 1. Correlation between leaf water potential and lipid peroxidation in coconut seedlings. Each point represents mean of six seedlings.

stress period there was an increase in all the genotypes which ranged between 7.74 (LCT × CGD) and 10.97 (AOT). However the increase in LP during stress period was not as drastic as that of reduction in leaf water potential. Compared to non-stress period the increase was only 4% (LCT) to 70% (AOT). During relief from stress in all the genotypes a decrease in MDA content ($\mu\text{mol g}^{-1}$ fr wt) was observed which ranged between 5.0 (LCT) and 8.64 (CGD × WCT). In general, compared to non-stress period, the level of MDA content increased by 20.7% during stress period and decreased by 21.8% during relief from stress.

The results thus show a negative trend between the two parameters, i.e. with an increase in LP a decrease in ψ_L during stress period and vice-versa during relief from stress. Hence our next approach was to understand the relationship between the two parameters. Although a negative trend was observed between ψ_L and LP, significant correlation has not been observed between the two parameters during stress or relief from stress. However, pooled data

indicated a negative relationship (Figure 1) with low r^2 value (-0.211).

Discussion

The results showed that although coconut seedlings are sensitive to water stress, it has the ability to recover once the stress is relieved after rewatering. The extent of recovery depends on the severity of the stress. In the seedling combinations a reduction in leaf water potential has been observed during stress period. However some of the seedling combinations (LCT and CGD × AOT) maintained higher potential than the other combinations. All the seedling combinations recovered to different degrees after rewatering. Although higher reduction in ψ_L was observed both in PHOT and AOT (90%) during stress period, recovery after relief of stress was found to be higher in PHOT (42%) than AOT (22%). This agrees with the report of Rajagopal *et al.* (1990) in adult coconut palms. On the basis of physiological and biochemical parameters they have categorized PHOT as relatively drought-tolerant and AOT as drought-suscep-

tible types. The better recovery potential of PHOT seedlings than AOT clearly shows that in coconut adaptability to stress condition is a heritable characteristic and ψ_L is a heritable trait. Further work has to be carried out to confirm this.

This was supported by the observations on lipid peroxidation. MDA content increased during stress period and accumulated more in weakly-resistant cultivar (AOT, 70%). As reported by Chempakam *et al.*, in adult palms (1993) this can be attributed to lower activities of radical scavenging enzymes in AOT than PHOT. One of the important aspects to be noticed here is that some of the cultivars like LCT and LCT \times CGD maintained low LP with higher ψ_L while PHOT \times CGD although it maintained lower LP, ψ_L was comparatively higher than others. Similarly, CGD \times AOT which had higher LP values maintained higher ψ_L . The very low correlation ($r^2 = -0.211$) observed between LP and ψ_L can be attributed to the above. In sugarcane, Venkataramana *et al.* (1987) reported a negative relationship between leaf water potential and membrane injury. However in tobacco, van Rensburg and Kruger (1994) observed higher increase in LP during drought stress and faster decrease during relief from stress in the drought-tolerant types than susceptible types.

The observations in the seedlings clearly showed that water relation of the coconut palms is getting affected more than lipid peroxidation during stress condition. Since recovery following rewatering is higher in lipid peroxidation than leaf water potential, this parameter, i.e. leaf water potential can be used as marker index for drought tolerance screening in coconut seedlings at the nursery stage. This corroborates with the screening methods developed by Rajagopal *et al.* (1988). Moreover, the results presented clearly indicate that recovery potential of the seedlings after the relief from stress is indicative on the seedling adaptability to water stress conditions. Further, the genetics of the important heritable traits

have to be looked into for improving the breeding strategies.

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