

# Analysis of Economic Crop Reflectance by Field Spectral Signature: Case Study Sugarcane

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**Abstract:** The study is aimed to collect and analyze spectral reflectance characteristics of sugarcane leaves infected by white leaf diseases using field spectroradiometer and chlorophyll meter. The results, then, will be applied to gain spectral index of infected sugarcane plot which can be related with spectral value from satellite imagery. K84-200 sugarcane variety was selected as a sample in this study. Classification of sugarcane sampling plots was performed according to a degree of severity. Spectral reflectance (Visible and IR) from sugarcane infected leaves were measured using field spectroradiometer. Correlation analysis between spectral reflectance and chlorophyll content, measured by chlorophyll meter, were performed. Spectral signature of samples of leaves from different degree of infected were then compared and various reflectance index were ,then, introduced including RedEdgeNDVI, GreenNDVI, RedEdge, Chlorophyll Index ( $CI_{RedEdge}$ ), Chlorophyll Index ( $CI_{Green}$ ), NDVI, EVI,  $\log(1/R737)$ , and Simple Ratio. It was found from the analysis that Red Edge NDVI yielded highest correlation with chlorophyll content in the sample leaves, around 0.94 of  $R^2$ . So this index would be useful for sugarcane infected plots detection and monitoring from satellite imagery.

**Key words:** Spectral Signature, Sugarcane white leaf disease, Red Edge band

## 1. Introduction

The usage of remotely-sensed data from air borne and space borne has been applied for the agronomic management since 40-year ago. In case of the agricultural applications, the spectral signature of each plant has mainly utilized to study because the different plants have particularly characteristics such as the leaf structure, nutrient and water status, leaf age, and leaf pigment. Moreover, the major factor influenced to the signature is chlorophyll. The content of chlorophyll is substance absorbed energy from the sun. As a result, these chlorophyll could indicate the physical condition of plant. The knowledge of this, thus, has been applied for the approach of yield estimation, damage monitoring and precision farming, etc.

Sugarcane, a one of economic crop in Thailand, is the main materials for several goods such as food, medicine, including alternative energy. In term of crop management, white leaf is an important sugarcane. The cause of disease is infection from a phytoplasma which *Matsumuratettix hiroglyphicus* is a carrier. This disease causes damage to sugarcane production. Generally, the agriculturists do not have neither adequate control nor well management on the sugarcane plots infected. These areas may possibly be totally removed and replanted with a high cost. Monitoring of this disease is needed for prior controlling and suppression.

## **2. Objectives**

2.1 To compare the relationship of the spectral signature and chlorophyll content between the white leaf disease infected and normal green leaves of sugarcane.

2.2 To evaluate the suited index value derived from spectral signature and chlorophyll content.

## **3. Methodology**

### **3.1 Materials**

3.1.1 Spectroradiometer (Fieldspec 3)

3.1.2 Chlorophyll Meter (SPAD-502)

3.1.3 Example of white leaves disease and normal green leaves using K84-200's sugarcane breed

3.1.4 SPSS for statistics analysis

3.1.5 Spectral Analysis and Management System Programs from CSTARs (2008).

3.1.6 Notebook

### **3.2 Method**

The K84-200 sugarcane variety sample plots, both infected from white leaf diseases and normal condition, were firstly identified. Sample leaves were then collected, according to degree of infected, from normal to high degree with a total number of 40 samples. Measurement of spectral reflectance (at the region of 350-2500 nm.) and chlorophyll content of sample leaves were performed using spectroradiometer and SPAD-502 respectively. Then, regression analysis of the parameters, measured from various spectral reflectance index and chlorophyll content were calculated. The reflectance index, developed from field spectral measurement, plant probe, included RedEdgeNDVI, GreenNDVI, RedEdge, Chlorophyll Index ( $CI_{RedEdge}$ ), Chlorophyll Index ( $CI_{Green}$ ), NDVI, EVI,  $\log(1/R737)$ , and Simple Ratio. The results of regression analysis from leaves chlorophyll content and reflectance index were then compared and evaluated.

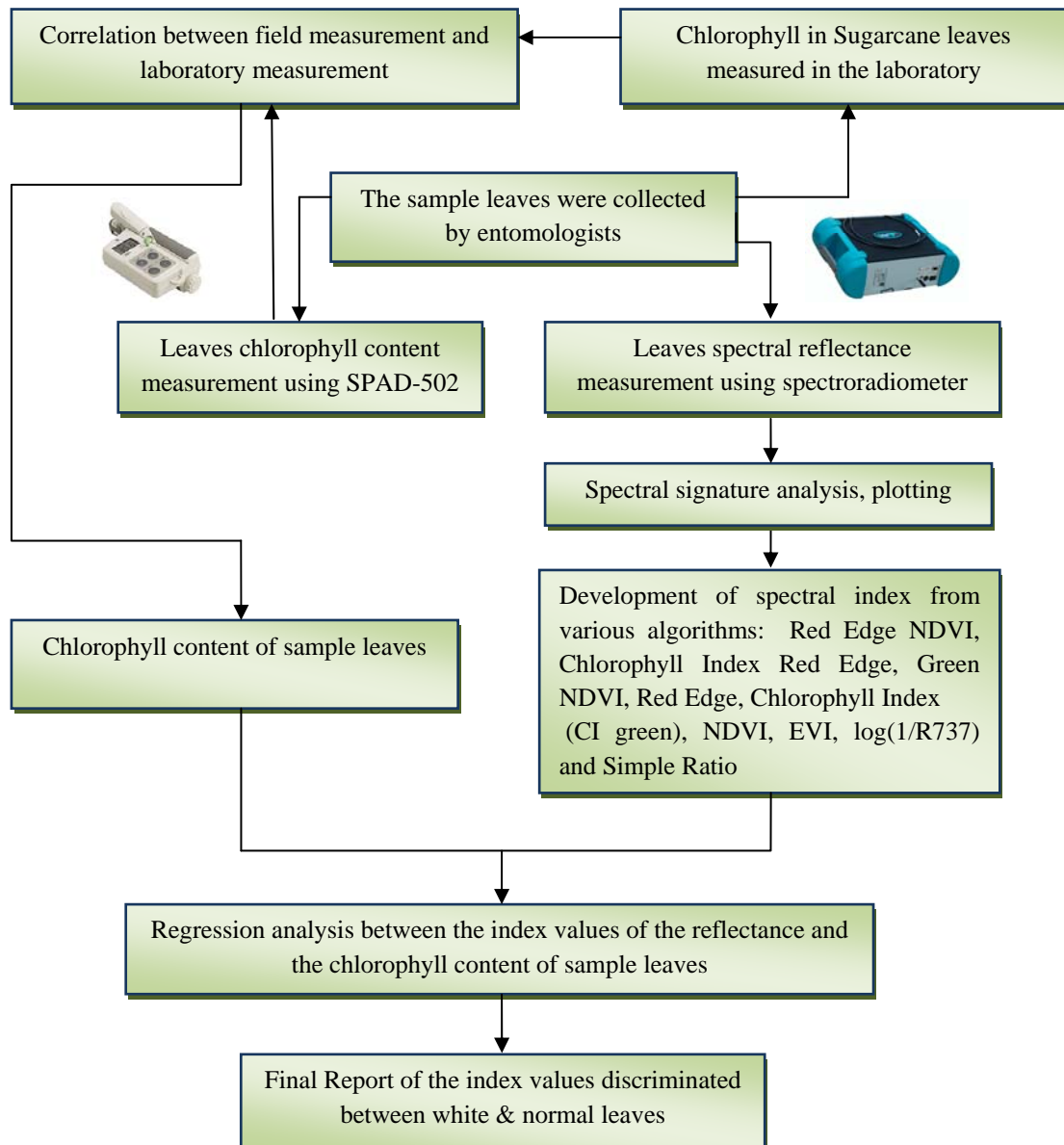


Figure. 1 The methodology of the study.

## 4. Results

### 4.1 The reflectance of infected and normal sugarcane leaves

The results indicated that the severe damage of white leaves revealed the highly reflectance or low absorption in the visible band. The normal green leaves, on the contrary, showed the low reflectance or highly absorption (as shown in Figure. 2). Regarding chlorophyll content, the amount of chlorophyll was declined according to degree of severity of the infected leaves; for example, the amount of extremely damage of white leaf would reveal the low chlorophyll. The values of the reflectance, thus, have been utilized to apply for the disease management, and discriminated the difference either white leaf disease or normal green leaf to indicate the initial stage of disease.

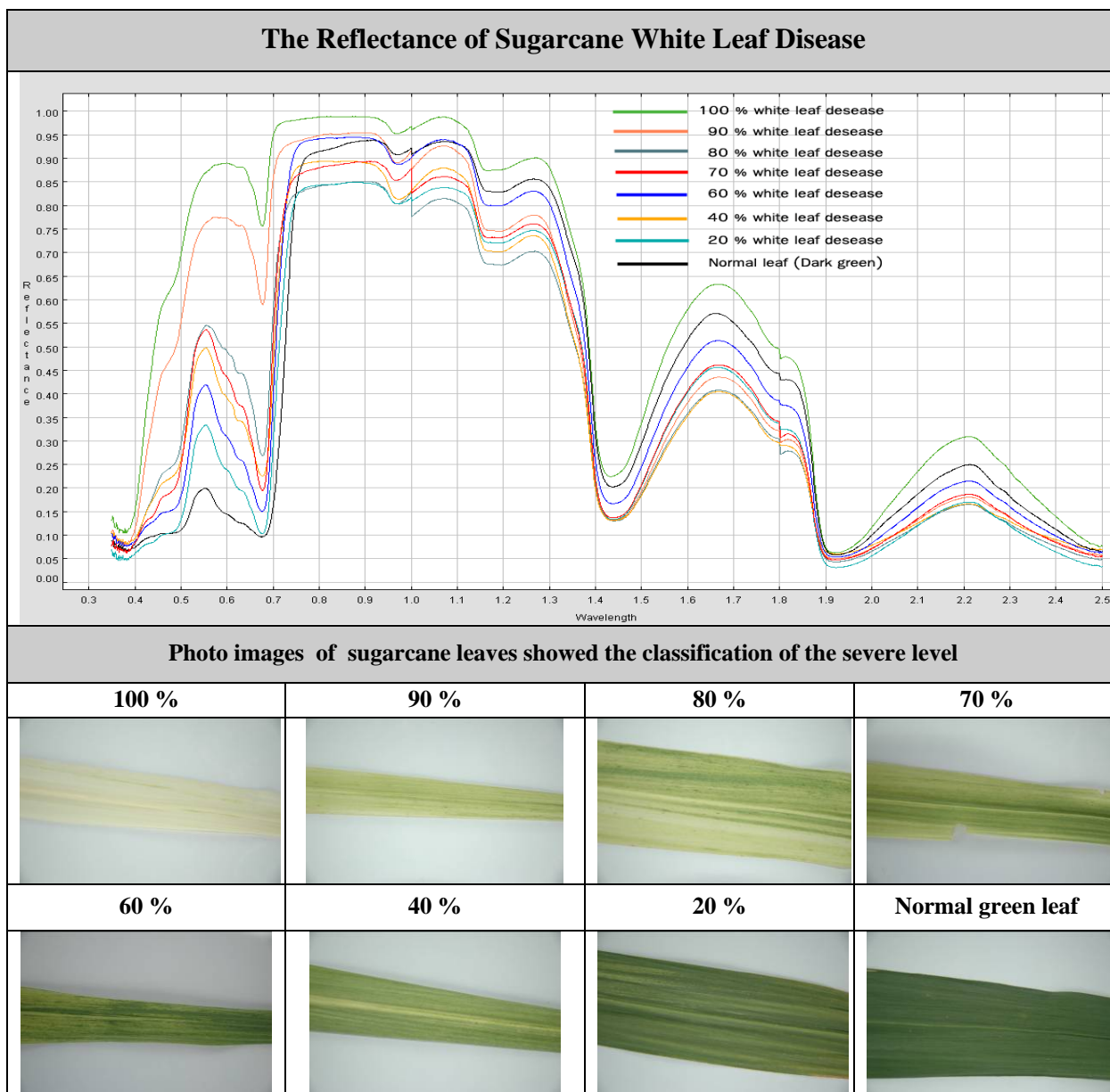


Figure. 2 The severe level of disease showed in the reflectance and sugarcane leaves

#### 4.2 The relationship between the reflectance and chlorophyll content of both leaves

4.2.1 The equation of the chlorophyll content between the SPAD-502 instrument and the laboratory measurement were developed from parameters measured from 40 samples leaves. The chlorophyll content measurement conducted in laboratory yielded the result could be shown below.

$$\text{Chlorophyll} = (0.0031 \times \text{SPAD502}) - 0.0129 \dots \dots \dots 1$$

Where:

Chlorophyll is the chlorophyll content measured in laboratory (mg./1000 mm.<sup>2</sup>)  
SPAD502 is the chlorophyll's values obtained from the SPAD-502 instrument

The coefficient of equation was 0.854, whereas the standard error of the estimate was 0.01498 mg. /1000 mm.<sup>2</sup> This equation was used to estimate the chlorophyll content of plant leaf from the value measured from Chlorophyll Meter SPAD-502 instrument.

4.2.2 Correlation analysis of spectral reflectance and chlorophyll content. It was found, in visible band, that spectral reflectance value of infected leaf was dramatically dropped as the chlorophyll content increased. However, for NIR region, there was poor correlation between infected leaf and chlorophyll content. Moreover, reflectivity from both normal leaf and infected leaf in NIR band. This demonstrated that visible band is useful for detection of sugarcane plots infected from white leaf disease. The result of this had already shown in Figure 3.

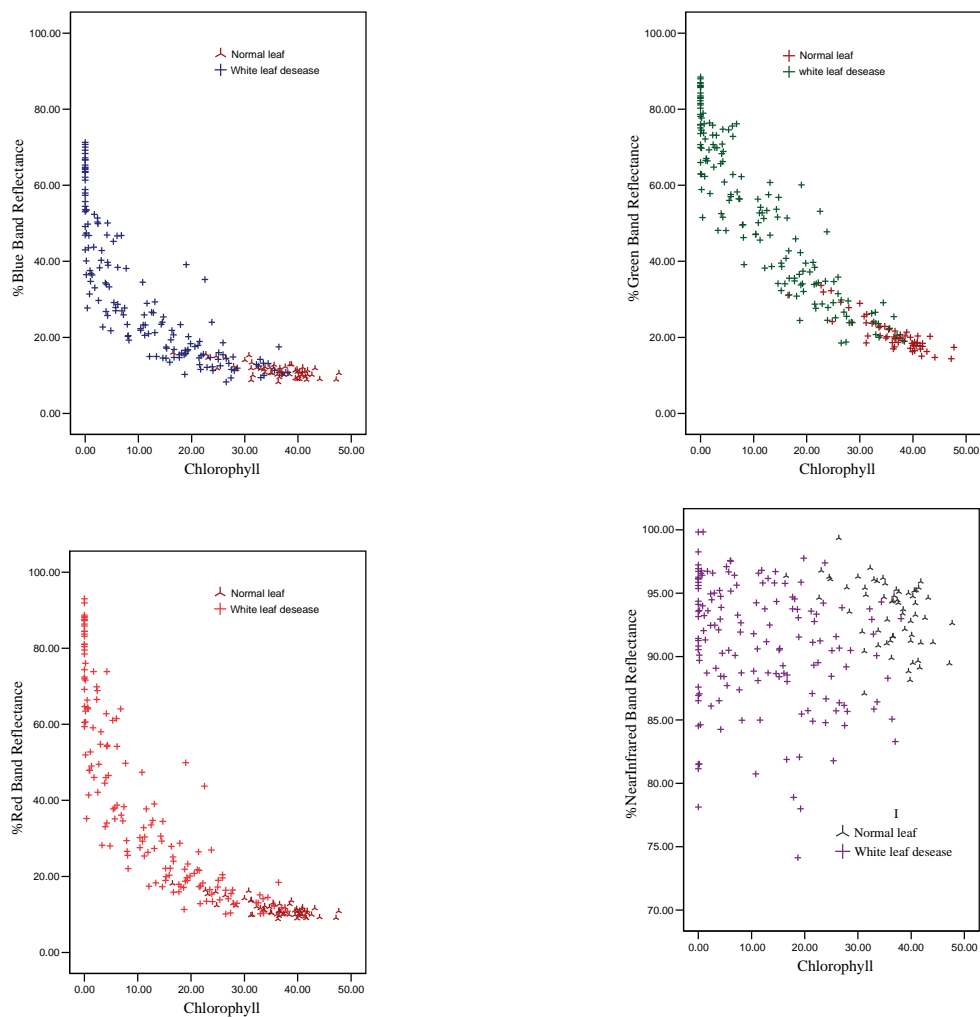


Figure. 3 Graphs of the relationship between chlorophyll and the reflectance in visible to infrared band of white leaves disease and normal green leaves.

4.2.3 Comparing of the correlation analysis between difference reflectance index and chlorophyll content. The results showed that the coefficient value ranking from high to low were RedEdgeNDVI, GreenNDVI, RedEdge, Chlorophyll Index ( $CI_{RedEdge}$ ), Chlorophyll Index ( $CI_{Green}$ ), NDVI, EVI,  $\log(1/R737)$ , and Simple Ratio which equal to 0.94 0.92 0.91 0.91 0.88 0.80 0.78 0.63 and 0.001, respectively (Table 2).

Considering these correlations, the results revealed that the best index value used to distinguish between white leaf disease and normal leaf was RedEdgeNDVI. In addition, GreenNDVI, Chlorophyll Index ( $CI_{RedEdge}$ ), RedEdge, and Chlorophyll Index (CI green) have probably showed the high coefficient values. There was noticeable that the coefficient values of NDVI and EVI revealed less than 0.80

In case of the simple ratio value, it was not suitable to verify the difference of both leaves because the coefficient was the lowest values. This index, thus, was not related with the chlorophyll content of sugarcane leaf.

## 5. Conclusions

The study on the spectral characteristics of infected disease Spectroradiometer found that the index value derived from either visible band or infrared band have usually been discriminated the difference of them. Because of the characteristics of white leaf disease infected leaf would be revealed the quite white (high degree of infected) and lower chlorophyll following the severe level of disease. Red Edge NDVI was the suitable index value to distinguish the difference of them as well as Red Edge NDVI (705-725 nm.), Chlorophyll Index (CI Red Edge), Green NDVI, Red Edge, and Chlorophyll Index (CI green).

## 6. Recommendations

6.1 Even though the study had already been verified only in the laboratory, the result would probably be transferred to apply with the remotely-sensed data for detecting the areas of disease.

6.2 In the past, the sensors of several EO satellites did not available or record in the red edge band. Nowadays, the RapidEye (Germany's satellite) successfully launched on August, 29 2008 (RapidEye AG. 2008) and available to record data in the red edge band. Therefore, the result of this research will apply in crop damage monitoring and assessment.

Table 2. The equations of the relationship between chlorophyll and the index values derived from Spectroradiometer

Index	Waveband	Equation	R <sup>2</sup>	Reference
Red Edge	R <sub>705-725</sub>	$R_{705-725} = 0.885 - 0.013Chl$	0.91	Gitelson et al.2003
	$\log(1/R_{737})$	$\log(1/R_{737}) = 0.037 - 0.002Chl$	0.63	Yoder and Pettigrew-Crosby,1995
Normalize Difference Vegetation Index	$(NIR - RED)/(NIR + RED)$	$NDVI = 0.232 - 0.016Chl$	0.80	Deering, 1978
Simple Ratio	$(NIR)/(RED)$	$SR = 2.530 - 0.002Chl$	0.001	Birth and McVey,1968
				Jordan, 1969
Chlorophyll Index	$(R_{NIR}/R_{GREEN}) - 1$	$CI_{GREEN} = 0.101 - 0.064Chl$	0.88	Gitelson et al.2003
	$(R_{NIR}/R_{RED..Edge}) - 1$	$CI_{RED.Edge} = 0.004 - 0.010Chl$	0.91	Gitelson et al.2003
Green NDVI	$(R_{NIR} - R_{GREEN}/R_{NIR} + R_{GREEN})$	$GNDVI = 0.120 - 0.014Chl$	0.92	Bushman and Nagel,1993; Gitelson et al.,1996
Red Edge NDVI	$(R_{NIR} - R_{RED.Edge}/R_{NIR} + R_{RED.Edge})$	$Red\ Edge\ NDVI = 0.004 - 0.010Chl$	0.94	Gitelson et al.1996
Enhanced Vegetation Index	$2.5 \times (R_{NIR} - R_{RED}/R_{NIR} + 6R_{RED} - 7.5R_{BLUE} + 1)$	$EVI = 0.383 - 0.022Chl$	0.78	Huete et al.,2002

Note: Chl = Chlorophyll content calculated from equation 1.  
R<sub>RED</sub> = Average values of reflectance during 630 – 690 nm.  
R<sub>RED Edge</sub> = Average values of reflectance during 705 – 725 nm.

R<sub>BLUE</sub> = Average values of reflectance during 450 – 520 nm.  
R<sub>GREEN</sub> = Average values of reflectance during 520 – 600 nm.  
R<sub>NIR</sub> = Average values of reflectance during 760 – 900 nm.

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