

Comparative physiological studies on the drought tolerance of three hybrids of coconut

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Abstract. — Drought tolerance of three hybrid crosses developed at CPCRI, Kasaragod were compared using physiological and morphological indices. Leaf water potential, stomatal resistance and specific leaf weight measured during stress and pre-stress periods indicated that MYD × WCT possessed better ability to conserve moisture. Morphological parameters also gave similar results. Based on the data, the three hybrids could be ranked for drought tolerance in the order, MYD × WCT > MOD × WCT > COD × WCT

Key words. — *Cocos nucifera*, coconut hybrids, drought tolerance

INTRODUCTION

As part of studies on the physiology of seedling vigour in coconut, we reported in an earlier paper (Shivashankar, and Kasturi Bai, 1988) that the hybrid MYD × WCT possessed superior growth characteristics at the juvenile stage in comparison with MOD × WCT and COD × WCT. These three crosses were subsequently planted in the field in 1985 for further evaluation. The major objective of the experiment was to work out of the relationship between seedling characters and their own yield as adult palms in order to develop physiological criteria for selection in the nursery.

Since coconut is grown predominantly as a rainfed crop throughout Kerala and other states of Southern India, the crop is subjected to long dry spells due to poorly distributed rainfall. Therefore, tolerance to drought is an important pre-requisite in ensuring high and stable yields. It is in this context, we undertook a comparative study of the three hybrids using certain physiological components which are known to be closely related to the tolerance of cultivars to drought. Based on the screening methods, drought tolerant genotypes in coconut have been identified recently (Rajagopal *et al.*, 1990).

METHODS AND MATERIALS

The experimental trial is located in the Institute farm campus on a red sandy loam soil. The three hybrids, Malayan Yellow Dwarf × West Coast Tall (MYD × WCT), Malayan Orange Dwarf × West Coast Tall (MOD × WCT) and Chowghat Orange Dwarf × West Coast Tall (COD × WCT) were planted during 1985 at a spacing of 7.5 m × 7.5 m. Fertilizers were applied in two split doses at the rate of 500g N, 1000g P₂O₅ and 1200g K₂O per palm per year.

The weather data for six years near the experimental site are summarised in table I. Besides, the microclimatic parameters, light, temperature and relative humidity (RH) at the

vicinity of experimental palms were measured with the steady state porometer (Licor-1600, U.S.A) at the time of sampling in November, January, March, and June representing pre-stress, mild stress, stress and post-stress treatments respectively. Soil moisture around the zone of maximum root density was determined in the basins of three palms by the gravimetric method (Dastane, 1972). Stomatal resistance was determined with steady state porometer on four leaflets from the sixth leaf (Rajagopal *et al.*, 1986). Leaf water potential (ψ) was determined with the Scholander chamber (plant water console 3000, soil moisture Co., USA) on three leaflets from each palm between 10.00 am and 12.00 noon during the stress period (Rajagopal *et al.*, 1987). Specific leaf weight (SLW) was measured as the dry weight/unit area of leaf.

The data of the number of functional and dry leaves on the crown were recorded at monthly intervals beginning in September 1990 and continued up to July 1991 and used for working out the percentage drying of leaves and the drought tolerance index (DTI) according to Pomier and de Taffin (1982).

TABLE I. — Weather data at Kasaragod from the time of planting up to the first flowering.

Month	Mean minimum RH (%)	Mean maximum temp (°C)	Rainfall (mm)	Pan evaporation (mm/day)
January	51.2	32.8	3.5	4.10
February	56.2	32.3	—	4.82
March	59.3	32.9	9.6	5.33
April	60.0	33.7	26.5	5.90
May	64.0	33.6	200.4	5.43
June	79.5	30.4	1004.2	3.40
July	80.8	29.6	651.2	2.92
August	81.8	29.1	689.3	3.08
September	75.0	30.2	244.0	3.70
October	71.0	31.3	148.2	3.72
November	61.2	32.6	101.0	3.68
December	51.5	33.3	17.3	4.03

Mean of six years data from 1985-1990

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Table II. — Rate of drying of leaves and drought tolerance index of hybrids

Hybrid	Mean no. of leaves	Mean no. of functional leaves (X)	Total no. of leaves at the beginning of dry season (N)	No. of dried leaves at the end of dry season (n)	Drought tolerance index $(\frac{n}{N} \times 100)$	Percentage drying of leaves $(\frac{n}{X} \times 100)$	Ranking for tolerance to drought
MYD × WCT	24.73 (0.638)	21.36 (0.436)	28.0 (0.685)	7.00 (0.299)	25.0	32.77	I
MOD × WCT	21.71 (0.957)	19.00 (0.843)	24.6 (0.970)	6.31 (0.394)	25.6	33.21	II
COD × WCT	21.25 (0.787)	17.77 (0.463)	24.3 (0.952)	8.85 (0.383)	36.4	49.80	III

Data are mean of 12 values

Values in parenthesis indicate the SE of mean

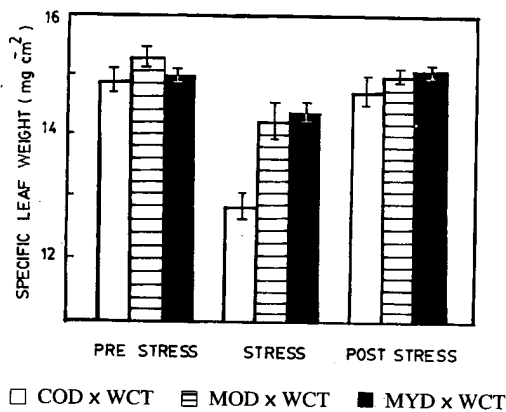


FIG. 1. — Specific leaf weight (SLW) of three hybrids under stress and recovery (vertical bars indicate the SE of the mean)

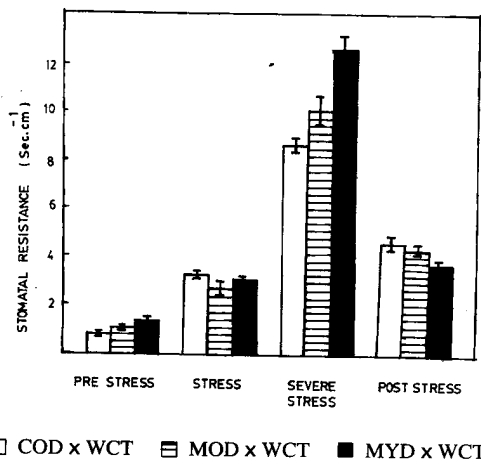


FIG. 2. — Stomatal resistance of hybrids during stress and recovery

RESULTS AND DISCUSSION

The typical weather in Kasaragod was characterised by an abundant rainfall between June and November followed by a dry spell. As is evident from table I, the intensity and duration of drought during the dry period was decided by the quantum of non-seasonal rainfall besides high temperature and evaporative demand. During 1990-91 the rainfall received between November 1990 and April 1991 was only 26.8mm. The prevalence of high radiation, temperature and vapour pressure deficit resulted in severe drought, which was further accentuated by low soil moisture content (7.6%) during the period. Under such conditions, the palms started to show drying of leaves. Differences in the number of dried leaves were noticeable among the hybrids. The number of dried leaves as a percentage of the number of functional leaves showed significant differences (Table II). MYD × WCT recorded the lowest percentage closely followed by MOD × WCT and COD × WCT. The rate of drying of leaves during the dry season is an important characteristic in the tolerance of a genotype to drought conditions. Thus the data showed the relatively higher tolerance of MYD × WCT as compared to MOD × WCT and COD × WCT. It is worth noting that the average number of leaves on the crown was 22 only as opposed to about 34 in the Ivory Coast for Dwarf × Tall hybrids of the same age.

The data of drought tolerance index showed that MYD × WCT gave the lowest value of 25.0 as against 25.6 for MOD × WCT and 36.4 for COD × WCT (Table II). Pomier and De Taffin (1982) while comparing the performance of certain hybrids under rainfed conditions found that the percentage of dry leaves (n) in relation to the total number of leaves on the crown (N) gave an excellent measure of the drought tolerance and designated it as the drought tolerance index. Accordingly, the data presented here shows that MYD × WCT possesses a relatively higher tolerance to drought.

Specific leaf weight (SLW) of the MYD × WCT hybrid remained significantly higher than COD × WCT under stress (Fig.1). A higher SLW is known to be associated with drought tolerance in cocoa (Balasimha *et al.* 1985) and also positively correlated with yield potential in annuals (Barnes *et al.*, 1969). SLW also shows positive correlation with leaf thickness and wa × contents in cocoa (Balasimha *et al.*, 1985). MYD × WCT is also found to accumulate more epicuticular wa × than the other two hybrids under stress (Voleti and Rajagopal, 1991).

The stomatal resistance, which was less than 2 sec. cm⁻¹ under pre-stress, registered a sharp increase in all the hybrids as a result of moisture stress in March. The soil moisture content during this period was 7.6% as against 11.3% during the pre-stress period (Table II). MYD × WCT hybrid displayed higher resistance than the other two hybrids. With the

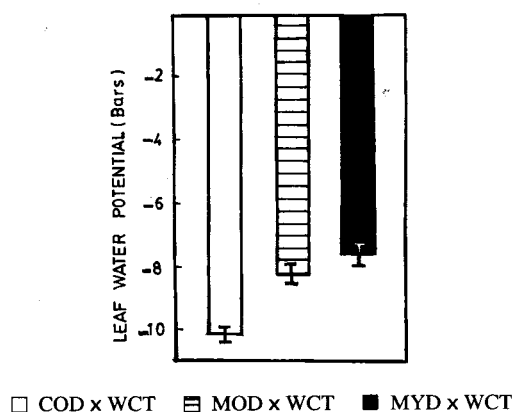


FIG. 3 — Leaf water potential of hybrids during stress (Vertical bars indicate the SE of the mean)

onset of monsoon rains, the stomatal resistance declined in all the hybrids (Fig.2). A higher stomatal resistance during drought stress is known to help in checking transpirational loss of water from the tissues (Turner, 1974). As such, MYD x WCT could be considered to possess a better mechanism for conservation of water under drought. This hybrid was also found to maintain a relatively higher leaf water poten-

TABLE III. — Weather parameters and soil moisture in the plot during the experimental period (1990-1991)

	Pre-stress	Mild-stress	Stress	Post stress
Radiation $W.m^{-2}$	291	363	361	237
Temp. °C	32.5	34.4	36.2	30.7
Vapour pressure deficit, m bars	16.4	22.6	27.8	22.4
Soil moisture, %	11.3	9.3	7.6	10.0

tial under stress (-7.60 bars) as compared to MOD x WCT (-8.24 bars) and COD x WCT (-10.07 bars) (Fig.3). Maintenance of a higher leaf water potential under stress conditions is a desirable trait as that would be enable the tissues to maintain favourable metabolic activities to withstand desiccation (Hsiao *et al.*, 1976, Turner 1974). Previous results from our laboratory have shown that the drought tolerant genotypes of coconut maintain a much higher leaf water potential both under natural drought (Rajagopal *et al.*, 1990, Shivashankar *et al.*, 1991) and air-drying of leaves (Rajagopal *et al.*, 1988) than the drought susceptible genotypes. Thus the body of data presented here shows that the degree of tolerance to drought follows the order, MYD x WCT > MOD x WCT > COD x WCT. The biochemical aspects of drought tolerance are presented in a separate communication.

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RESUME**Etudes physiologiques comparatives de la tolérance à la sécheresse de trois cocotiers hybrides**

S. SHIVASHANKAR, K.M. GEORGE, V. RAJAGOPAL et S.R. VOLETI, *Oléagineux*, 1993, 48, N°8-9, p. 357-360

Tolérance à la sécheresse de trois croisements hybrides créés au CPRCI de Kasaragod a été comparée à l'aide d'indices physiologiques et morphologiques. Le potentiel hydrique des feuilles, la résistance stomatique et le poids spécifique des feuilles mesurés pendant des périodes de stress et de pré-stress montrent que le NJM × GCO retient mieux l'humidité. Les caractères morphologiques donnent des résultats comparables. Selon ces données, les trois hybrides peuvent être classés dans l'ordre suivant en ce qui concerne leur tolérance à la sécheresse : NJM × GCO > NOM × GCO > NOC × GCO.

Mots clés. — *Cocos nucifera*, cocotiers hybrides, tolérance à la sécheresse.

RESUMEN**Estudios fisiológicos comparativos de la resistencia a la sequía de tres cocoteros híbridos**

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La resistencia a la sequía de tres cruzamientos híbridos creados en el CPRCI en Kasaragod fue comparada mediante índices fisiológicos y morfológicos. El potencial hídrico de las hojas, la resistencia estomática y el peso específico de las hojas medidas durante los períodos de estrés y de pre-estrés señalan que el EAM × GCO retiene mejor la humedad. Los caracteres morfológicos dan resultados comparables. Según estos datos, los tres híbridos pueden ser clasificados en el siguiente orden relacionado con su resistencia a la sequía: EAM × GCO > ENM × GCO > ENC × GCO

Palabras claves. — *Cocos nucifera*, cocoteros híbridos, resistencia a la sequía.