Abstract— Nitrogen (N) plays important role in the crop/plant’s life cycle. It is the main plant mineral nutrient needed for chlorophyll production and other plant cell components such as amino acids, nucleic acids, proteins. Crop yield is affected by plant N status. Plants usually contain Nitrogen (N) up to 5% by its weight. There are various techniques of estimating N in the plants such as Chemical analysis of leaves, Leaf Colour matching Chart etc. These techniques are time overruling and costlier. Electronic handheld equipment has been developed that gives instant and accurate N content of the plants to the farmers. This will enable crop growers to quickly and easily decide on proper application of fertilizer and also help in environment protection.

Keywords— Colour Sensor, Embedded System, N Estimator, Segmentation.

I. INTRODUCTION

Application of Nitrogen based fertilizer in proper quantity is important because this nutrient gets vanished from the soil system. The study on the suitable nutrition management of a plant is being done. Its accurate assessment in plants is a key to nutrition management. Plants normally have 5% nitrogen by weight. Nitrogen is a major constituent of the chlorophyll that augments photosynthesis. The concept of nutrition management ‘as much as exactly needed’ is termed as Site Specific Nitrogen Application (SSNA) [1]. However, the efficient but effective use of fertilizer for crop depends on the estimation of crop nitrogen deficiency and variation in the farm during the application. It will also avoid application of more than what is required of fertilizer. Hence we need to determine nitrogen content of the crop and decide right amount of nitrogen fertilizer application so as to prevent unwanted nitrogen losses and its serious impact on the ecosystem. The excessive dose of urea swells insect & pests attack on the crop. This leads to utilization of higher dose of insecticides and pesticides. This in turn results in higher cost of production, more environmental contamination and worsening of the quality of product crop. Moreover, nitrates drips down in to the earth with the use of excessive urea.

Nitrogen in excess of 10 milligram per litre of water is unfit for our consumption [2]. Stephan M. Haefele et. al. in their research paper on rice leaf investigate the effect of selected abiotic stresses on chlorophyll and leaf N concentration in a greenhouse trial and also discuss about reliability of SPAD or LCC measurements for leaf N estimates [1]. Bijay Singh et.al. in their work on Rice and Wheat leaves for the Indo-Gangetic plain in the northwestern INDIA conclude that results of N applications to rice based on LCC shade were reasonably consistent with those using the chlorophyll meter[2]. V.K. Tewari et. al. in their paper used Digital Image processing the Otsu segmentation [3]. Presently various techniques of indirect sensing of the plant reflectance can be classified as the ground based remote sensing, air borne remote sensing, and satellite based remote sensing techniques such as LCC, Chemical (Lab. processes), etc. The Chemical lab process techniques are not only costly but time consuming also. However, there is one more technique of estimating nitrogen content using a color sensor, which is quick and much cheaper. The assessment of nitrogen through greenness of the plant leaf using electronic sensor is one of the novel techniques [2].

The main advantage of N estimation using color sensor is that this device will directly display the content of Nitrogen in any plant leaf. A device is designed for assessment of nitrogen content in a one-month old cultivated cotton crop. This device will be useful to farmers to judge deficiency/ sufficiency of nutrition required for the plant and decide how much fertilizer is needed for better crop growth. This device can be called an innovation over the typical used chemical process & LCC for Nitrogen (N) estimation due to its instant results and accuracy. This paper discusses traditional methods and design of embedded system for N estimation using colour sensor.

II. TRADITIONAL PROCESS

Nitrogen requirement for plant is not the same throughout the growth period. Application of Nitrogen (N) without assessing with the demand of the crop often ends up in enhanced N losses. The finest use of N should match requirement of the
crop. Thus application of nitrogen as per demand of the cotton plant is called 'Need based N management'. Present popular methods to measure nitrogen content are Chemical Process [4], Leaf Color Chart [4], and Image processing [3]. Chemical process was developed by Johan Kjeldahl, a Danish chemist, in 1883. Kjeldahl method [5] is for quantitative measurement of nitrogen substances. The chemical process has following steps – A leaf samples of fourth node from field are plucked and dried in oven at 60°C. Further they are crushed and 5ml Sulphuric Acid is added to 0.2gm weight in 50ml volumetric flask. The solution is kept overnight before it is put on Hot plate for digestion until vapour disappears. Hydrogen peroxide up to 3ml is added after cooling and again heat treated to about 80° to 100°C temperature until content becomes colour less. After cooling it’s volume made is 50ml. 0.2ml of aliquot is taken in in 25ml volumetric flask to prepare standard solution of 0.2, 0.4, 0.6, 0.8 & 1ppm from 5ppm std. [4] solution. Spectrophotometer readings are taken on 410nm scale. The Nitrogen content is given by following equation.

$$N_{ppm} = \frac{\text{ppm} \times \text{volume after digestion}}{100} \times \frac{\text{weight of sample}}{V_{m}}$$

This method is the accurate but at the same time it is time-consuming method. As this method may take a weeklong of duration to get the results, it is not suitable for quick determination nitrogen concentration in the large crop area. Moreover it is a destructive method also.

Leaf Colour Chart (LCC) method is used to estimate nitrogen in cotton leaves by way of comparing shades. The LCC is real time tool for management of N management in Rice, Cotton etc and has proven to be cost conservative [2]. LCC is a visual method but gives subjective indication of plant nitrogen deficiency and is an inexpensive, easy to use technique. It is also alternative to chlorophyll measuring - SPAD (Soil Plant Analysis Development) meter. It compares leaf color intensity that correlates to leaf N status. LCC has 6 shades color varying from light yellowish green to dark green. Sample is taken from a fortnight old plant leaf. Leaf color is compared with the shades of color on LCC. Fig. 1 shows standard LCC.

From the above discussed traditional processes, we observe that by using Chemical process we get N content but after a delay of 2-3 days. Moreover, if leaves get excessive dried during handling of chemical process it may not give precise output. Whereas, the LCC method is merely based on the approximation. It therefore has less accuracy and thus has inherent errors. That is why a need is felt to design an automated accurate sensing electronic device to estimate Nitrogen value in the crop and with real time output. The design of an embedded system with green color sensor is presented in this paper.

### III. IMAGE PROCESSING TECHNIQUE TO DETERMINE GREEN COLOR RANGE

Image Processing Technique using MATLAB on images provided by CICR was applied to find out the range of green color. In this we applied the histogram analysis.
Fig. 3. Colour Range

A histogram is a graphical depiction of the distributed data. It is an approximation of the probabilistic distribution of a continuous variable and was first pioneered by Karl Pearson. Fig. 4 shows the scale and the image.

Fig. 4 (a) Leaf Image

Fig. 4 (b) Histogram of Leaf Image

Above Fig. show Leaf Images and their Histograms, X-axis shows Intensity of Green Color and Y-axis shows Probability of Green Color. Here highest peak of Histogram shows highest intensity of green color in that image. We concluded the green range of leaves is from 150-200.

IV. COLOUR SENSOR BASED N ESTIMATOR SYSTEM

Method of digital Image processing (DIP) involves taking photographs of plant leaves and processing those photographs using image processing algorithm. DIP is quite accurate but is again time consuming. Since DIP does not give instantaneous results an innovative colour sensor based electronic handheld system was developed. This system is a combination of LCC and DIP methods. The embedded system has been designed using accurate colour sensor to give estimate of N content of a leaf. The benefit of this system is that one can take the reading of a plant without plucking its leaves. Moreover, one gets the measurement on the spot instantaneously. CICR, Nagpur extended their help in development of this system by way of giving required inputs on correlating greenness of leaf with N content.

The N estimator system consists of a high accuracy programmable colour sensor interfaced with a microcontroller. The system is packaged in a handheld device and is a self sufficient with onboard power supply. The system consists of TCS3200 programmable colour sensor. This device has configurable silicon photodiodes and it has light-to-frequency converter on single monolithic CMOS integrated circuit. The output of the device is a frequency directly relative to the light intensity (irradiance). The device has two control pins to scale the output. Digital inputs and digital output are directly interfaced to a microcontroller. Atmega 32 is a 8-bit microcontroller in low-power CMOS technology using AVR designed RISC architecture. The ATmega32 gives throughput about 1 MIPS by executing more instructions in a single clock cycle. This helps the system to optimize power consumption at higher processing speed.

Fig. 5 shows the block diagram of the system. The colour sensor is calibrated using standard the green colour. A Code is developed to estimate nitrogen content from the sensor output. System calculates the appropriate value of the green color using signal processing technique and the resultant value is fed to the microcontroller for processing and to display the nitrogen contents on the LCD.
V. COLOUR SENSOR AND ITS CHARACTERIZATION

The color analyzer is composed of 4 modules; the light emitting module, the color detection module, the data processing module and the display unit. The lighting module comprises of the bright white light-emitting diode (LED) as a source of this analyzer. The color detection module employs TCS3200 as the color sensor. TCS3200 color sensor is a programmable color intensity-to-frequency converter. The silicon photodiode and the circuitry of current-frequency converter are integrated in a single CMOS circuit with filters of red, green and blue (RGB) colours. Figure 6 shows the pin package and the functional block diagram of TCS3200. TCS3200 color sensor has four filter types. When the incident light illuminates the TCS3200 color sensor, different filters can be selected. The different colors and light intensities correspond different frequencies. The typical output frequency range is 2 Hz ~ 500 kHz.

Agriculture research has concluded leaf chlorophyll concentration and leaf nitrogen (N) content in various agricultural crops are closely related, because the chlorophyll molecules contain the majority of leaf N. (Peterson et al. 1993). Fig 7 shows the spectral response of chlorophyll. Chlorophyll has one peculiar characteristic. In the spectrum of light, Leaf Chlorophyll does not absorb light in Infrared spectrum of light. This characteristic of chlorophyll is used to design chlorophyll meters. However, our system uses method of measuring green texture of leaf with color sensor. This system illuminates plant leaf to make instantaneous and nondestructive readings of chlorophyll of leaf by using LED of peak wavelength corresponding to green spectrum of light [6].

The handheld device has microcontroller that handles digital inputs and output. The microcontroller is programmed to initialize the sensor and read the green texture of leaf and computes chlorophyll content from the read texture. The sensor output is a frequency output which is converted into equivalent nitrogen content using the relation of reflectance with N content.

The system block diagram is given below.
VI. RESULTS AND CONCLUSION

The estimator was tested with leaves of cotton plant taken from the field. The same sets of leaves were also put for chemical testing to compare the results of N estimator. CICR provided approximated values of percentage of nitrogen data set (by chemical process) with which we could compare our results. CICR, Nagpur helped us in characterization the sensor.

The results have very small but constant deviation from the results of conventional chemical process. The hand held device can be used for any kind of leaf in broad daylight or in the night. Results are shown in the table below.

<table>
<thead>
<tr>
<th>Actual Leaf</th>
<th>Nitrogen Detection Using Chemical Process</th>
<th>N Content Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Leaf Image 1]</td>
<td>3.57</td>
<td>3.78</td>
</tr>
<tr>
<td>![Leaf Image 2]</td>
<td>4.60</td>
<td>4.81</td>
</tr>
<tr>
<td>![Leaf Image 3]</td>
<td>1.22</td>
<td>1.43</td>
</tr>
<tr>
<td>![Leaf Image 4]</td>
<td>2.33</td>
<td>2.54</td>
</tr>
</tbody>
</table>

REFERENCES


[4] Images of cotton leaves and Results of Chemical Process given by CICR, Nagpur


