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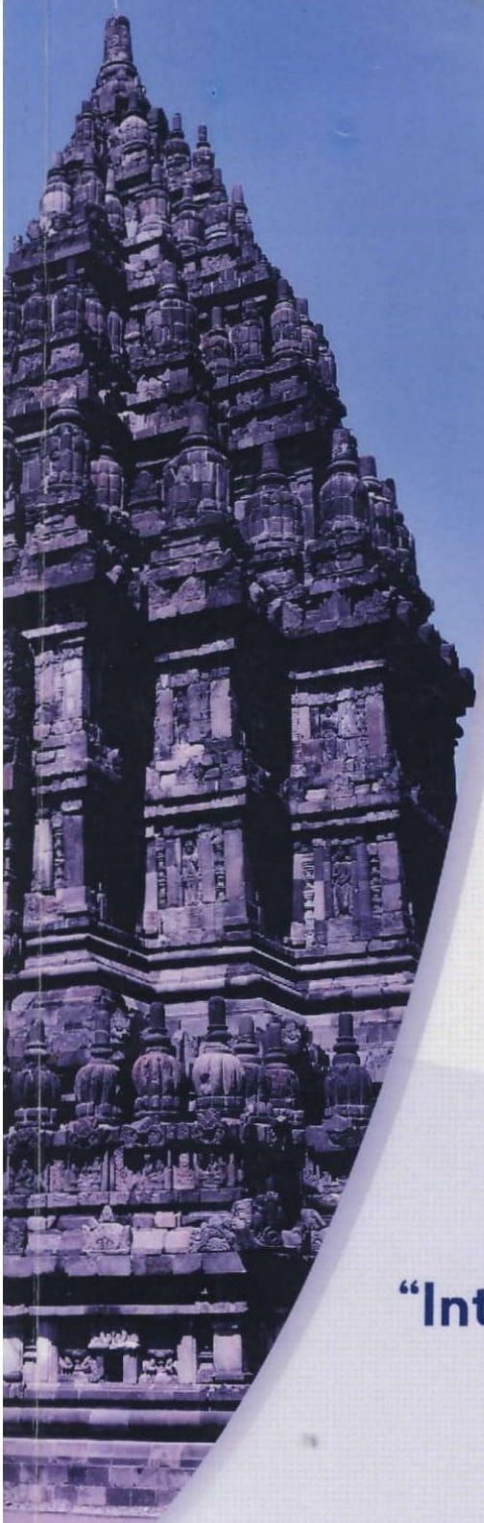

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Rapid Nitrogen Determination of Soybean Leaves Using Mobile Application

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***Abstract*—Nitrogen is one of the important nutrients elements for the growth of soybean plants. In this paper we propose mobile application that can be used nondestructively to estimate the nitrogen content of soybean leaves. We named this software "Mata Daun". The primary concept of this software is to relate the RGB (Red, Green, Blue) value of the captured soybean image with its nitrogen content. Furthermore, the captured image is processed into Enhanced Color Visibility (ECV) index using digital image processing method for the ease of software algorithm process. Calibration process and field trial were conducted to found the relation between ECV index and soybean leaves nitrogen content. The calibration result showed that the nitrogen readings by this application had a fairly strong relationship (R^2 =0.70) with the soybean leaves nitrogen content (Agriexpert CCN-6000 readings). The field test result also gave the same strong positive relationship between predicted and real soybean leaves nitrogen content (R^2 =0.93).**

Keywords—nitrogen; soybean; RGB; image processing; mobile application (key words)

I. INTRODUCTION

Nutrients deficiency, particularly nitrogen, can lead to a physiological imbalance in soybean plants. One of the impact is a reduction in yield during harvest[1,2]. Addition of fertilizer is needed to fulfill the shortage of necessary nutrients on plants. Prior to fertilizer application, information about the levels of nitrogen in plant is required to avoid excessive nitrogen fertilizer application. High amount of nitrogen in plant tissue can increase the attack from pests and diseases and also can harm the plant if the dose is high [3,4,5]. The most accurate method to determine levels of nitrogen in plant tissue is laboratory test. The laboratory test result requires longer time due to the complexity of sample preparation. Usually, it needs 3-7 days from sample preparation to the result. The complexity of laboratory testing process is one of the barriers for farmer to check nitrogen level of plant leaves at the beginning of the growing season. The lack of farmer's knowledge about nitrogen status of their plant can drive to excessive use of fertilizer that can be harmful to their plant and surrounding environment. In this paper we propose a mobile application called "Mata Daun". This mobile application is intended to help soybean farmers in determining real time plant nutrient status at low cost. With the ability to estimate the nitrogen content of soybean leaves nondestructively and rapidly, we hope this mobile application can improve the farmer's knowledge about their soybean plant nutrient condition.

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II. METHODS

A. Hardware

Samsung smart mobile phone type Wonder I8150 was used to conduct all the mobile application experiment. This mobile phone embedded with 1.2 Gigahertz processor, 2 Gigabyte Read Only Memory, 5 megapixels camera and 2.3.5 Ginger Bread Android operating system. The white paper background reference was a sheet of 80 gram A4 size white paper.

B. Software

Mobile application was developed based on JAVA language. It is compatible with Android version 2.3 up to 4.0.

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Digital image processing algorithm was embedded to obtain estimation of the nitrogen content of soybean leave being observed. Mobile device's camera captured reflected light from soybean leaf surface and white paper background reference. The captured light was then converted into RGB (Red, Green, Blue) format. Afterwards, global thresholding method was applied into RGB image to automatically identify the RGB value of soybean leaves and white paper background references. Both RGB value was then converted into Enhanced Visibility (ECV) index. ECV index used in the "Mata Daun" application is a development from Color Visibility (CV) index which is used in the "Bai Khao" mobile application [6]. The improvement that was made is the color correction mechanism to deal with illumination variation problem. Color correction was made by the addition of the corrected white paper background RGB value to the index equation. Below is the description of ECV index equation:

$$ECV = \frac{(Rs+(255-Rr)}{255} + \frac{(Gs+(255-Gr)}{255} + \frac{(Bs+(255-Br)}{255} \quad (1)$$

Rs= Average red value of soybean leave image

Rr= Average red value of white reference image

Gs= Average Green value of soybean leave image

Gr= Average Green value of white reference image

Bs= Average Blue value of soybean leave image

Br= Average Blue value of white reference image

Figure 1 shows the illustration of the "Mata Daun" mobile application usage to estimate soybean leaves nitrogen content. The color correction algorithm implementation in this mobile application could significantly minimize the variation of ECV index caused by the sun light illumination changes. Color correction method was also used by Sumriddetchkajorn [7] to minimize bias of predicted chlorine concentration resulted from their mobile application reading.

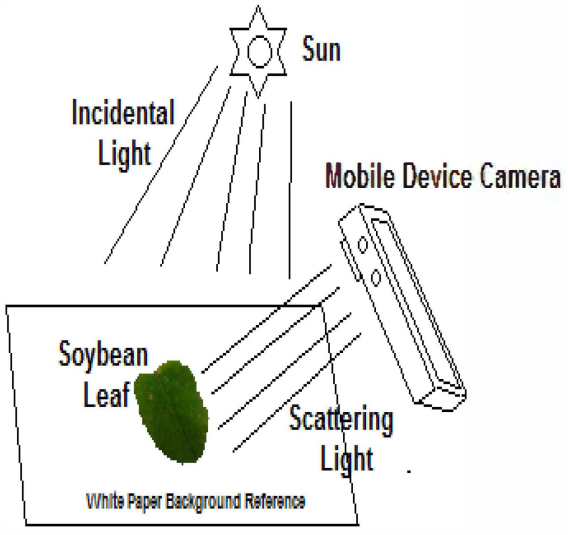

Figure 1. Illustration of the mobile application usage for soybean leaves nitrogen estimation.

III. PERFORMANCE EVALUATION

A. *Enhanced Color Visibility Index Stability Under Different Ilumination Conditions*

An experiment was conducted in shaded and open area which is differ in illumination value (Shaded area=1,266±57 lux, open area illumination =9,833±152 lux) to verify the performance of the color correction mechanism. Test was performed at daylight (09.00 A.M- 11.00 A.M) under trees (shaded area) and under the sun (open area). In this experiment 40 samples were used, thus the total sample was 20 for each conditions. The result in figure 2 shows that predicted nitrogen meter value by ECV index in both area gave relatively the same response (coefficient of variation = 0.05 or 5%). There is no significant difference between ECV in shaded and open area. Through this validation test, the reliability of ECV index in different illumination condition was confirmed.

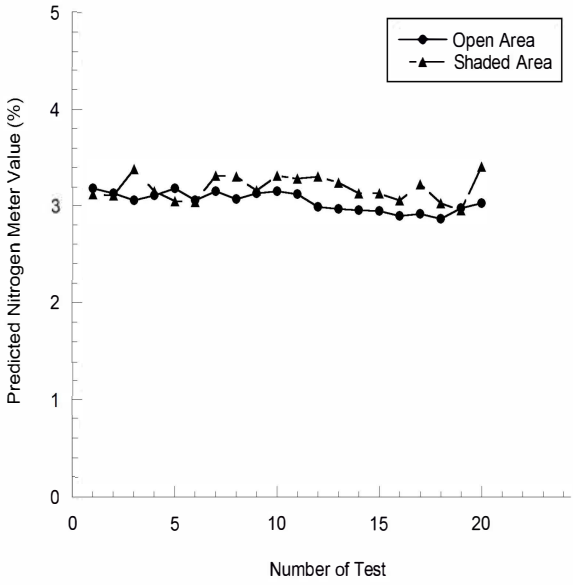

Figure 2.Ilumination changes response of Predicted Nitrogen Meter Value by Enhanced Color Visibility (ECV)

B. *ECV Index and Nitrogen Content Relationship*

In this section, an experiment was conducted to understand the relationship between ECV index and nitrogen content of soybean leaves. 30 soybean leaves were used for this purpose. An Agriexpert CCN-6000 nitrogen meter was used to determine nitrogen content of soybean leaves. Power trend curve was fitted to draw the relationship between nitrogen content obtained from nitrogen meter reading of soybean leaves and ECV index. The power equation is Y=235.04*X^(-1.17) (R^2=0.70). This equation was used as a mathematical model in our mobile application to obtain nitrogen estimation from ECV index.

Although the coefficient of determination of the model is not as high as in "Bai Khao" mobile application [6], it still

show good nitrogen reading value. In the future we plan to add the size samples of our model to improve the accuracy. We also plan to use other approximation methods, instead of mathematical model (i.e. neural network or fuzzy), to enhance our prediction about the relationship between soybean leaves nitrogen content and ECV index. In this research, nitrogen laboratory test for "Mata Daun" result comparison has not been conducted, this comparison research is still in progress in our on going research.

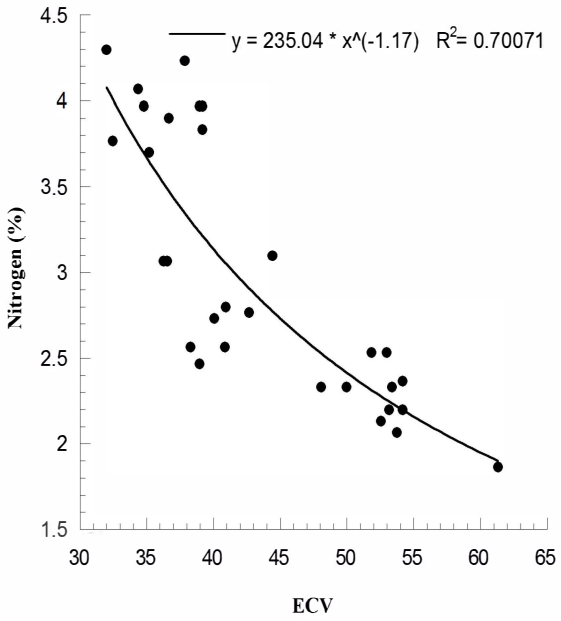

Figure 3. Relationship model of nitrogen meter CCN-6000 Agriexpert reading and Enhanced Color Visibility (ECV) Index

IV. FIELD TEST

To know the performance of our mobile application on the field, a field test experiment was conducted. 20 soybean leaves samples were used to obtain the correlation value between predicted value and real value of soybean leaves nitrogen content reading. The image acquisition process on the field is shown in figure 4, while the result page is shown in the figure 5. The mobile application result page shows the value of predicted soybean leaves nitrogen. We also designed this mobile application with an embedded web service function. In this way users could save the reading result on the database and access those results anytime as long as it is connected with internet. For future development, we plan to expand this mobile application capability to give a suggestion to farmer about their soybean plant condition based on the mobile application reading. This development is intended to give the farmer a solution about their plants continuously. Based on the experience of "Mata Daun" users on the field, users need bigger and simple result screen which is easier to read on the field. As the result, figure 6 shows fairly strong relationship between predicted and real soybean leaves nitrogen content. It shows that the coefficient of determination is 0.93 which is proved the reliability of mobile application reading on the field. For the next development we will combine this test with fertilizer treated plot to enhance the accuracy of the reading result.

Figure 4. Image acquisition process using "Mata Daun" mobile application : acquisition process on field (left) and screenshot of the result (right)

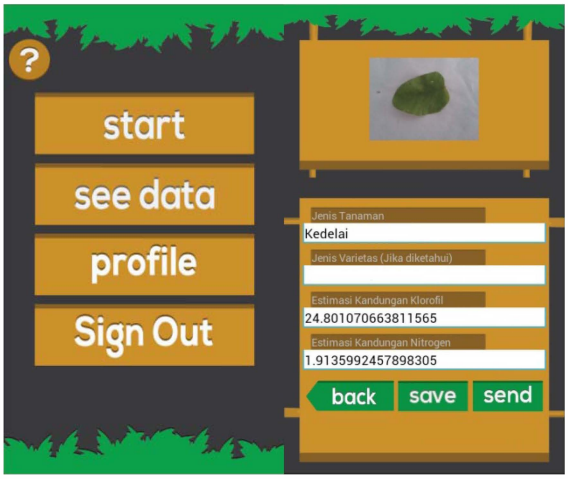

Figure 5. Screenshot of "Mata Daun" mobile application: main page (left) and result page (right)

Based on our field test, to get the best nitrogen meter value prediction with "Mata Daun", it is recommended to use this mata daun version only with Panderman, Anjasmoro and Kaba Soybean variety. The others variety maybe will deliver different result regarding to different physical characteristics such as leaf thickness which is directly connected with soybean leaf nitrogen concentration. Beside the soybean variety, the position of the user while take a leaf picture also give slightly different result. It is also recommended to take a picture 20 cm above the soybean sample leaf. A stable measurement position will give a stable prediction.

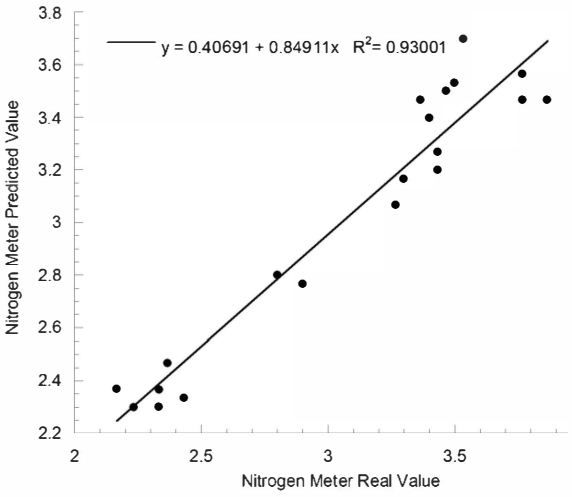

Figure 6. Correlation of nitrogen meter CCN-6000 Agriexpert predicted and real value

V. CONCLUSIONS

This paper proposes mobile application for the determination of soybean leaves nitrogen content. Our aim is to help farmers to conduct their own plant nitrogen determination test just in time and at low cost with reliable result. Our experiments shows that "Mata Daun" mobile application predicted value was reliable to be used at the field. With the strong relationship between predicted value and real value these mobile application can be as an alternative for conventional plant leaves nitrogen test. We do hope with the application of this software by the farmer, their productivity could be increased.

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REFERENCES

[1] Shaahan, M.M.; A.A. El-SAyed, E.A.A; Nour, A.E.1999. Predicting Nitrogeb, Magnesium and Iron Nutritional Status in Some Perennial Crops Using a Portable Chlorophyll Meter. *Scientia Horticulturae*, **82**:339-348

[2] Fageria, N.K.; Baligar, V.C.; Jones, C.A. 2011. Growth and Mineral Nutrition of Field Crops. CRC Press. New York.

[3] Foth, H.D. 1994. Dasar-Dasar Ilmu Tanah. Penerbit Erlangga. Jakarta

[4] Xian, L.Z.; Xiao-Ping, Y.; Heong, K.L.; Cui. 2007. Effect of Nitrogen Fertilizer on Herbivores and Its Stimulation to Major Insect Pest in Rice. *Rice Science*, **14**(1): 56-66.

[5] Hoffland, E.; Jeger, M.J.; Beusichemn, M.L. 2000. Effect of Nitrogen Supply Rarte on Disease Resistance in Tomato Depends on The Pathogen. *Plant and Soil*, **218**:239-247.

[6] Intaravanne, Y.;Sarun S. 2012. BaiKhao (Rice Leaf) App: A Mobile Device-based Application in Analyzing the Color Level of the Rice Leaf for Nitrogen Estimation in Optoelectronic Imaging and Multimedia Technology. Ed. Tsutomu Shimura; Guangyu Xu; Linmi Tao; Jesse Zheng. Proc. Of SPIE vol. 8558.

[7] Sumriddetchkajorn, S.; Kosom C.; Yuttana I. 2013. Mobile Device-based Self-referencing Colorimeter for Monitoring Chlorine Concentration in Water. *Sensor and Actuators B*, **182**:592-597.