Journal of Plantation Crops 23 (1): 64-65 June, 1995

Changes in Chlorophyll Fluorescence during Cocoa Leaf Development

During the leaf development, changes in the photosynthetic characteristics including several anatomical and biochemical parameters take place (Sestak and Siffel, 1988; Somersalo and Aro, 1987). Flush growth periodicity, lack of significant chlorophyll synthesis and photosynthetic activity in expanding leaves of cocoa are unusual features of leaf development (Baker and Hardwick, 1973). Chlorophyll fluorescence measurements are now increasingly applied to various fields of plant physiology as they are directly or indirectly related to photosynthesis (Krause and Weis, 1984). This measurement also helps in understanding spectral characteristics and their relationships with pigments during leaf ontogeny (Siffel, *et al.* 1985). The objective of this paper is to study the chlorophyll fluorescence indices in developing leaves of cocoa trees.

Cocoa (*Theobroma cacao* Linn.) trees of about 22 years age cultivated under the shade (mean PAR 475 mol m^{-2} s^{-1}) of arecanut palms were used in the experiments. Leaves of different developmental stages were sampled from seven trees during June. Chlorophyll fluorescence was measured using the Plant Efficiency Analyser (Hansatech Instruments Ltd., Norfolk, U.K.) in atleast 2 flushes from each tree. A leaf clip was attached to the excised leaf and dark adapted for 30 minutes. The dark adapted leaf was fitted with sensor unit over the clip and shutter plate opened for fluorescence measurement. The light level used was 80 per cent of LED (2400 E m^{-2} s^{-1})at 650 mm. The stored data was transferred through a software package to a computer-AT (Hindustan Computers Ltd.) for study. Chlorophylls were extracted in 80 per cent acetone and measured spectrophotometrically (Lichtenthaler and Wellburn, 1983). Net photosynthesis (P_N) was measured using LI-6200 portable photosynthesis system as described earlier (Balasimha *et al.*, 1991). Leaf area of cocoa was calculated by regression equations using length measurement (Reynolds, 1971).

The results of chlorophyll fluorescence, P_N and chlorophyll content in relation to leaf age is presented in Table I. In cocoa, the development of chlorophyll and photosynthesis differs from temperate plants (Baker and Hardwick, 1973). When a leaf develops, the chlorophyll accumulation begins with leaf unfolding (Sestak and Siffel, 1988). However, in cocoa, chlorophyll synthesis is enhanced subsequent to termination of leaf expansion (Table I). In

Table I. ***Leaf area, fluorescence (arbitrary units) parameters, chlorophyll pigment contents and PN in cocoa***

Age (days)	Leaf area (cm^2)	Fo	F_M	Fv	Fv/F_M	Chl *a* (mg/g)	Chl *b* (mg/g)	Carot-enoid (mg/g)	P_N (μ mol m^{-2} s^{-1})
2	16.3	459	1010	551	0.545	0.171	0.077	0.049	ND*
5	62.3	631	1543	912	0.591	0.269	0.121	0.064	ND
10	137.7	775	2191	1416	0.646	0.303	0.136	0.073	ND
15	180.2	679	2753	2074	0.753	0.536	0.227	0.098	1.679
30	200.3	665	2925	2265	0.772	0.958	0.378	0.222	5.134
C. D. (P=0.01)	67.1	102	342	335	0.062	0.223	0.010	0.033	1.285

*Not detected

CPCRI, Contribution No: 888

cocoa, the leaves are pale green or pink due to presence of anthocyanins. The leaves become dark green only after full expansion *i.e.* by about 30 days of ontogeny. Thus, the leaves synthesize chlorophyll very slowly during expansion and major synthesis occurs only after full expansion is reached (Baker and Hardwick, 1973). In linear relationship with chlorophyll, the fluorescence indices *viz.*, F_O, F_M and F_V also increased accordingly. There is a close linear relationship between chlorophyll- *a* with F_M (r=0.69, P=0.01) and F_V (r=0.71, P=0.01). Thus, a significant increase in fluorescence indices along with that of chlorophyll after leaf expansion, results in enhanced photosynthetic rates.

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