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PREFACE

Welcome to the 4th Proceeding of International Conference of Information Technology Systems and Innovation (ICITSI) 2017. The international conference was held in Bandung,23-24October 2017. ICITSI 2017 is hosted by School of Electrical Engineering and Informatics, Institut Teknologi Bandung, and sponsored by IEEE Indonesia Section.

We invited world renowned academics for keynotes, namely Prof. Jemal H. Abawajy, PhD., DSc., SMIEEE (Director Distribute System and Security Research Cluster, Faculty of Science, Engineering and Build Environment, Deakin University), and Kangbin Yim – Soon chunhyang (SCH) University.

We received 247 submissions for ICITSI 2017. After thorough reviews by reviewers, our Program Committee accepted 86 papers (acceptance rate: 34.82%) for the conference. Afterwards, 70 from 86 accepted papers were officially registered for the conference noted by camera-ready submission for IEEExplore publication and conference proceeding. Later, all authors with registered papers are enlisted to present the paper at the conference. We would like to thank all invited speakers, authors, reviewers, participants, committee members, and sponsors for their supports and contributions in this conference.

Suhardi (ITB, Indonesia)

General Chair of ICITSI 2017

TABLE OF CONTENTS

SCHEDULE
INTERNATIONAL CONFERENCE ON INFORMATION TECHNOLOGY SYSTEMS AND INNOVATION (ICITSI 2017)
Bandung, October, 23-24 2017
(Aula Timur Institut Teknologi Bandung, Jalan Ganesha No. 10 Bandung)

Date 1 : Monday, October 23 2017
Venue : Aula Timur – ITB Ganesha Campus

Time	Agenda	Venue
08.00 – 09.00	Registration	Aula Timur ITB
09.00 – 09.15	Report by General Chair	Aula Timur ITB
09.15 – 09.30	Welcome Speech by Dean SEEI ITB	Aula Timur ITB
09.30 – 09.45	Foreword from IEEE Indonesia Section Chair	Aula Timur ITB
09.45 – 10.00	Invitation to 2018 ICITSI, Bandung - Padang, local committee UNAND Padang	Aula Timur ITB
10.00 – 10.15	Opening by Rector ITB	Aula Timur ITB
10.15 – 10.30	Break	Aula Timur ITB
10.30 – 12.00	**Keynote Speakers:** Theme: Leveraging Service Computing to Accelerate Digital Economy 1. **Dr. Sinta Dewi, S.H., LL.M** - Universitas Padjajaran (Data Privacy Preserve in the Digital Economy Era) 2. **Kangbin Yim** – Soon chunhyang (SCH) University (Cyber Security and Forensic Challenges in Digital Economy Era) 3. **Antonio** Varriale– Blu5 Labs Ltd. (Security Solution Development based on System on Chips)	Aula Timur ITB
12.00 – 13.00	Lunch Break	
13.00 – 15.00	Parallel Session I – Oral Presentation	Aula Timur ITB: Room A – E
15.00 – 15.30	Break	
15.30 – 17.00	Parallel Session II – Oral Presentation	Aula Timur ITB: Room A - E

AGENDA

Pameran & Seminar Smart Campus

"Leveraging SmartCard Research to Implement Smart Campus"

Bandung, 23 – 24th 2017

Senin - Selasa, 23 & 24Oktober 2017 Tempat: Aula Barat – Kampus ITB, Ganesha	
09.00– 16.00	Pameran SmartCard Indonesia (Anggota konsorsium SmartCard Indonesia)
Selasa, 24 Oktober 2017 Tempat: Aula Barat – Kampus ITB, Ganesha	
07.30 – 08.00	Registrasi
08.00 – 08.15	Sambutan Ketua Konsorsium
08.15 – 08.30	Pembukaan: Direktur Jenderal Riset dan Pengembangan KemenRistekdikti – Dr. Muhammad Dimyati
08.30 – 08.45	Photo Session and Coffeebreak
08.45 – 11.00	Sesi Plenary: "Leveraging SmartCard Research to Implement Smart Campus" 1. Keynote Speaker: Direktur Jenderal Riset dan Pengembangan KemenRistekdikti – Dr. Muhammad Dimyati 2. Keynote Speaker:Penasehat Konsorsium SmartCard Indoensia - Dr.Ir. Richard Karel Willem Mengko 3. Keynote Speaker: Direktur Utama PT INTI – H. Darman Mappangara, M.Eng., SC 4. Keynote Speaker: Dewan Riset Nasional bidang Teknologi Informasi
11.00 – 12.15	Rencana Roadmap Penelitian Smart Campus 2018 – 2020 sebagai kelanjutan dari Penelitian SmartCard (Dr. Ir. Setiadi Yazid – Universitas Indonesia)
12.15 – 13.15	Lunch &Break
13.15 – 14.45	Pembahasan Komisi-komisi: - KomisiA: Infrastruktur Smart Campus (IoT, Big Data, CC) - KomisiB: Aplikasi Smart Campus - KomisiC: Security, Forensic Ready, Perlindungan Data Pribadi dan Regulasi Smart Campus
14.45 – 15.10	Break Sholat
15.10 – 16.00	Pleno Finalisasi Roadmap Penelitian Smart campus
16.00 – 16.30	Penutup

NB : * dalam konfirmasi

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Measurement of Chlorophyll Content to Determine Nutrition Deficiency in Plants : A Systematic Literature Review

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***Abstract*—Smart Farming utilizes information technology to facilitate farmers in carrying out their daily activities. One of the devices that can be used in supporting smart farming is a chlorophyll meter. This device could also be applied to monitor nitrogen deficiency status in plants. Nitrogen is the main element required for chlorophyll biosynthesis. By using chlorophyll meter, we could optimize the application of nitrogen fertilizer to increase yield, reduce the production cost, and circumvent excessive pollution to the environment. The chlorophyll meter is available in the market, however the price is still very expensive. Thus, the challenge is to develop a cheap and reliable chlorophyll meter tool. This paper provides a systematic review on the chlorophyll content measurement using the spectral properties of the plant. By using a systematic literature review method, 28 papers were selected as primary studies. Based on these primary studies it is known that chlorophyll content can be estimated by detecting reflected or transmitted light from the leaf using spectral sensor in visible and near infrared region.**

Keywords—smart farming, chlorophyll meter, systematic literature review, spectral properties

I. Introduction

Fertilization is a very important issue in agriculture. However, fertilization is generally carried on without precise information on plants conditions. Less fertilizer supply results in low yield, while excessive fertilizer increases the production cost and not environmentally friendly. Nitrogen is one of the essential elements which is normally present in any kind of plants fertilizers. All plants require sufficient supply of nitrogen for biosynthesis of chlorophyll and other plant cell elements such as amino acids, nucleic acids, proteins, etc. [1] . Therefore, nitrogen deficiency will cause a severe effect on plants growth and development. As a basic element for chlorophyll structure, nitrogen status in the plants could also be monitored based on the chlorophyll measurement. Low nitrogen correlate to lower chlorophyll content, which results in chlorosis symptom as detected in leaf organs. On the other hand, sufficient nitrogen supply will support optimum chlorophyll biosynthesis. As the plant yield is influenced by the nitrogen status, current research has allocated their effort to optimize the use of nitrogen fertilization as well as economical and environmental considerations [1]. Basically, Smart Farming emphasizes the application of information technology into agriculture to deliver a more productive and sustainable production. One of the tools that can be used in supporting smart farming is chlorophyll meter. By using chlorophyll meter, service monitoring system of nutritional deficiencies in plants can be realized so that yield can be increased, production cost can be reduced, and pollution caused by excessive fertilizer can be avoided. The chlorophyll meter has been available in the market, but the price is still very expensive. This has prompted researchers to develop a cheap and robust chlorophyll meter. Currently, we could not find any systematic reviews on the chlorophyll content measurement for monitoring nutritional deficiencies in plants. Therefore, the main focus of this paper is providing a review based on the selected articles published between 2013 and 2017 which discuss the measurement of chlorophyll content using the spectral properties of the plants.

II. Related Work

A. Measurement Method of Chlorophyll Content

Several techniques including Dumas combustion and Kjeldahl digestion have been developed to estimate the nitrogen content in plants. However, these protocols are labor-intensive and very destructive as they could only be applied on the extract of plant tissues [2]. Alternatively, the spectral properties of the plants could be used to measure the status of nitrogen. However, in high nitrogen supply, chlorophyll reaches saturation state; thus, it becomes a constraint in detecting excessive nitrogen content. Furthermore, other types of stresses might affect the spectral properties of leaves. The relative value of chlorophyll content obtained by employing a nitrogen plot reference in a field should reduce the influence of other factors of the nitrogen status on farmland, thereby increasing the sensitivity of spectral detections [2]. In order to achieve a better nitrogen status measurements, such indexes and methodologies should be adapted accordingly. For this, satellite imagery is one the options to determine nitrogen plant status across the field. However, this protocol is a lengthy process because the obtained images are not quickly updated to support the input for nitrogen status management. In addition, this system is also prone to atmospheric conditions interferences, which impedes its signal perception [2]. Hence, an alternative approaches including fast and robust chlorophyll detection technique should be developed to overcome this problem.

B. *Nature of Plants Spectral*

The nature of the plants spectral depends on many factors such as developmental positions, stress condition, microclimate of leaves, and plant species [3]. In this review we high light the working principle for measuring the chlorophyll content by using plant spectral properties. Basically, leaves are subjected to light source, then the reflected or the transmitted light is detected by a visible and near-infrared sensor. Subsequently, this information will be used to provide the calculation of chlorophyll content. The nature of plant spectral depicted in the Fig.1.

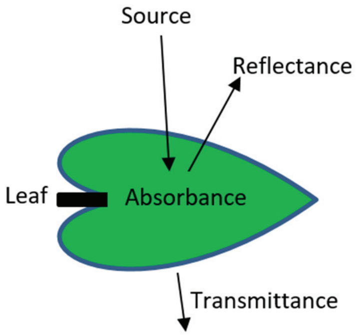

Fig.1. Nature of Spectral Plant

Light energy is absorbed by a green pigment called chlorophyll in the chloroplast. This energy is then converted into chemical energy through photosynthesis. Out of all the radiated solar radiation, only certain wave lengths are efficiently harvested by plants to process photosynthesis. Chlorophyll a absorbs blue violet light (400 - 490 nm) and red (620 - 750 nm) while chlorophyll b absorbs blue light (450 - 500 nm) and orange (595 - 610 nm), reflects yellow light (570 - 590 nm) and green (500 - 570 nm) [1]. Chlorophyll has maximum absorption in the red light (600 - 700 nm) and blue light (400 - 500 nm). No absorption in areas near infrared light [4].

C. *Chlorophyll meter*

Currently, various chlorophyll meters are available in the market to estimate the chlorophyll content quickly without damaging the plants such as atLEAF+, CL-01, CCM-200, and SPAD-502 [5]. The approximate chlorophyll content of these chlorophyll meters is derived from the measurement of light absorption by chlorophyll at a certain wavelength especially between the visible light region with maximum chlorophyll activity and in the infrared region (where light absorption by chlorophyll is very small. For example, SPAD-502 chlorophyll meters, atLEAF + and CL-01 use wavelengths of 650 nm, 660 nm, and 620 nm respectively as the maximum absorption area of chlorophyll, while all three use 940 nm in the infrared region. The CCM-200 chlorophyll meter uses wavelengths of 653 and 931 nm [5]. Several studies have also reported the development of chlorophyll content measuring devices Maleki et.al [1] used spectral sensors (TCS230), ATmega32 microcontroller and wavelength 620 nm up to 700 nm to estimate nitrogen content in lettuce leaves. As a comparison, nitrogen measurement was carried out by using a SPAD chlorophyll meter. The results showed that the intensity of sunlight affects the linear correlation between chlorophyll content and the sensor data (r^2=86). Interestingly, the distance between leaves and sensor is a critical point as the best results were obtained at a distance of 1-3 cm. Moreover, the sensor showed a better performance than the leaf color chart [1]. Tanapat Soochalearn et al. [6] created a low cost sensors (LCS) to assist cassava farmers in estimating and mapping the chlorophyll content in cassava leaves. The tool was made up of color sensors (RGB TCS230, TAOS Inc., USA) [6]. The sensor was calibrated for chlorophyll measurement by correlating the greenness index of the cassava leaf samples with a value as measured by the SPAD-502 chlorophyll meter standard [6]. The GPS receiver was connected to a device which stores the information of position at the time of measurement simultaneously [6]. The analysis of the linear correlations for R, G, and B was generated in the determination coefficient (R^2) of 0.9493, 0.9704, and 0.9849, respectively [6]. The evaluation of leaf greenness by using SPAD-502 meter resulted in root mean square error (RMSE) 0.9688 and R^2 0.97 showed satisfactory accuracy [6].

III. METHODOLOGY

The systematic approach was chosen to examine the literature of the chlorophyll content measurement. A systematic review is the process of recognizing, assessing and interpreting all research results in order to provide answers to research questions [7] . This review is based on the guidelines made by B.Kitchenham and Charters [7]. Methods of study, style and drawing were adopted from (Jatoth et al.) [8]. As shown in Fig. 2, the review consists of three stages: planning, conducting and documenting.

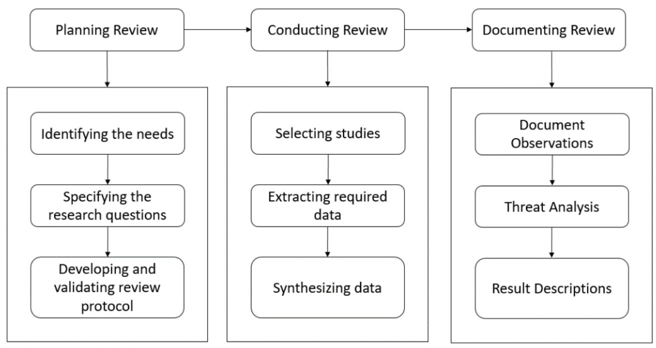

Fig.2: Research methodology (Based on [8], [7], [9])

III.1. Planning Review

III.1.1 Identifying the Needs

This stage intends to show that similar systematic review has not been published yet. Taken together we were focusing on chlorophyll content measurement by employing different database source i.e. Scopus, ACM Dig Lib, IEEE Xplore Dig Lib, Springer Link, ProQuest and Science Direct. From the search results, there are no systematic review papers on the chlorophyll content measurement found in all sources by using the following search string.

(systematic literature review)

AND

(chlorophyll OR nitrogen)

III.1.2 Determining the Research Questions

The question in this research was designed to keep the review focused. The research questions and motivations presented by this literature review are shown in table 1.

TABLE I. RESEARCH QUESTIONS AND MOTIVATIONS

ID	Research Questions	Motivations
RQ1	What is the most significant journal discussing chlorophyll measurements?	Identify the most significant journal
RQ2	What are research topics, method and wavelength selected by researcher?	Identify the research topics, method, and wavelength
RQ3	What are the research challenges	Identify the research challenges

III.1.3 Constructing and Validating the Review Protocol

In this stage, we defined the review scope of the study to explain the search string to extract the literature. We also improved review scope, search strategy, filtering based on inclusion / exclusion criteria. We specified the scope and objectives of this review through PICOC criteria (Population, Intervention, Comparison, Outcomes and Context) [7]. Table 2 shows the PICOC structure of the research question.

TABLE II. COVERAGE AND OBJECTIVES OF THE SYSTEMATIC LITERATURE REVIEW

Criteria	RQ1	RQ2	RQ3
Population	Journal	Research topics	Research challenges
Intervention	Internal or external validation, data extraction and synthesis		
Comparison	Similar studies in the field of chlorophyll measurement		
Outcomes	Journal categorization, research topics, method, wavelength and research challenges		
Context	Systematic investigation to integrate peer reviewed research on measurement of chlorophyll content		

III.2 Conducting Review

III.2.1 Selecting studies

The conducting stage of this review comprising study selection, result extraction, followed by synthesizing information [8]. At the stage of choosing a study, we determined the search terms, and the motivations as described in the planning review section. The list of customized search string for each website page are shown in Table 3.

TABLE III. CUSTOMIZED SEARCH STRING FOR EACH WEBSITE PAGE

Scopus	TITLE-ABS-KEY ((chlorophyll OR nitrogen) AND (sensing OR sensor) AND (visible OR infrared OR nutri ent) AND (content OR concentration) AND NOT (unmanned OR remote OR imaging OR m odis OR landsat OR meris OR underwater)) AN D (LIMIT-TO (DOCTYPE , "ar "))
ACM Digital Library	(+chlorophyll nitrogen photosynthetic leaf nutrient devices sensor -unmanned -remote -imaging -modis -landsat -meris -hyperspectral -multispectral -canopy -underwater)
Science Direct	TITLE-ABSTR-KEY((chlorophyll OR nitrogen) AND (photosynthetic OR leaf OR nutrient) AND (sensor) AND (devices)) and not TITLE-ABSTR-KEY((unmanned OR remote OR imaging OR modis OR landsat OR meris OR hyperspectral OR multispectral OR canopy OR underwater))
Springer link	(chlorophyll AND nitrogen) AND (sensor AND device) AND (photosynthetic OR leaf OR nutrient) AND NOT (unmanned OR remote OR imaging OR modis OR landsat OR meris OR hyperspectral OR multispectral OR canopy OR underwater OR camera)
IEEE Xplore Digital Library	chlorophyll AND NOT (remote sensing OR MODIS OR MERIS OR lansat OR Satellite)
ProQuest	(chlorophyll AND nitrogen AND devices AND sensor) NOT (unmanned OR remote OR imaging OR modis OR landsat OR meris OR hyperspectral OR multispectral OR canopy OR underwater OR camera)

III.2.1.1 Initial selection

We extracted 410 research articles (Table 4) through different literature sources published between 2013 and 2017 (through October 2017) via query in Table 3.

TABLE IV. NUMBER OF EXTRACTED PAPERS

No	Search Database	Result
1	ACM Dig Lib	2
2	Scopus	217
3	Science Direct	2
4	Springer Link	67
5	IEEE Xplore Dig Lib	25
6	ProQuest	97
	Total	410

III.2.1.2 Final selection

In the final selection, we applied inclusion and exclusion criteria (Table 5) by reading the abstraction part of all candidates of primary study, and we obtained 28 primary study papers (Table 6).

TABLE V. CRITERIA OF INCLUSION AND EXCLUSION

Inclusion	- Articles in peer reviewed papers - The articles discuss the techniques of measuring chlorophyll using nondestructive method through the spectral properties of the plant - Papers that explicitly discuss design, realization and test; use of chlorophyll meter; and method
Exclusion	- Books, book titles, and theses - Editorial

	- The articles discuss the techniques of measuring chlorophyll through chemical, and satellite

TABLE VI. NUMBER OF PAPERS AFTER INCLUSION AND EXCLUSION CRITERIA WAS APPLIED

No	Search Database	Result
1	ACM Dig Lib	0
2	Scopus	23
3	Science Direct	0
4	Springer Link	2
5	IEEE Xplore Dig Lib	2
6	ProQuest	1
	Total	28

IV. RESULT AND DISCUSSION

Data from the aforelisted search databases were extracted based on the rank journal, year of publication, topics, methods and wavelengths. All the selected paper were identified as high quality papers from Q1, Q2, Q3 and Q4 rank journals (Table 7).

TABLE VII. LIST OF PAPER DISTRIBUTIONS PER PUBLICATION CHANNEL

Publication Channel	Quartiles	Amount
Applied Spectroscopy Reviews	Q1	1
Chiang Mai University Journal of Natural Sciences	Q4	1
Computers and Electronics in Agriculture	Q1	1
Environmental and Experimental Botany	Q1	1
Environmental Evidence	Q1	1
European Journal of Agronomy	Q1	1
Field Crops Research	Q1	1
IEEE Sensors Journal	Q1	1
IEEE Trans on Instrumentation and Measurement	Q1	1
Journal of Agricultural and Food Chemistry	Q1	1
Journal of Sensors	Q3	1
Nongye Gongcheng Xuebao/Trans of Chinese Society of Agricultural Engineering	Q2	1
Nongye Jixie Xuebao/Trans. of the Chinese Society for Agricultural Machinery	Q2	2
Pedosphere	Q2	1
Photosynthetica	Q2	2
Plant Method	Q1	1
Precision Agriculture	Q1	1
Res Journal of Applied Sciences, Engineering and Technology	Q3	1
Scientia Agricola	Q2	1
Sensors	Q2	5
Sensors & Transducers	Q4	1
The Scientific World Journal	Q2	1

Table 7 shows that the highest number of papers discussing the measurement of chlorophyll content using nondestructive method with spectral properties was found in *Sensors* journal. Subsequently, we also obtained that many papers discussing the measurement of chlorophyll content using nondestructive method with spectral properties were published in 2017 (Table 8).

TABLE VIII. LIST OF PAPERS ON CHLOROPHYLL MEASUREMENTS BY YEAR OF PUBLICATION

Year of Publication	Reference	Amount
2013	[10], [11], [12], [2], [13], [14], [15]	7
2014	[16], [17], [18]	3
2015	[19], [20], [21], [22], [23], [24], [25]	7
2016	[5], [26]	2
2017	[27], [28], [29], [30], [31], [32], [33], [6], [34]	9

The research topics on the measurement of chlorophyll content are shown in Table 9. We classified papers based on several topics such as: design, realization and testing; use of chlorophyll meter; and methods.

TABLE IX. RESEARCH TOPICS ON THE CHLOROPHYLL CONTENT MEASUREMENT

Research Topics	Reference
Design, realization and test	[22], [6], [25]
Use of chlorophyll meter	[16], [5], [33]
Method, etc.	[10], [19], [27], [28], [11], [20], [29], [12], [30], [21], [23], [31], [2], [24], [32], [13], [34], [18], [15], [26], [17], [14]

TABLE X. RESEARCH TOPICS ON DESIGN, REALIZATION AND TEST

Title	Reference
Multi-crop chlorophyll meter system design for effective fertilization	[22]
A Low-cost Sensor for Measuring and Mapping Chlorophyll Content in Cassava Leaves	[6]
Design and test of nutrition diagnosis system for wheat canopy based on spectroscopy	[25]

From Table 11, chlorophyll content can be estimated by detecting the reflected or transmitted light from leaves using spectral sensor in visible and near infrared region. Methods and wavelengths were used in papers, products and patents are shown in Table 11.

TABLE XI. METHODS AND WAVELENGTH

Method Wavelength (nm)	Reflectance	Transmittance
300, 1100	[25]	
350 – 750	[6]	
425 – 450, 650 – 670, 950		[22]
520 to 580, 690 to 740		US7746452B2
620, 940		CL-01
650, 940		SPAD502, TYSA
653, 931		CCM200, MC100
640, 940		atLEAF
660 to 690, 760 to 1100		US 4295042 A
700, 840	CM1000, US 6020587	

There are two research challenges in this systematic literature review such as how to develop a cheap, yet reliable chlorophyll meter tool and how to integrate chlorophyll meter tool and internet of things to build services monitoring of deficiency nutrition in plants.

V. CONCLUSION

This systematic literature review is an early stage of its main goal to develop of a chlorophyll meter tool. By using systematic literature review method, 28 papers were obtained and used as our focus of study. *Sensors* journal is the main journal which published a number of papers on the measurement of chlorophyll content using nondestructive method with spectral properties. Furthermore, chlorophyll content can be measured by detecting the reflected or transmitted light using spectral sensor in visible and near infrared region. This systematic literature review, however, has several shortcomings, merely discussing the measurement of chlorophyll content by using spectral properties of the plant. For future perspective, it is necessary to develop a cheap, yet reliable chlorophyll meter tool and employ the integration of chlorophyll meter devices with the Internet of things to provide monitoring services in plant nutrition status.

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