
UNIVERSITI PUTRA MALAYSIA

# DETERMINATION OF OIL PALM LEAF NITROGEN CONCENTRATION BY REFLECTANCE SPECTROSCOPY

AHMAD SARWANI HAJI ADNI

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# DETERMINATION OF OIL PALM LEAF NITROGEN CONCENTRATION BY REFLECTANCE SPECTROSCOPY

**By**

**AHMAD SARWANI HAJI ADNI**

**Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science**

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**DEDICATION**

**This thesis is dedicated to all staff and top management for their support**

Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

**DETERMINATION OF OIL PALM LEAF NITROGEN CONCENTRATION BY REFLECTANCE SPECTROSCOPY**

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**January 2010**

**Chairman: Dr. Anuar Abdul Rahim,PhD**

**Faculty : Agriculture**

Nitrogen (N) presents in plant materials usually in the form of protein and its analysis in the laboratory usually involve digestion process. In the digestion process, protein nitrogen is converted to the ammonium form by heating with concentrated sulphuric acid in the presence of a catalyst mixture of sodium sulphate and selenium. The method for determining the final ammonium may be either by distillation, as in the classical Kjeldahl method, or by an instrumental analysis. In recent years, a new method has been developed to measure N content in leaves using a fiber optic spectrometer. This method allows N content in leaves to be determined in situ and it can provide real time data of N content in leaves. Compared to the traditional destructive methods, this method will reduce the cost of analyzing the plant nutrient contents by minimizing chemical cost, time and labor requirements. Furthermore, since this technique does not involve the use of chemicals, there will be no generation of chemical waste. An example of this new method is the miniature fiber optic spectrometer with specially designed leaf probe, the Ocean Optic HR2000 High Resolution Miniature Fiber Optic Spectrometer. However, to get

accurate data from this probe, a relationship between the data obtained from the sensor must be correlated with actual foliar nutrient levels measured in the laboratory. Very few studies have been conducted to determine the relationship between the N data obtained using the leaf probe and the N level measured in the laboratory.

The objective of this study, therefore, was to determine the relationship between the reflectance measurements using the Ocean Optic HR2000 High Resolution Miniature Fiber Optic Spectrometer with N concentration determined using the traditional wet-chemistry procedure (Kjeldahl digestion technique) from fresh oil palm leaf of different fertilization treatments and from fresh oil palm leaf of different ages. Significant relationships were found between reflectance of fresh oil palm leaves with N from Kjeldahl method. The N concentration in the leaf samples of oil palm from different ages analyzed by the Kjeldahl technique ranged from 1.89 % to 3.24 %. When the oil palm leaves from each field were analyzed separately, the highest relationships were measured in the red region of the spectrum between 699.98 to 700.87 nm. The use of pooled data to obtain the regression equations resulted in precision greater than that achieved with the single-field data. The best regression line in predicting leaf N concentration from the measured reflectance was obtained using the combined (pooled) data and the equation was Leaf N=2.7935-0.0014Reflectance. The difference between the mean of actual N concentration and the mean of predicted N concentration from pooled data was only 0.031%, which was not statistically significant ($P \geq 0.05$, df=266) according to the performed t-test. The results indicate that the reflectance spectroscopy method using the Ocean Optic HR2000 High Resolution Miniature Fiber Optic Spectrometer was reliable for the determination of N concentration in fresh oil palm leaves.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk penganugerahan ijazah Master Sains

**PENENTUAN KANDUNGAN NITROGEN DALAM DAUN KELAPA SAWIT MELALUI SPEKTROSKOPI KEPANTULAN**

Oleh

**AHMAD SARWANI HAJI ADNI**

**January 2010**

**Pengerusi: Dr. Anuar Abdul Rahim, PhD**

**Fakulti: Pertanian**

Nitrogen (N) biasanya hadir di dalam daun sebagai protin dan analisa N di makmal melibatkan proses penghancuran. Dalam proses ini, protin N ditukarkan kepada bentuk ammonium secara memanaskannya dengan asid hidrogensulfat dengan kehadiran campuran pemangkin terdiri dari garam sodium sulfat dan selenium. Penentuan kandungan ammonium akhir dilakukan samada secara kaedah penyulingan, seperti dalam kaedah tradisi Kjeldahl, atau melalui kaedah analisa peralatan. Beberapa tahun kebelakangan ini, satu kaedah baru menetukan kandungan N menggunakan alat spectrometer gentian optic telah dibangunkan. Melalui kaedah ini, kandungan N dapat dianalisa secara terus di lapangan. Berbanding kaedah lama yang merosakkan, kaedah ini dapat mengurangkan kos analisa kandungan nutrisi kelapa sawit dengan cara mengurangkan kos bahan kimia, masa dan keperluan tenaga kerja. Selain dari itu, oleh kerana teknik ini tidak memerlukan penggunaan bahan kimia, tiada sisa buangan kimia yang dihasilkan. Satu contoh kaedah baru ini ialah dengan menggunakan spectrometer

mini yang direka dengan alat deria daun, HR2000 Mini Spektrometer Berresolusi Tinggi model Ocean Optic. Walau bagaimanapun, untuk mendapatkan data yang tepat, satu bentuk hubungan di antara data dari alat deria dan kandungan nutrisi daun dari analisa makmal perlu dibena. Hanya beberapa penyelidikan telah dijalankan untuk menentukan hubungan tersebut. Oleh yang demikian, kajian ini bertujuan mendapatkan hubungan di antara data kepantulan melaui Spektrometer Mini HR 2000 Gentian Optik Berresolusi Tinggi model Ocean Optic dan peratusan kandungan N melalui analisa kimia di dalam makmal (teknik Kjeldahl) pokok kelapa sawit segar berbeza pembajaan dan daripada pokok pelbagai usia.

Hasil ujian didapati, hubungan yang signifikan telah diperolehi di antara data pantulan daun kelapa sawit segar dengan kandungan N melalui kaedah Kjeldahl dengan kandungan N di antara 1.89 % to 3.24 %. Apabila daun kelapa sawit dari lapangan berbeza di analisa secara berasingan, hubungan tertinggi diperolehi dalam kawasan spectrum merah di antara 699.98 dan 700.87 nm. Penggunaan persamaan regrasi hasil data terkumpul menghasilkan keputusan yang lebih tepat berbanding keputusan diperolehi daripada persamaan regrasi individu. Persamaan regrasi terbaik untuk menganggarkan kandungan N diperolehi dari data yang digabungkan dan persamaan tersebut ialah Y=2.7935-0.0014x di mana Y ialah kandungan N dan x mewakili bacaan pantulan. Perbezaan purata di antara kandungan N sebenar dan N dijangka daripada data yang terkumpul ialah hanya 0.03%, di mana ianya tidak signifikan apabila diuji secara kaedah t ($P \geq 0.05$, df=266). Hasil ujian ini menunjukkan kaedah teknik pantulan menggunakan Spektrometer Mini HR 2000 Gentian Optik Berresolusi Tinggi model Ocean Optic didapati berkesan untuk menentukan kandungan N daun kelapa sawit segar.

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I certify that a Thesis Examination Committee has met on 13 January 2010 to conduct the final examination of Ahmad Sarwani Haji Adni on his thesis entitled "Determination of Oil Palm Leaf Nitrogen Concentration By Reflectance Spectroscopy" in accordance with Universities and Universitiy Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master in Science.

Members of the Thesis Examination Committee were as follows:

**Samsuri Abd. Wahid, PhD**
Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

**Siva Kumar Balasundram, PhD**
Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

**Ahmad Husni Mohd Haniff, PhD**
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

**Izham Ahmad, PhD**
Doctor
Sustainable Development of the Tropical Fruit Industry
International Tropical Fruit Network (TFnet)
Malaysia
(External Examiner)

**BUJANG BIN KIM HUAT, PhD**
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 20 May 2010

This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master in Science. The members of the Supervisory Committee were as follows:

**Anuar Abd. Rahim, Ph.D.**
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

**Che Fauziah Ishak, Ph.D.**
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

**Mohd Hanafi Musa, Ph.D.**
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

---

**HASANAH MOHD GHAZALI, PhD**
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 June 2010

## DECLARATION

I hereby declare that the thesis is based on my original work for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

**AHMAD SARWANI HAJI ADNI**

Date : 13 January 2010

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