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Indexing certain physiological parameters on drought management in rainfed coconut

S. VINCENT, R. RETHINARAJA AND S. RAJARATHINAM
Coconut Research Station, Veppankulam 614 906, Tamil Nadu

Abstract: The genotype of coconut East Coast Tall was studied for its tolerance of drought through the physiological parameters by using different drought management practices. During the time of stress (April, May, June) the treatment like coconut husk burial in the basin had significant difference by higher stomatal resistance (rs) low transpiration rate (Tr). This was supported by Lower Stomatal Index. Further the leaf samples registered higher CSI, higher NR activity, with higher content of protein and total sugars. The same trend of results were observed in proline, relative water content and epicuticular wax content.

Key words : Coconut, Rainfed, Stress, Physiological parameters, Biochemical constituents.

Introduction

Coconut is grown as a rainfed crop in certain parts of Tamil Nadu and Kerala. During summer months dry weather prevails resulting in high evaporative demand ie., both atmospheric and soil drought. The coconut palms suffer stress under the above conditions (Rajagopal *et al.* 1988). It has long been recognised that certain physiological and biochemical attributes can be employed to screen crop plants for their tolerance to drought. Some of the well known tests for desiccation tolerance are (1) Chlorophyll stability index (2) Proline content (3) Stomatal resistance (4) Transpiration rate and (5) Epicuticular wax content. Balasimha *et al.* (1985) reported the physiological traits of drought tolerance in cocoa. The present study was undertaken to indexing certain physiological parameters on drought management of rainfed coconut.

Materials and Methods

The study was under taken at Coconut Research Station, Veppankulam during 1998 to 2001. Four coconut palms *(Cocos nucifera* L.) of the East Coast Tall genotype were selected under randomised block design comprising four replications of four trees per replication. The 30 years old ECT palms planted with 7.5 x 7.5 meter spacing on sandy loam soil are being grown under rainfed conditions and using normal agronomic practices including application of recommended doses of fertilizers.

Treatment details

T_1 - Control- Rainfed condition (Recommended doses of organic and inorganic fertilizers)

T_2 - Burial of coconut husk in the basin

T_3 - Mulching basins with dry coconut leaves

T_4 - Application of additional dose of potash 1 kg

T_5 - *Colopagonium* sp. (in the basin)

T_6 - Control

Agro meteorological parameters *viz.* air temperature, rainfall and pan evaporation were recorded during the pre stress (October, November, December) and stress (April, May, June) periods. Ecophysiological parameters like stomatal resistance, transpiration rate and leaf temperature were measured by using a Portable Steady State Porometer (Model 1,600; LI - Cor Instruments) as described earlier by Rajagopal *et al.* 1988. These measurements were taken between 10 to 12 AM. The Pan evaporation data was obtained with the USWB class A Pan set up at the climatological station in the institute farm.

The soil moisture content near the experimental field was determined gravimetrically at two depths *viz.* 30 cm and 60 cm in the basin (around the stem at a distance of one metre) of two trees per treatments during the pre stress and stress periods.

From the physiologically matured leaf ie., the 11th from the top, epidermal peelings able 1. Observations on stomatal frequency (SF), stomatal index (SI) and ecophysiological parameters.

No.	Treat-ments	Stomatal frequency (SF) (No/mm²)	Stomatal Index (SI)	Ambient temp°C	Leaf temp°C	Stomatal resistance rs (S/cm)	Transpiration rate (μg/cm²/S)
	T_1	559	26.2	33.1	33.3	6.1	5.1
	T_2	564	25.1	33.2	33.3	8.2	3.6
	T_3	552	25.3	33.2	33.2	7.8	3.9
	T_4	569	26.0	33.1	33.3	7.2	4.2
	T_5	562	26.1	33.2	33.3	6.9	4.4
	T_6	561	25.9	33.1	33.3	6.3	4.9
	Mean	569.5	25.9	33.2	33.3	7.0	4.35
	CD(P=0.05)	-	0.80	-	-	1.8	1.3

Table 2. Agroclimatic conditions during experimental period (mean of 3 Months for 3 years)

S.No	Parameters	Stage I pre stress	Stage II stress
1.	Air temperature (°C)	29.6	38.6
2.	Rainfall (mm)	218.6	59.3
3.	Pan evaporation (mmd^{-1})	1.42	2.98

Table 3. Observations on biochemical parameters

S.No.	Treatments	CSI (%)	NR activity (μmol/NO_2/g/h)	Protein (mg/gm of tissue)	Total sugars (%)
1.	T_1	26.3	10.3	0.32	0.87
2.	T_2	28.4	10.8	0.37	0.94
3.	T_3	27.7	10.5	0.35	0.91
4.	T_4	26.9	10.4	0.34	0.90
5.	T_5	27.1	10.4	0.33	0.90
6.	T_6	26.6	10.3	0.33	0.89
Mean		27.2	10.45	0.34	0.90
CD(P=0.05)	1.8	0.4	0.3	0.06	

were taken for the study of stomatal frequency and stomatal index. The stomatal resistance and leaf temperature were determined with the Steady State Porometer on the 11th leaf as described earlier for coconut (Rajagopal *et al.* 1986).

The epicuticular wax content (ECW) was extracted from the leaflets, using the method described by Ebercon *et al.* (1977) and followed for coconut (Rajagopal *et al.* 1988). Segments of 3 x 1 cm were cut from the leaflets and 20 of them were plunged into 15 ml chloroform, vigorously shaken for 12 seconds and then decanted. This extracts the wax from both surfaces of leaflet. The colour developed with dichromate was read at 590nm using spectro photometer. ECW was carried out only during the stress period.

Leaf samples taken from the 11th leaf from the top were used for the bio chemical analysis like chlorophyll contents, nitrate reductase activity, soluble protein content, total sugars, proline content and relative water content as per the procedure.

Results and Discussion

The stomatal frequency (SF) and stomatal index (SI) are shown in Table 1. Among the treatments, there was no significant difference in stomatal frequency. Whereas in stomata index (SI) the treatment with burial of coconut husk in the basin registered significantly lower SI (25.1) followed by T_3 (25.3) when compared to control (26.2). Stomatal frequency and its behaviour play a major role in water conservation in many species. A direct relationship between SF and transpiration rate was shown in coconut palms by Rajagopal *et al.* (1990). The stomatal frequency and sensitivity to the moisture stress create the humidity gradient between the environment and leaf surface and brings about the tolerance capacity in any given species under adverse condition (Ciha and Brun, 1975).

The agroclimatic conditions revealed distinct differences between the pre stress and stress period (Table 2). During the stress period the temperature increased by about 9°C as compared to pre stress period. These are reflected on pan evaporation which rose from 1.42 mmd^{-1} to 2.98 mmd^{-1} between two periods. This was further supported by low rainfall which was received during stress period (59.3 mm) when compared to pre stress (218.6 mm).

The changes in the agroclimatic conditions revealed the extent of atmospheric and soil drought. High evaporative demand existed in the atmosphere during March which resulted in the high soil water deficit at all depths. In response to these conditions the treatments showed variation in stomatal resistance and transpiration rate (Table 1).

In general the treatment T_2 had higher stomatal resistance (8.2 Scm^{-1}) with lower transpiration rate (3.6 μg cm^{-2} S^{-1}). No significant difference was observed in leaf temperature. Stomata play an important role in regulating the water balance in coconut (Milburn and Zimmerman 1977; Rajagopal *et al* 1986). The present study indicate clearly that they conserved moisture (9.77%) from the treatment T_2 which was effectively utilized through effective stomatal regulation when compared to control (6.06%).

During the pre stress period, in general all the treatments showed no significant difference between them. Whereas in stress, the biochemical parameters like chlorophyll stability index (SI), nitrate reductase activity, protein and total sugars showed variations (Table 3).

The results revealed that the treatment T_2 recorded significant values in CSI (28.4%) NR activity (10.8 μmol NO_3/g/h), protein (0.37 mg/gm of tissue) and total sugars (0.94%) when compared to control. The treatment T_3, though

Table 4. Observations on proline, ECW and RWC in coconut leaf samples.

S.No.	Treatments	Proline (μg g^{-1})	ECW (μg cm^{-2})	RWC (%)
1.	T_1	25.2	114.3	76.4
2.	T_2	26.0	115.8	81.5
3.	T_3	25.6	115.2	79.6
4.	T_4	25.2	115.2	78.9
5.	T_5	25.3	115.0	78.2
6.	T_6	25.2	114.9	77.0
Mean		25.4	115.0	78.6
CD(P=0.05)		0.7	1.2	3.3

not significant, recorded comparatively higher values than other treatments. The same trend of results was noticed in proline (26 mg g^{-1}), relative water content (81.5%) and Epicuticular wax content (115.8 mg cm^{-2}) (Table 4).

Hall and Jones (1961) reported that ECW content was an important factor in combating stress, through reducing cuticular loss of water from the leaf surface, when stomata were closed. The high temperature during dry season probably resulted in high ECW (Ebercon *et al.* 1977). Chlorophyll stability index and proline are other important biochemical attributes which can be employed to screen the crop plants for their tolerance to drought (Rajagopal *et al.* 1988). Heat stability of the chlorophyll pigments has been described as an index for drought tolerance in plants and direct correlation between low CSI values and drought resistance has been reported in coconut genotypes (Chacko Mathew and Ramadasan 1973). The present results supported the suggestion that higher CSI and proline content enhanced the tolerance of palms to drought.

From the present studies, it could be concluded that higher stomatal index, less nitrate reductase activity, low protein, lesser content of total sugars comprising with low ECW, low CSI, lesser content of RWC and proline during stress period caused the palms to lose more water through transpiration by offering lesser stomatal resistance. With high stomatal diffusive resistance, further aided by high ECW levels, helped in good water conservation in the leaf tissues (Rajagopal *et al.* 1988). The findings of the investigation shows that it is possible to identify the tolerant palms with desirable tolerant characters and it helps to improve the palms physiologically active through various drought management practices.

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