

Chlorophyll stability index as an aid in screening for heat tolerance in cocoa (*Theobroma cacao* L.)*

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Chlorophyll stability index (CSI) of 20 cocoa genotypes were estimated. Results showed that CSI varied from 25.0 to zero. The highest CSI was recorded for the Criollo variety and the lowest in the NC 34, a genotype obtained from Nigeria. The CSI is inversely related to the heat resistance of chlorophyll and thus may be related to drought tolerance. The 'P' combinations (hybrids derived from the collections of Pound) are considered as more tolerant to heat and moisture stress, and such combinations are found to have low CSI values. This finding is further supported by higher proline accumulation and better germination and seedling growth of these genotypes under induced moisture stress. Thus in cocoa, CSI seems to be a parameter that can be used for screening for heat tolerance.

The cocoa tree is very sensitive to water deficiency. Lemee (1955) showed that photosynthesis, growth and transpiration are markedly reduced when soil moisture drops below 60–70 per cent of the available range. When a cocoa leaf loses about one sixth of its water content necrotic areas start appearing on the leaf blade and it has also been demonstrated that a 5 per cent dehydration of the leaf leads to complete cessation of photosynthesis (Alvim, 1965). In the cocoa growing areas of India (Kerala and Karnataka), there is a long drought period of about five to six months, and this is a major constraint in extending the cocoa cultivation to unirrigated areas. Wood & Lass (1973), after surveying the areas in South India to assess their suitability for cocoa growing assert that the immediate requirement of cocoa growing in India is to develop drought tolerant or resistant genotypes. In order to screen the available cocoa germplasm for drought tolerance laboratory and field trials have been initiated at the Central

Plantation Crops Research Institute's Regional Station at Vittal. During the course of this work a study was also carried out on the chlorophyll stability index (CSI) of some cocoa genotypes in order to determine whether CSI could be taken as a criterion for predicting heat and drought tolerance. CSI has been defined as the difference between the light transmission of chlorophyll extracts from heated and unheated samples of leaves (Kaloyereas, 1958). The lesser the CSI, the greater the stability of the chlorophyll and greater could be the heat tolerance. CSI has been previously used by workers to screen for heat and drought tolerance in many annual crops (Kaloyereas, 1958; Sahadevan, 1961; Murthi & Majumdar, 1962; Kilen & Andrews, 1969; Maillard, Daniel & Ochs, 1974).

MATERIALS AND METHODS

Twenty cocoa genotypes – 19 Forastero and one Criollo, all six-year-old – were

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TABLE 1. CHLOROPHYLL STABILITY INDEX OF TWENTY COCOA GENOTYPES*

Type/parentage†	CSI
NC 34 (P ₉ xP ₇)	0.0
NC 38 (P ₁₀ xP ₁)	0.5
Redaxil	1.5
NC 30 (P ₃ xP ₄)	2.0
NC 9 (P ₁ xP ₇)	2.4
NC 37 (P ₇ xP ₆)	2.5
NC 56 (C ₄₂)	2.5
SCA 6	4.0
Na 33	4.5
NC 53 (C ₇₆)	5.5
NC 12 (P ₉ xP ₅)	5.7
ICS 6	6.0
Amel x Na 32	9.0
Na 39 (T/12)	10.0
Na 31	10.0
PAF x Na 32	12.0
Tree No. 27 ‡	12.0
NC 36 (T _{85/5} xNa 32)	17.0
IMC 67	20.0
Criollo	25.0

* Mean of two readings.

† The NC types are the Nigerian clones, (Parentage given in parenthesis). 'P' indicates the Pound collections, the progenies of which were received from Malaysia. SCA 6, Na 31, Na 33 and IMC 67 are well known Forastero (Upper Amazon) types. Amel x Na 32 and PAF x Na 32 are progenies of hybrids received from Malaysia. Red axil is probably an Amelnado type, producing coloured pods and leaf petioles – received from Malaysia.

‡ A high yielding tree, parentage unknown.

used in the present study (Table 1). Fully mature leaves were used for measuring CSI. Leaf samples from four trees were collected and using a leaf punch, leaf discs were cut from all the

leaves, pooled and a sample of 0.2 gm weighed into a tube and suspended in 10 ml of distilled water. The tubes were heated in a thermostatic water bath at 60°C for one hour. Identical samples kept in distilled water at room temperature formed the controls. After one hour the chlorophyll was extracted from both the treated and control samples with 80 per cent acetone and suction filtered through Whatman No. 1 filter paper. Repeated extractions were done till the residue became completely colourless. The filtrate was made up to constant volume and transmission read at 663 nm in a Spectromic 21 spectrophotometer. The difference in transmission between the control and heated samples is represented as CSI.

RESULTS AND DISCUSSION

The CSI values showed considerable differences among the genotypes studied (Table 1). The highest CSI was recorded for the Criollo variety (25.0) and the lowest in NC 34 (Zero). Among the 19 Forastero types studied IMC 67 gave the highest CSI.

Criollo in general is considered more delicate than the Forastero types. In fact the cultivation of Criollo variety has been long discontinued owing to its delicate nature and poor yields though its product is superior in quality to other cocoa varieties. The high CSI value observed in the present study indicates its high susceptibility to heat damage. Among the Forasteros IMC 67 seems to be very sensitive to heat damage.

The lowest CSI is recorded in the case of NC 34, a genotype received from the Cocoa Research Institute of Nigeria. This is a hybrid derived from a cross

between two Pound collections, P₉ x P₇. The P (Pound) combinations in general are known to be more tolerant to drought (V.A. Jacob, personal communication). This view is further supported by the present studies in which the hybrids between Pound collections have very low CSI. These genotypes (NC 34, NC 38, NC 9, NC 37, NC 12, NC 30 etc.) may thus prove more successful under the prevailing growth conditions of Kerala and Karnataka. In a related study of 33 Nigerian types it was also found that hybrids among Pound collections in general have very low CSI (Ravindran, 1978).

Since the CSI values appear to be related to information on the reaction of genotypes to drought, they may constitute a useful preliminary tool in assessing the heat tolerance of cocoa genotypes. Preliminary studies with some cocoa genotypes conducted in this laboratory have also shown that the low CSI types accumulate more proline and gave better germination and seedling growth under induced moisture stress (Ravindran, 1978). Both these are characters often used for screening for heat and drought tolerance (Sullivan & Eastin, 1974). The shade level, under which the trees under testing are grown, could influence results; results may vary

for trees of the same clone, grown under different light regimes.

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Anybody who throws his weight around is going to stumble sooner or later.

— Franklin P Jones