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RESEARCH PAPER

Relationship between Photosynthetic Pigments and Chl Value Readings in Oil Palm (*Elaeis guineensis* Jacq.) Leaves

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ABSTRACT

The chlorophyll content meter (*CCM*-200) is a portable simple device that measures greenness or relative chlorophyll content of leaves. The use of this instrument saves time, space and resources compared to that of available traditional destructive methods. The main objective of this study is to establish a relationship between photosynthetic pigments extracted in dimethylsulphoxide (DMSO) with *CCM* readings in oil palm leaves. A positive linear mathematical model was the best fit relationship between chlorophyll (Chl) value measured with chlorophyll meter and photosynthetic pigments in oil palm.

Key words: Chlorophyll, carotenoids, *CCM*-200, *Elaeis guineensis* Jacq.

Abbreviations: Car - carotenoids; CCM - chlorophyll content meter; Chl - chlorophyll; DMSO - dimethylsulphoxide; FM - fresh mass; SLA - specific leaf area.

INTRODUCTION

Chlorophylls (Chl) are important pigments involved in capture of light for photosynthesis and other photochemical reactions. The amount of light absorbed by leaf in plants is related to chlorophyll content. The methodologies used for extraction of chlorophyll in plants are generally destructive that extracts leaf tissues using organic solvents like acetone (Mckinney, 1941; Bruisna, 1961), dimethylsulphoxide (Hiscox and Israelstam, 1980; Inskeep and Bloom, 1985; Ritchie, 2008). Also these standard methods of Chl estimation are time consuming and require destructive sampling. Non-destructive optical methods have been developed recently based on absorbance and/or reflectance of radiation by intact leaves. The 'Chl index' got from these non destructive methods indicates relative Chl content and doesn't express absolute Chl content per unit mass or unit leaf area. These newer methods are very rapid, non-destructive and can be used in field (Hawkins *et al.,* 2007).

Relationships between total chl concentration and chl index have been established in many species (Schaper and Chako, 1991; Uddling *et al.,* 2007), but some have failed to show its applicability across different species. Cassol *et al.* (2008) has observed a linear and positive relationship between Chl index and Chl content in maize, cucumber, raddish and floss silk tree. However, the relationship between Chl value and photosynthetic pigment concentration in coffee leaves was a polynomial quadratic mathematical model (Netto *et al.,* 2005).

MATERIALS AND METHODS

The study was carried out to determine the existence of a relationship between photosynthetic pigments extracted in dimethylsulphoxide and Chl value measured by hand held chlorophyll content meter (*CCM*-200) in oil palm. Oil palm leaves of different ages were collected from various tenera crosses in experimental plantations from Directorate of Oil Palm Research, Pedavegi, West Godavari district, Andhra Pradesh, India (16° 43'N, 81° 09'E with a mean sea level of 13.41 m).

177 leaf samples were used for the study. The sample leaves were transported in insulated covers devoid of light and brought to Plant Physiology

laboratory of Directorate of Oil Palm Research, Pedavegi. A hand held chlorophyll content meter, *CCM*-200 (Opti-Sciences, Inc., Hudson, USA) was used for the study. The instrument gives relative Chl content of leaf sample by measuring optical absorbance at two wavelengths namely 653 and 931 nm. Five readings were made on each leaf disc of 5.0 sq.cm and mean of them were used for all analysis. The results are expressed in 'Chl value'. After taking readings, each disc was cut into fine strips and placed in a test tube containing 5 ml of dimethylsulphoxide. The test tubes were later incubated at 70°C for 30 min. After cooling the extract in dark, a 3 ml aliquot was analyzed with the help of spectrophotometer (Scanning Mini Spec SL 177, Elico, Hyderabad, India) at 480, 645 and 663 nm. The Chl a, Chl b, total Chl and carotenoids were determined as per Hiscox and Israelstam (1980). The concentrations of photosynthetic pigments were converted into unit area or fresh mass (FM) basis. First order polynomial equations were used to arrive at ranking of best calibration equation. Correlation coefficients were also used to assess goodness of fit of equation.

RESULTS AND DISCUSSION

The Chl value obtained from hand held chlorophyll meter in oil palm leaves ranged from 72 to 156 in oil palm leaves with a mean Chl value of 110 (Table 1). The Chl a content based on fresh mass and leaf area ranged from 2.00 to 8.25 mg g^{-1}(FM) and 1.71 to 7.05 mg cm^{-2} respectively. The Chl b content ranged from 1.58 to 5.68 mg g^{-1}(FM) and 1.35 to 4.80 mg cm^{-2} on leaf area basis. The total Chl content in oil palm leaves based on fresh mass and leaf basis ranged from 3.58 to 13.87 mg g^{-1}(FM) and 3.06 to 11.85 mg cm^{-2} respectively. The carotenoids in oil palm leaves ranged from 0.71 to 1.15 mg g^{-1}(FM) and 0.61 to 0.98 mg cm^{-2} on leaf area basis. Similar differences in Chl values along with their specific leaf area have been reported among groundnut genotypes (Sheshshayee *et al.,* 2006). The specific leaf area (SLA) in sampled oil palm leaves ranged from 0.90 to 1.26 cm^2 g^{-1} with a mean value of 1.17.

The relationship between chl values and photosynthetic pigments namely Chl a, Chl b, total Chl and Car (FM and leaf area basis) in oil palm are presented in table 2. The coefficients of determination for linear equations were very high and significant ($p<0.01$). A positive linear mathematical model was the best fit relationship between Chl value measured with chlorophyll meter and photosynthetic pigments measured spectrophotometrically. Similar linear mathematical models have been fitted in most of studies (Cate and Perkins 2003; Wang *et al*., 2005; Cassol *et al*., 2008). In contrast, non-linear relationships between Chl value and Chl content have been reported in some studies (Richardson *et al.,* 2002; Uddling *et al*., 2007). Netto *et al*., 2002 in papaya has also reported that the relationship among Chl value and Chl a and total Chl content was exponential, polynomial quadratic (Car) and cubic (Chl b). The non linearity in empirical relationships between Chl value and photosynthetic pigments could be non uniformity in distribution of Chl in leaves. Similar findings have been reported by Uddling *et al.,* 2007. The above results indicate that hand held chlorophyll meter (*CCM*-200)

Table 1: Chlorophyll (Chl) value estimated by SPAD meter, Chl a, Chl b, total Chl and carotenoids (Car) determined spectrophotometrically [mg(Chl) g^{-1}(FM) and mg(Chl) cm^{-2}(leaf area)] and specific leaf area (SLA) [cm^2 g^{-1}] in oil palm leaves. (n = 177)

Parameter	Mean±SEM
Chl value	110±2.06
Chl a [mg(Chl) g^{-1}(FM)]	4.79±0.15
Chl a [mg(Chl) cm^{-2}(leaf area)]	4.09±0.13
Chl b [mg(Chl) g^{-1}(FM)]	3.68±0.10
Chl b [mg(Chl) cm^{-2}(leaf area)]	3.15±0.08
Total Chl [mg(Chl) g^{-1}(FM)]	8.47±0.24
Total Chl [mg(Chl) cm^{-2}(leaf area)]	7.24±0.21
Car [mg(Chl) g^{-1}(FM)]	0.97±0.01
Car [mg(Chl) cm^{-2}(leaf area)]	0.83±0.01
SLA [cm^2 g^{-1}]	1.28±0.12

Table 2: Relationship between chlorophyll (Chl) value (x) and Chl a, Chl b, Total Chl and carotenoids (Car) (Y) in oil palm leaves. **: p<0.01.

Parameter	[mg(Chl) g^{-1}(FM)]	r^2	[mg(Chl) cm^{-2}(leaf area)]	r^2
Chl a	Y= 2.917+0.07x	0.96**	Y= 2.493+0.059x	0.97**
Chl b	Y= 1.454+0.046x	0.98**	Y= 1.243+0.039x	0.96**
Total chl	Y= 4.371+0.116x	0.94**	Y= 3.736+0.099x	0.97**
Car	Y= 0.537+0.004x	0.84**	Y= 0.459+0.003x	0.88**

could be successfully used for establishing a relationship between Chl value and photosynthetic pigments.

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