Nitrogen Status Estimation of Rice Crop in Western Tract of Odisha based on Image Processing Techniques

Prabira Kumar Sethy, Yogesh Bhitiria, Nalini Kanta Barpanda, Amiya Kumar Rath

Abstract*: Nitrogen is the main component among all nutrients for rice crop growth and production. The leaf nitrogen concentration (LNC) is highly correlated with chlorophyll content. There are many devices like Leaf Color Chart (LCC), SPAD, at LEAF+ for measurement of chlorophyll &/ or nitrogen. As these devices are cost effective and unavailable with all farmers, a digitize image acquisition and interpretation system is required. The paper proposed a site-specific nitrogen status estimation method based on image captured by smartphone, generation of corresponding hexadecimal code and then compare with the hexadecimal code of each swap of LCC. The methodology achieve of 87.27% accuracy with consideration of different rice field, shooting time and growth level.

***Index Terms*: Nitrogen Status Estimation, LCC, Channel Extraction, Hexadecimal code, Image processing**

I. INTRODUCTION

In precision agriculture, it is needful to estimate the nitrogen status of rice crop for healthy growth and large production. The nitrogen content of most Indian soil varies from 0.03 to 0.07 percent as against 0.1 to 0.17 percent in Europe and American soil (T.J. Mirchandani. 1936 [1]). Nitrogen is the nutrient, which limits the most the rice production worldwide. In Asia, where more than 90 percent of the world's rice is produced, about 60 percent of the N fertilizer consumed is used on rice (Stangel and De Dutta, 1985[2]).Leaf Color Chart (LCC) is a standard chart to assess leaf color level. It is developed by the International Rice Research Institute (IRRI) for monitoring the status of nitrogen level by matching the color of rice leaf with the swap of LCC.LCC has five green strips, with color ranging from yellow green to dark green. It determines the greenness of the rice leaf, which indicates its N content [3]. To perform the observation it requires a very good color perception of surveyor’s eye, and it should be performed consistently throughout the crop growth. Even though there is availability of some instruments and use by many researcher but not popular among farmer. According to statistic the number of mobile phone user from 2013 to 2019 is consistently increase.
The statistic in Fig. 1 shows the number of mobile phone users in India from 2013 to 2019. For 2017, the number of mobile phone users in India is expected to rise to 730.7 million. In this same year, the number of smartphone users in India is predicted to reach 340 million and could reach almost 468 million by 2021 [4].

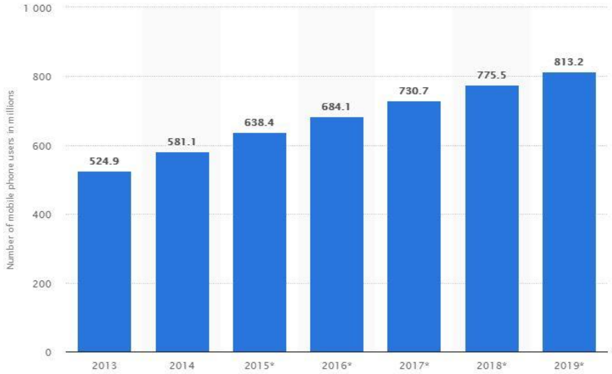

Fig.1 The statistic of the number of mobile phone users in India from 2013 to 2019.

Considering the prevalent utilization of cell phones among people, this innovation will be utilized to capture, analyse and estimate the leaf color with our proposed procedure.
Several researcher reported various methodology for estimating the nitrogen status of rice crop as well as other crops. Yuita Arum Sari et al.2013 [4] proposed a method of relative color calibration, which makes the system, learns color chart automatically without depending on specific standard color. K- Nearest- Neighbour (KNN) classification is used for color learning process in RGB color space. The method is successfully tested with two smartphone devices in different lighting condition. The test shows an average accuracy above the threshold value of 83%. Shah Jahan Leghari et al. 2016 [6] designed a modern mirror made LCC named Nitrom and claim that it is stronger against sunlight and no sectional color can reduce its brightness and thus does not become dim in color due to adverse effect of heat or light, because, its mirror functioning as protection from all environmental factors including sunlight and precipitation. I. Wayan Astika 2010 [7] proposed a color level estimation of rice leaf using smart phone camera in two lighting condition i.e. body shadow and open sunlight. The KNN is used for classification purpose of different color level and it is validated with LCC and achieve 66% in body shadow & 68% in open sunlight. Mohd. Soom et al. 2013 [8] used Tetracam Agriculture Digital Camera to acquire high spatial and temporal resolution images to determine the status of N and predict the grain yield of rice. They use 12 pots of rice plant with nitrogen treatment. The image samples were collected in different growing stages and achieved coefficient of correlation for normalized difference vegetative index NDVI i.e. R^2 is 0.78. Yuan Wang. 2014 [9] proposed a methodology to estimate the chlorophyll content and leaf nitrogen concentration (LNC) using 13 number of color indices

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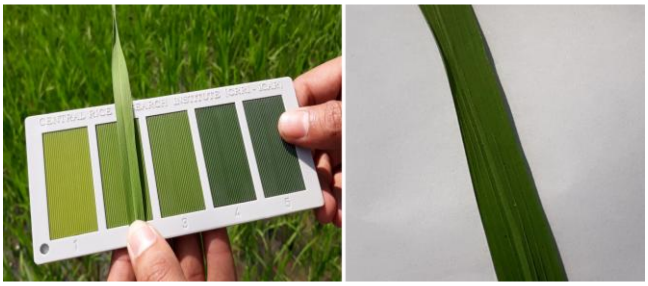
with three 3 color space and validated with SPAD. The author claim that the La*b* color model is more correlated with the SPAD measurement. Mohammad Mehdi Saberioon. et al. 2013 [10] proposed assessment of color indices using digital camera for estimating nitrogen status. Here the color indices derived from images captured by two different kinds of conventional digital cameras and extracted twenty-seven most common color indices through six growth stages. The results indicated that both cameras could be used as sensors to determine the status of nitrogen in rice plants. In addition, there were strong relationships between most indices, especially color indices that are associated with green and SPAD measurement values.

II. PROPOSED METHODOLOGY

The methodology consists of two parts: first it generate the hexadecimal code for each swap of LCC and second part estimation of nitrogen status by comparing the hexadecimal code of test leaf image with hexadecimal code of each swap of LCC. Here the generation and comparison is by with hexadecimal code because hexadecimal represent standard and specific color palette.

A. Collection of sample

The images were captured using smart phone of 12 Megapixel camera from five different places of western tract of Odisha i.e.Attabira(longitude:83.7748,latitude:21.3717),Dhanakauda(longitude:84.1627,latitude:21.51532),Bhoitikira(longitude:85.745390,latitude:20.968730),Saranda(longitude:86.386612,latitude:22.266991),Attabira (longitude: 3.782660,latitude:



21.371950) and Bargarh (longitude:83.643300, latitude). The samples of RLB on-field images are shown in figure 1.

(a) (b)

Fig.1 Collection of image sample (a) Testing of rice leaf using LCC (b) photo shoot of rice leaf using smart phone camera with white back ground.

B. Generation of Hexadecimal Code for each swap of LCC

The LCC is collected from IRRI, Cuttack by cost of 120INR. Then we take the photo of LCC using smart phone camera of 12Megapixel camera. The each swap of LCC is separated using Microsoft photo editor. The LCC consists of five strip from yellowish green to deep green. The LCC and its five-separated swap are shown in Fig.2and Fig.3. The generation of hexadecimal code for each swap is as follows:

Step-1: take the image of LCC and separate each swap by using Microsoft editor.

Step-2: Extract Red, Green and Blue channel of each swap.

Step-3: Calculate the mean of each extracted channel of all swap and rounded off the values.

Step-4: Generate the hexadecimal code for each swap according to the values of R, G and B.

The rounded mean values of Red, Green and Blue with hexadecimal code of each swap with Nitrogen status is illustrated in Table 1.

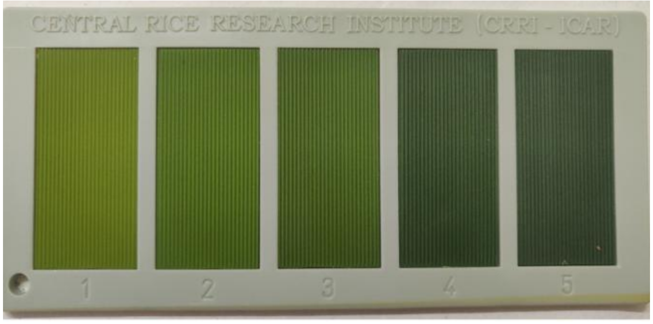


Fig.2 Leaf Color Chart (LCC).

(1) (2) (3) (4) (5)

Fig. 3 Different Swap of LCC from (1) to (5).

Table 1. Mean values of RGB of each swap of LCC with its Hexadecimal code.

SWAP	Mean R	Mean G	Mean B	Hexadecimal code	Nitrogen Status
SWAP1	101	115	33	657321	Nitrogen Deficient
SWAP2	80	102	34	506622	Less Nitrogen
SWAP3	73	93	37	495D25	Average Nitrogen
SWAP4	59	74	45	3B4A2D	More than average Nitrogen
SWAP5	63	76	53	3F4C35	Sufficient Nitrogen

The Table 1 illustrates the mean values of R, G & B of each swap of LCC with its corresponding Hexadecimal code.

C. Nitrogen Status Estimation of Rice Leaf using Digital Image.

The nitrogen estimation of rice leaf has following steps:

Step-1: The images are collected from different rice field on 07th March of 2019 in between 8AM to 5PM. This is second seasonal cultivation of rice crop in this region. The all rice field are cultivated just before 1month to 2 month.

Step-2: The leaves of rice are place on the palm (palm is covered by white paper) and take the photo from a distance of 30 to 40 cm on body shadow. The advantages of white background are that all R, G and B values of white color are same. So the for further extraction of individual

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channel and averaging of each color component does not lead any error.
Step-3: Extract the individual channel i.e. Red, Green and Blue.
Step-4: Averaging all channels and rounded off to the integer value.
Step-5: Convert each R, G and B value to its Hexadecimal Value.
Step-6: Concatenate the three hexadecimal codes to a single string. So hexadecimal code of sample image is generated.
Step-7: Compare the hexadecimal code of test sample with the LCC swap and estimate the nitrogen status.

III. RESULTS AND DISCUSSION

The 55 number of samples are collected from rice field for estimation of nitrogen status. As per our collection all, the samples have color blend in between swap 1 and swap three, which indicates no samples have sufficient nitrogen concentration. According to report of G.C. Sahu et al. 2003 [11] the western Odisha especially Sambalpur and Bargarh district have laterite, mixed red and yellow red soil. In Sambalpur district, the soil is laterite soil, which contain very less nitrogen. Again the mixed red and yellow soil are present in both Sambalpur and Bargarh district in which the upland soil have low nitrogen & phosphorus and low land have low nitrogen & medium phosphorus.

Table 2. Performance analysis of proposed methodology.

Swap	LCC	Estimated
1	5	4
Between 1 &2	20	18
2	5	4
Between 2 & 3	20	19
3	5	3
Accuracy	87.27%	

Table 2 show the performance analysis of proposed methodology, which illustrate in detail as below and achieve accuracy 87.27%.

- Out of five samples total four samples are estimated correctly which is matching SWAP1 of LCC.
- Out of 20 samples total 18 samples are estimated correctly matching in between SWAP1&two of LCC.
- Out of five samples total four samples are estimated correctly matching with SWAP2 of LCC.
- Out of 20 samples total 19 samples are estimated correctly matching in between SWAP 2 & 3 of LCC.
- Out of five samples total three samples are estimated correctly matching with SWAP3 of LCC.

IV. CONCLUSION

The proposed methodology is capable of estimating the nitrogen status of rice leaf using smart phone camera which overcome the unavailability of LCC or other chlorophyll &/ or nitrogen measuring instruments. This methodology generates the hexadecimal code & implies a standard color palate, which is globally acceptable. This work can further expanded by using more than one smartphone to analyses the variation of accuracy with the resolution of camera. Again, the samples of all variety with different growing stage may be examined.

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