An innovation method for compact Nitrogen Deficiency Plant Monitoring System for Farmers at a Cost Efficiency Manner

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***Abstract*— It is found that lack of necessary nutrients will influence on plant growth and fruit production. Without sufficient amounts of nitrogen in the soil, plants are impotent to produce proteins and nucleic acid required for their growth and survival. Therefore, nutrient monitoring, atmosphere and pest control are the key factors for farmers and agriculturalists. The chlorophyll meter detects the nitrogen content of plant using absorption and reflection technique. This meter is expensive and beyond the reach of farmer. Hence a low cost alternative which is as accurate as spad meter is proposed. The proposed nondestructive method uses the reflection technique, which senses the leaf transmittance and compares it with leaf colour histogram provided by the agricultural university. Sensor data are further processed to control the status of the nitrogen content in the plant. From the nitrogen status, the quantum of nitrogen fertilizer required will be displayed for the guidance of the farmers.**

***Index Terms*— Agriculture field study, farmers, spad meter, histogram, sensors.**

I. INTRODUCTION

Overall requirement for agricultural production is anticipated to enhance by more than 50% within 2050 due to increase in population [1], [2]. Conversely, climatic change, water availability, pollution in atmosphere may lead to low productivity. Nitrogen is one of the most key nutrients of chlorophyll among Carbon (C), Oxygen(O), Hydrogen (H), Potassium (K), Phosphorus (P), Calcium (Ca), Zinc (Zn), Magnesium (Mg), Sulphur (S), and Chlorine (Cl) for plants. Similarly deficiency in nitrogen affects a plant through various ways such as leaf colour, leaf area, leaf weight, plant size, and plant growth. In severe case plant growth may get arrested. Nitrogen status can be detected using visual diagnosis, soil testing, foliar analysis,[2] plant analysis and tissue testing [3]. These techniques are time consuming, destructive, requires for test sample and so on [4]. The physical limitations of this technology have motivated the researchers to seek for alternative ways to monitor the nitrogen s tatus precisely. In recent times, highly precise nitrogen content in the plant can be estimated using optical sensors [5-7]. There are extensive varieties of optical sensors available for agricultural application, which begins with sensors to sense the soil quality to sensors set up to detect the protein content. These sensors are working with the principle of soil and plants have unlike relations with illumination of light permitting to spot out its deficiency.

Mark Seelye et. al[12] proposed the automatic monitoring of plant health status for plants growing in a modified micro propagation system. This monitoring system consists of camera, RGB colour sensors, and environmental sensors fitted in the custom built robotic arms for continuous monitoring of the health status of tissue by comparing the sensor outputs to pre-determined optimum values. In standardized leaf colour chart that capture the appropriate range of rice leaf colour in Asia derived from the real colours of rice leaves. They built the four panel leaf colour chart that gives the information pertinent to the status of nitrogen content.

The proposed device is a compact design so that the village farmers can use without difficulties to measure the nitrogen deficiency in plant by sensing the depth of greenness of leaf and it informs the farmer about the amount of Nitrogen fertilizer needs to be applied in an automatic manner. Foremost thing in this device is that it is of small in compact with very cheaper than old instrument, so that all farmers can benefit from it.

II. ENTIRE DEIGN EXPLANATION

Using optical sensors that use either reflection or absorption principle we can measure the quality of the leaves green richness. The quantity of chlorophyll present in the leaf can be indirectly measured by estimating the depth of the green colour in the leaf. The farmers can use this technique to examine the nitrogen content in the plant and find out the amount of nitrogen fertilizer required for the plant. In this research paper we proposes a compact device to measure the nitrogen deficiency in plant by using reflection type of optical sensor, from the leaf colour data, one can estimate the nitrogen deficiency in the plant. The device is calibrated with the leaf colour charts released by agriculture universities in the respective regions. The leaf colour chart is a chart which consists of four or six green colour panels, each colour panel representing a degree of greenness of the leaf which a healthy crop should possess at different stage of its growth. In manual method, the colour of the leaf is compared with the colour panels present in the chart according to the stage of the plant's growth. If the depth of the leaf colour is lesser than the critical colour in the leaf colour chart, thus the plant has nitrogen deficiency. The manual method may lead to low accuracy due to human intervention. To overcome this drawback, automatic nitrogen deficiency detector based on the above principle is developed.

III. PROPOSED SYSTEM

The cheaper measurement system is developed using two components microcontroller and histogram colour sensor and is shown in Fig.1.The developed nitrogen deficiency detector is built using the four LED, colour sensor (TCS3200), Microcontroller (MSP 430G2553), LCD display and push button switches shown in Fig.1 and it can assess the leaves thickness up to 5mm . The device has test area where a leaf should be placed and four LED source will illuminate from the top of the aperture at wavelengths, red at 750nm and of NIR at 980nm, the reflected light is sensed using a colour sensor (TCS3200). The colour sensor detects the colour of the leaf placed under the test area and generates a frequency corresponding to it and it is fed to the microcontroller (MSP 430G2553). The microcontroller counts the number of square pulses sent by the colour sensor. This leaf colour count value is taken as the indicator to access the degree of green colour present in the plant. The leaf colour count is correlated with the leaf colour chart provided by the agricultural universities to create a look up table data. This look up table data is preloaded in the microcontroller and it is used to detect the nitrogen deficiency in the plant. Then, the microcontroller sends the information to LCD display about the nitrogen fertilizer requirement by comparing the sensor reading with the look up table data.

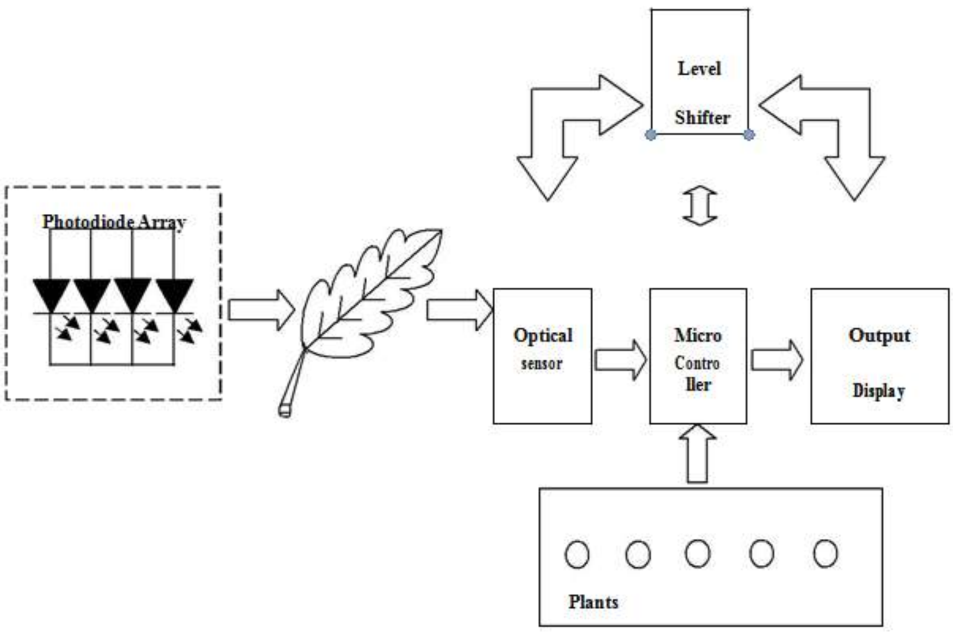

Fig 1 Block diagram for Nitrogen deficiency detector

IV. PROCEDURE FOR DESIGN OPERATION

When the device is switched on, the LCD will display "Kindly place the leaf to be tested and ask to start the process". The device has a leaf area on its top right corner where the leaf should be placed. After the leaf is placed, the user should press the BEGIN button. Once the BEGIN button is pressed, the four LED emits the light signals at 750nm and 980nm. The colour sensor senses the light signal. Then device initializes the sampling process by showing a message "OPERATION BEGINS TO DETECT GREEN RICHNESS". The microcontroller counts the square pulses generated by the colour sensor. Once the leaf colour count is counted, microcontroller stores this data in the register and it sends a message to the display as "OPERATION ENDS". And then the sensor reading will be displayed within a second on the LCD screen. Subsequently the microcontroller sends the message as "Select Ur Crop" in the display. Then, press the appropriate crop push button. Now, Microcontroller compares the leaf colour count with the look up table data corresponding to the crop. If the comparison is completed, the leaf colour count value will be displayed, after a few seconds, the device displays the nitrogen status as "Good Level", "Deficiency Level of Nitrogen at this stage" or "More quantity of Nitrogen Level" depending upon the leaf colour count. This device has sufficient in-built memory, so that it can store around 1500 readings and it can assess the nitrogen deficiency status of any plant by providing the leaf colour histogram. The proposed measurement system has been assembled, tested and calibrated with the existing measurement device, like spad meter. The readings are approximately matching.

V. RESULTS AND DISCUSSIONS

The key role of the device is to get the data from the optical sensor. The optical sensor senses the reflected signal from the leaf samples. An open source software Energia is used to write the program in MSP430G2553 microcontroller for receiving the data from the sensor using timers, interrupts and ports. The program is written as per the flow chart shown in Fig.2

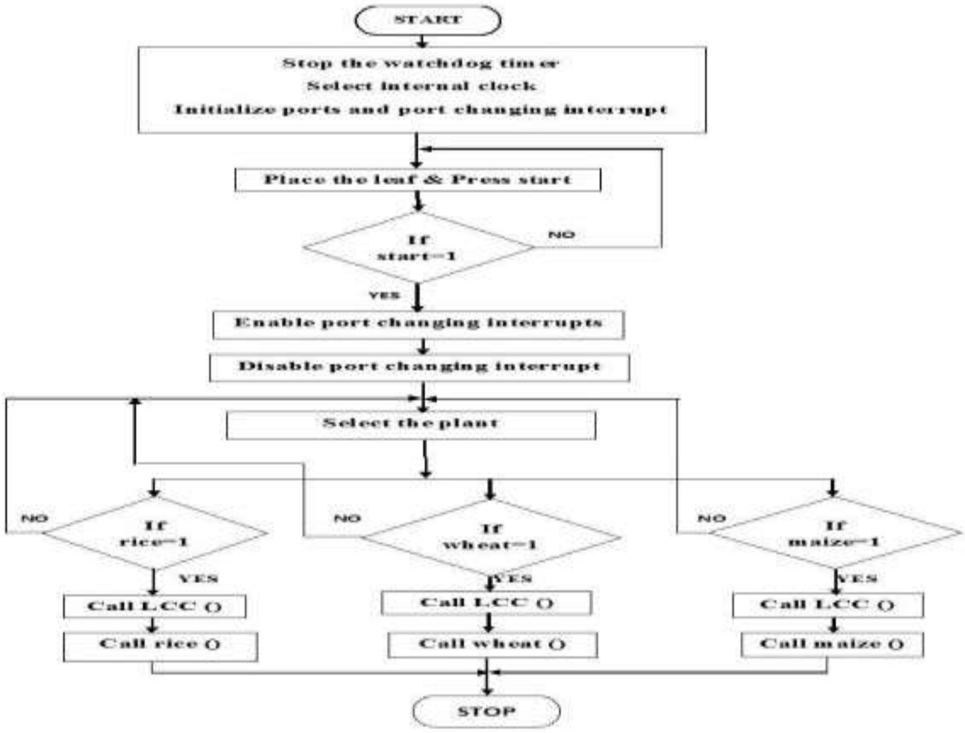

Fig 2 Flowchart for finding the nitrogen deficiency detector

The first step is to find out the leaf colour count of the leaf under test. The leaf colour count is the counter value of the microcontroller that detects the time period of the square wave generated by the optical sensor. The optical sensor generates the different frequency wave depending upon depth of the greenness of the leaf. Time period is inversely proportional to the frequency and it is correlated with leaf colour count. The timer is started at the rising edge of the square pulse and the timer is stopped at the rising edge of the next square pulse, illustrated in Fig.3

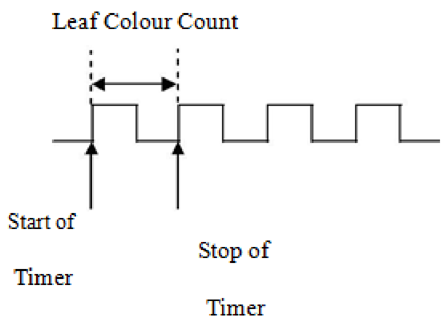

Fig 3 Illustration of finding the Leaf colour Count

Timer 1 and a port changing interrupt is used to find the leaf colour count value. Port changing interrupt is a programmable interrupt where interrupt can be programmed to the rising edge, falling edge or change in port. For this application, rising edge is assigned as the port changing interrupt. The timer is switched on when the port changing interrupt occurs for the first time. The next time when port changing interrupt occurs, the timer is stopped. The timer value is stored to a variable and the timer is reset when the port changing occurs for the third time.

The values are grouped into three categories viz.

- Good
- Deficiency Level of Nitrogen at this stage
- Core quantity of nitrogen level

The Leaf colour count for the three categories can be seen in the display. If the value lies in Nitrogen Inadequate region the liquid crystal display shows "Add Nitrogen Fertilizer" message to the users. Similar procedure is followed for wheat and maize.

VI. COMPARISION OF RESULTS

Three samples of rice leaf covering nitrogen inadequate, nitrogen adequate and nitrogen excess conditions are collected. They are inserted into the device and count values noted. These leaves are compared physically with six panel leaf colour chart. From this, the count value bands for nitrogen inadequate, nitrogen adequate and nitrogen excess were determined and stored in the device. Now the device is ready for operation.

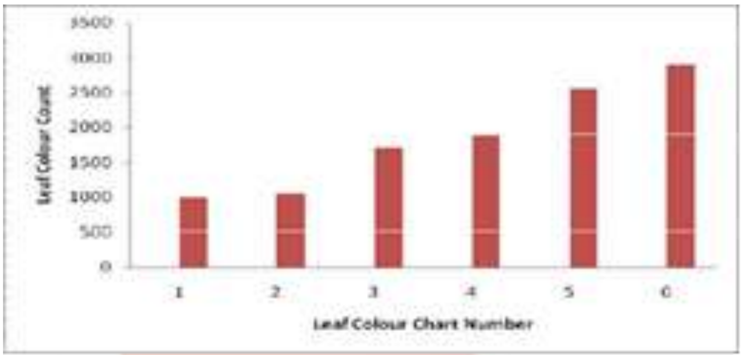

Fig 4 Calibration of TCS3200 without proper cover for rice plant

The agricultural university provides the leaf color chart with the amount of nitrogen fertilizer required for the each color in the chart. From this leaf color chart, the depth of the green in the leaf can be manually matched with leaf colour chart as shown in Fig.5 by placing the leaf in the closer to the respective colour. But it gives inaccurate results due to human interventions. To overcome this drawback, the automatic plant nitrogen deficiency detector is developed and tested in the field for the maize crop as shown in the Fig.6.

Fig 5 Using manual method testing the richness of leaf

The readings are taken to twenty days old maize plant of its growth stage. Three readings were taken for three different leaf colors as shown in Fig.7. The first one was a light green color leaf matching the first panel of the leaf color chart, second was matching the fourth panel of the leaf color chart and the last sample matching the sixth panel of leaf color chart

VII. CONCLUSION

With this research work we conclude that leaf colour charts can prone to error as farmers can make mistake in colour comparison. Low cost device display can be made in local languages also, to help farmers who are less educated and cannot understand English language. Being a programmable device, several crops can be added, produced data can be made available. Colour count value may differ from region to region. Leaf colour may be analyzed in the laboratory using expensive SPAD meter and colour count value can be calculated. There values can be programmed in this local portable meter, which is now regionalized. However, schedule for taking the reading, quantity of nitrogen fertilizer per acre etc. are all determined by agriculture university/college, Government/Private agencies who are vested with the responsibilities of advising farmers in that region.

REFERENCES

[1] N. Alexandratos and J. Bruinsma, World Agriculture Towards 2030/2050:The 2012 Revision. Quebec City, QC, Canada: Food and Agriculture Organization of the United Nations, 2012.
[2] Asundi Anand, OiWah Liew, Bingqing Li, and Jenny Chong, "Optical sensors enhance plant nutrient monitoring" 1st February 2006, SPIE Newsroom.
[3] Rania Basyouni, Bruce Dunn, (2013) "Use of Optical Sensors to Monitor Plant Nitrogen Status in Horticultural Plants" Division of Agricultural Sciences and Natural Resources, Oklahoma State University
[4] Omar, A. F. B., & MatJafri, M. Z. B. (2009). Optical Sensor in the Measurement of Fruits Quality: A Review on an Innovative Approach. International Journal of Computer and Electrical Engineering, 1(5).
[5] Miranda, C., Girard, T., & Lauri, P. E. (2007). Random sample estimates of tree mean for fruit size and colour in apple. Scientia Horticulturae, 112, pp. 33-41.
[6] Kang, S. P., & Sabarez, H. T. (2009). Simple colour image segmentation of bicolour food products for quality measurement. Journal of Food Engineering, 94, pp. 21-25.
[7] Climate Change 2013: The Physical Science Basis," IPCC, Geneva, Switzerland, Sep. 2013.