Estimation Of Chlorophyll Content In Maize Leaf: A Review

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Abstract— *Leaf colour is analogies to the chlorophyll status of the plant. The nutrition and health of the plant is majorly based on its chlorophyll and nitrogen status. And also the chlorophyll occupy a habitual role in the physiology and fruitfulness of the green plants. In this paper we have estimated the chlorophyll status of various maize field. The images were captured using the Unmanned Aerial Vehicle (UAV) and it is segmented to cleave the green pixel. We have compared the various algorithm to get a better correlated with laboratory measured chlorophyll content of the plant and finally we observed correlation value of -0.84.*

Keywords— *Leaf colour, Unmanned Aerial Vehicle (UAV), Chlorophyll content*

I. Introduction

Precision agriculture or satellite farming is a farming management concept. Which is one of the key direction in modern agricultural development, it managing specific field areas based on inter and intra variability within the field. PA gives new perspective to the farmers to set their farm and crop by incorporating new technologies in contrast to the conventional farming. As it identify the alteration occurring in the field and relate it to the spatial data supervision action gets simpler, productivity, quality of the crop is improved. [1].The goal is to optimising the returns on input while preserving the resources. The practise of precision has been enable by tools such as Global positioning system (GPS), Global navigation satellite system (GNSS). Using GPS we can locate the precise position of field and it allows for creation of map of spectral variability. Through which we can measure the crop yield, train features, topography, total organic matter content, moisture level, nitrogen level, pH, Ec, Mg, K etc...

Based on the carrying platform of the sensors, field of its application imaging spectroscopy is separated into two groups: spectroscopy which is based on remote sensing platforms, it includes satellites and aircrafts is useful in extensive regional application; and spectroscopy which is based on small ground application platforms is epigrammatic, stretchy and movable. Such ground application platforms are used to estimate the plant chlorophyll content, several biochemical parameters. They are also used to wit weeds [11-15].

The processed image collected during the cultivation time is used to squeeze crop condition information for the purpose of management [2]. The chlorophyll content of the leaf, water status can be measured by analysing, overlapping aerial image of visible and infra-red spectrum collected by an unmanned aerial vehicle. Wealth and security of the nation come from its land and hence its need to be sustainable, innovative and high productivity agriculture which will be profitable and provide both food and energy security for the country. Hence, it is believed that some advance farming technologies will help to promote the next green revolution to Indian agriculture[3].

Leaf colour is directly proportional to its chlorophyll content and the health of the plant. The farmer always keep an eye on the colour of the leaf. They thought yield of the crop is based on the appearance of the plant. The healthy crop shows delight appearance compared to the diseased crop. Invigilating the hectares and hectares of cultivated land is time consuming and requires more labour force. To overcome this farming management concept is utilized.

Aerial photographs obtained by the UAV and the advanced image processing technology give precise information of the crop. In past two decades lot of image processing algorithm is proposed to estimate the chlorophyll and nitrogen status of the plant based on the RGB colour space.

Kawashima and Nakatani [22] observed that (R-B)/(R+B) gave good results for estimating chlorophyll status in wheat. Yuzhu et al. [28] comply that G/(R+G+B) is best for evaluation of nitrogen status in pepper. Suzuki et al. [24] made the assessment of chlorophyll status in broccoli by using G/(R+G+B). Cai et al. [25] observed that R/(R+G+B) gives favouring results in estimation of chlorophyll content of cabbage, Adamsen et al. [26] found the linear relationship G/R and SPAD in wheat leaves. He also stated that this ratio respond to both chlorophyll concentration and number of wheat leaves.

Su et al. [23] computed the chlorophyll character of the algae by developing a linear RGB. He evidenced that RGB features can be infer to descry the chlorophyll status. Hu et al. [27] evinced that the RGB colour list of R, G and R+G+B, R-B, R+B, R+G had meaningful correlation with chlorophyll concentration of leaves. Vollmann et al. [28] got averaged G value of leaves. He used a Sony digital camera to capture leaf images and it was analysed by Segma Scan Pro software. By using SPAD values as a reference the obtained G value is used to estimate the chlorophyll range in leaves.

Additionally, there are few studies which utilize other colour models to estimate Ch and N status. Wiwart et al [16] used HSI and L*a*b colour models to examine nutrient deficiency in faba bean, pea and yellow lupine. Graeff et al [17] afford a nigh relationship between the nitrogen status and the L*a*b colour model of broccoli leaves.

D. E. Karcher and M. D. Richardson [18] developed the Dark green Colour Index (DGCI) algorithm using HSI colour model to measure greenness grades. Rorie, et al, Raper.B, et al [19,20] obtained an optimistic output by using DGCI algorithm to evaluate the nitrogen status in corn and cotton leaves.

Borhan et al.,[10] cultivated the potato in green house later he developed two laboratory based multispectral imaging systems, and extracted the attributes from color (red, green, and blue) and multispectral bands (550, 710, and 810 nm) to estimate the chlorophyll and nitrogen status.

II. MATERIALS AND METHODS

A. Experimental design

The agricultural land before sowing maize grains is stabilized by using organic manure. Cow dunk and farm debris are used for this purpose which increase the nutrition of the soil. After application of manure the land is left out for a month and seedlings were sown. At the particular stage of growth UAV is used to capture photograph then it is transferred to the computer and processed using Matlab 2013a. The image consist of soil, maize plants, weeds in order to separate the leaf pixel segmentation is done. From the segmented image to extract the RGB values RGB color space is converted into HSV color space then HSV color space is converted into double data type. Various RGB algorithms are used entropy value is evaluated from the resultant image to estimate the chlorophyll status of the plant. They are compared with the laboratory chlorophyll.

B. UAV

The Unmanned aerial vehicle (UAV) commonly known as ‘aerial robot’, ‘drone’ was adopted by Department of Defence (DOD) and the Civil Aviation Authority (CAA) of the UK [5]. The applications of drones are expanding with each passing minute in all sectors and agriculture is no exception. The technology of unmanned aircrafts can be used for collecting valuable information in the agriculture sector, which can be used to avoid damage caused by pest infestation.

Small Unmanned Autonomous Vehicles (UAV) are being used for several monitoring application such as power line inspections, structural damages in buildings and crops development in farms. [6]. In agriculture drones enable the farmers to make better decisions regarding the management of their form to enhance productivity.

In our study we have used DJI Pantom44k resolution drone to inspect the growth of maize field. The images are captured at the visible range and stored for offline analysis and processing to estimate the chlorophyll status of the leaves.

Fig. 1 Unmanned Aerial Vehicle used in investigation

C. K means clustering

K-means is one of the best unsupervised classification algorithms that solve the well-known clustering problem. It is a popular machine learning algorithm, it is iterative in nature. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centers, one for each cluster. K-means algorithm consists of two separate phases. In the first phase it calculates the k centroid and in the second phase it takes each point to the cluster which has nearest centroid from the respective data point[7]. Euclidean is one of the distance measures used on K-means algorithm. Euclidean distance between an observation and initial cluster centroid is calculated. Based on the distance each observation is assigned to one of the cluster based on the minimum distance.

Fig. 2: Original image

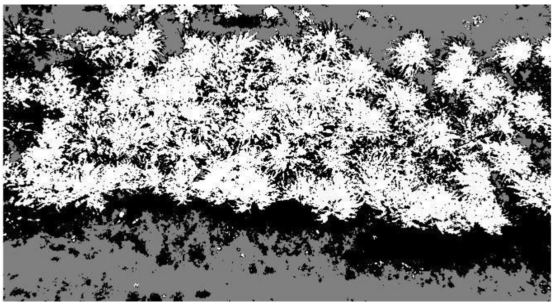

Fig. 3 Image labeled by cluster index

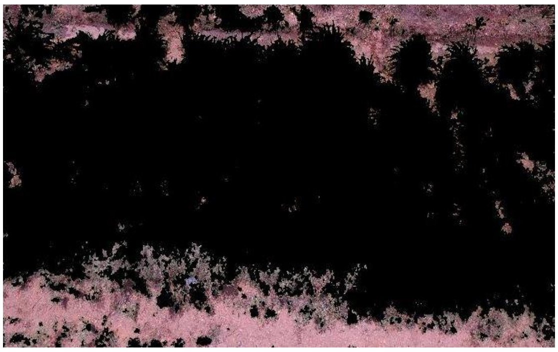

Fig. 5 Object cluster2

D. Chlorophyll

Chlorophyll (Ch) an active biological component which is vital for photosynthesis. It allow the plants to absorb energy from the sun light.[4]. Here carbon dioxide and water are powered by the sunlight to generate glucose and oxygen. The chemical equation is explained below

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{CHLOROPHYLL}]{\text{SUNLIGHT}} \underset{\text{GLUCOSE}}{C_6H_{12}O_6} + 6O_2$$

Chlorophyll pigment is the strong absorber of light energy in blue region of electromagnetic spectrum followed by the red portion. Contra wise it is the penniless absorber of light in green and near-green portion of electromagnetic spectra, they reflect green pigment. This is the reason which makes the chlorophyll-containing tissues to reproduce green color in their appearance. Chlorophyll, the photoreceptor is at the centre of the photosynthetic oxidation-reduction reaction spotted into several kinds such as: Chlorophyll a which is present in all the plants and algae; Chlorophyll b which is present only in green plants and it absorbs only the blue light; Chlorophyll c found only in the photosynthetic members of the Chromista as well as the dinoflagellates; Chlorophyll d absorbs far red light at 710 nm, just outside the optic range found in marine red algae; Chlorophyll e which is rare type of chlorophyll that is found in certain bacteria like Tribonema bombycinum and Vaucheria hamate; Chlorophyll f which is recently discovered absorbs light at 706 nm and shorter than chlorophyll d.

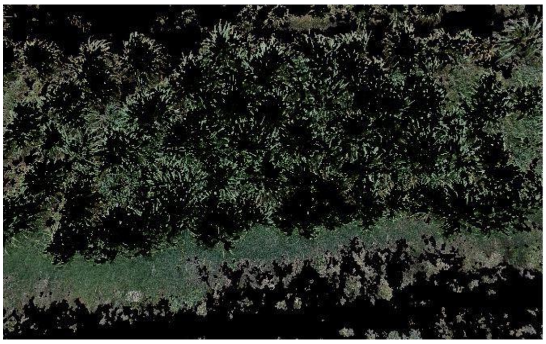

Fig. 4: Object cluster1

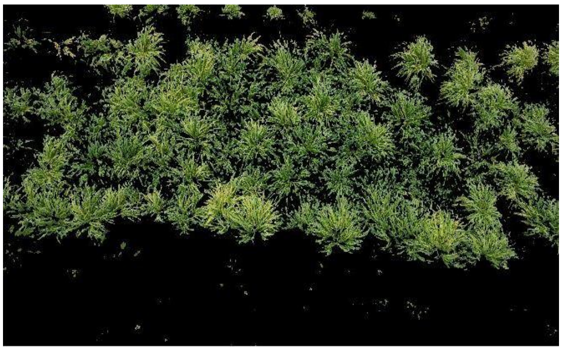

Fig. 6 Object cluster3

The concentration of chlorophyll in leaves is estimated by using two different methods destructive testing method and non-destructive testing method. The first method the laboratory based techniques which utilize acetone and spectrophotometer for the extraction of chlorophyll. This method is very accurate but the main disadvantage held in this method is time consumption. Later the non-destructive testing method is easy to use and provide quick results but them may not provide the result as promising as destructive approach. [8].

E. Laboratory Chlorophyll Extraction

The samples are collected from the respective maize field. The fully expanded leaf is cut down into $1cm^2$, it is weighted to the accuracy of 0.1g. The sample is cut into small fragments and grinded for 3 to 5 minutes in a mortar by adding acetone and magnesium carbonate. 7mL chilled aqueous 80% acetone is added to the extract then centrifuged for 5 min at 300 rpm and the absorbance are determined at 630, 645 and 665nm using a Spectrophotometer. Chlorophyll 'a' was measured using the equation given below

Chl a = 11.6 x 665nm – 0.14 x 630nm – 1.31 x 645nm

III. Result and Discussion

New The following algorithm are used to estimate the chlorophyll status of the plants

$$(R-B)/(R+B) \quad (1)$$

Kawashima & Nakatani [22] proposed the above algorithm to estimate the chlorophyll content in wheat plants. They used portable digital video camera to procure the images of the plants and shift the images to the computer by using Photoshop (ver.1.0.7, Adobe systems, USA) to extract the R G B values of the image. They correlated the true chlorophyll value with the value obtained from above algorithm and acquired a relation around -0.81

$$G/(R+G+B) \quad (2)$$

Suzuki et al.[24] evolved the above formula to identify the concentration of chlorophyll in broccoli leaves. They thought some deviations may occur in natural lighting condition so set an artificial lighting system and acquired an image using digital camera.

$$R/(R+G+B) \quad (3)$$

In order to estimate the chlorophyll content of the cucumber leaves Cai et al. [25] proposed the above formula.

$$G/R \quad (4)$$

This formula was applied by Adamsen et al. [26] to predict the chlorophyll status of wheat plants. Cai et al. [25] also applied the same formula in the images of cucumber leaves to determine the chlorophyll status. Both of them used digital camera for their studies.

$$R+G \quad (5)$$

Hu et al. [27] in his study used a digital camera for acquiring images of barley leaves afterwards analysed the images using Adobe Photoshop CS3 Extended 10.0 software (2009 Adobe Systems Inc., USA) with respect to the above formula.

$$G-R/2-B/2 \quad (6)$$

M. Ali et al. [9] Proposed the above equation to estimate the Ch and N. In order to diverge from the existing studies they used hand-held portable scanner (Pico – Australian made) with (40 × 22) cm reference plate to acquire images. For the purpose of reducing variability in terms of angle, distance and lighting conditions they adopt this technique. To extract the green (G), red (R) and blue (B) values from the leaf pixel the acquired images were processed in Matlab.

$$logsig\frac{G-\frac{R}{3}-\frac{B}{3}}{255} \quad (7)$$

M. Ali et al. [8] Introduced the logarithmic sigmoidal transfer function. The algorithm they proposed non-linearly maps thenormalised value of G, with respect to R and B.

$$\frac{\frac{255}{R+B}-\frac{255}{R-B}}{3} \quad (8)$$

Karthika et al. [21] used this formula to estimate the chlorophyll content in the papaya leaf. Here the red blue bands are taken to determine the green band which is responsible for chlorophyll. The difference of red, blue bands are applied and divided by three bands. From this one can estimate the value of Chlorophyll

Entropy value is calculated for the image resulting from above RGB algorithm and correlation is made between lab chlorophyll and entropy value. The results are shown in table1. The algorithm no 8 proposed by Karthika et al.[21] shows better correlation result compared to other algorithm.

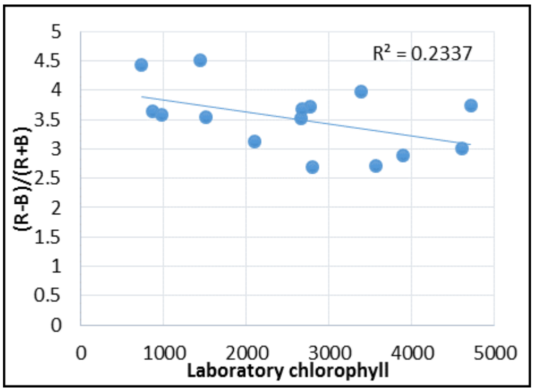

Fig. 7: Lab Ch vs. (R-B)/(R+B)

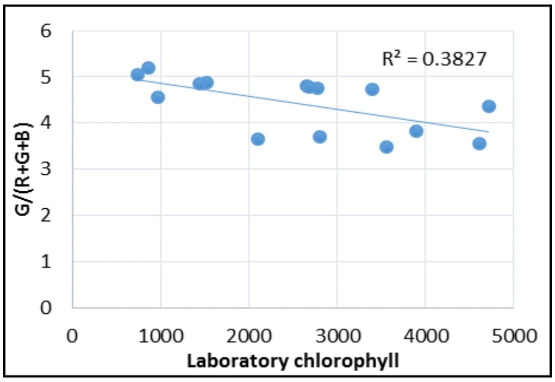

Fig.8: Lab Ch vs. G/(R+G+B)

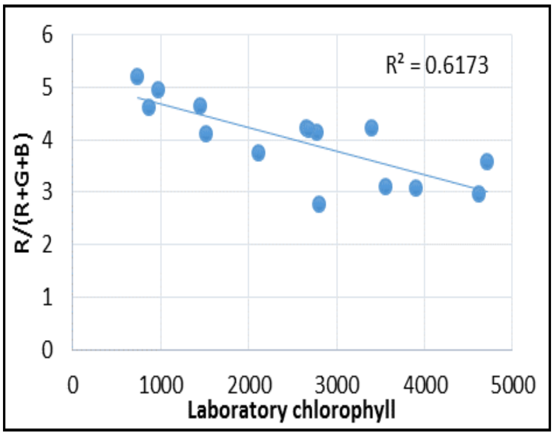

Fig.9: Lab Ch vs. R/(R+G+B)

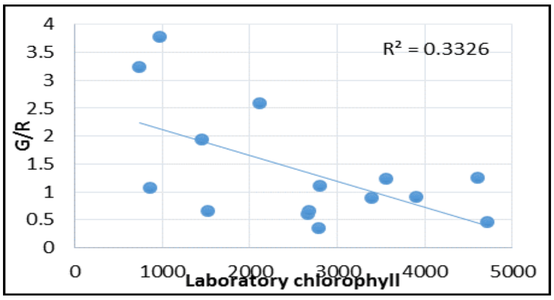

Fig. 10: Lab Ch vs. G/R

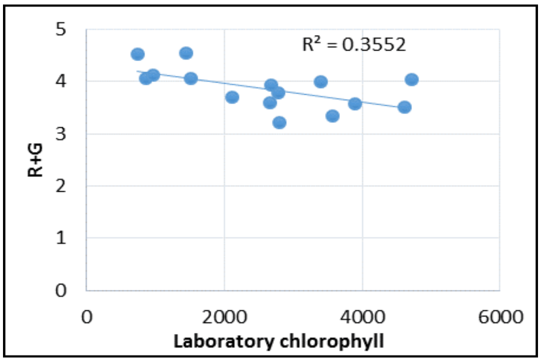

Fig. 11: Lab Ch vs. R+G

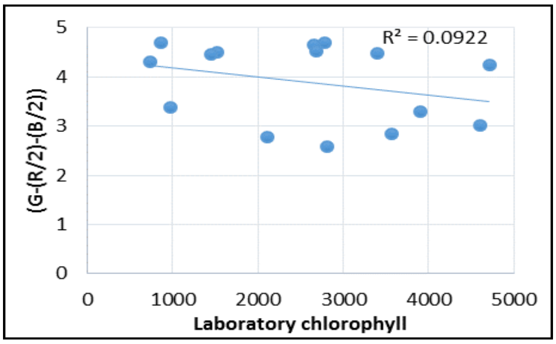

Fig. 12: Lab Ch vs. (G-(R/2)-(B/2))

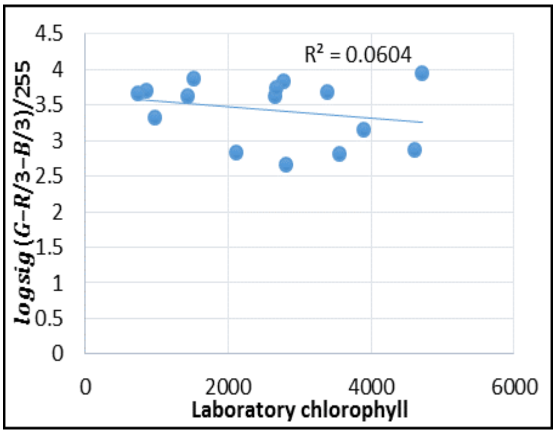

Fig. 13: Lab Ch vs. $\frac{G-\frac{R}{3}-\frac{B}{3}}{255}$

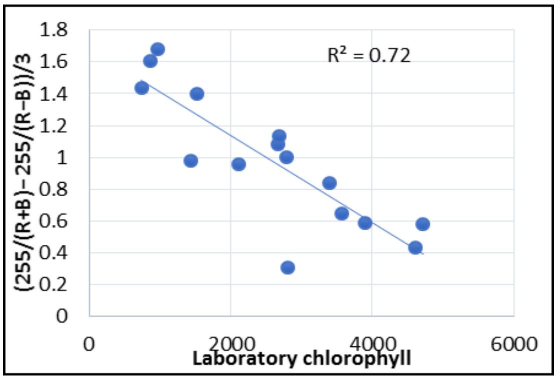

Fig. 14: Lab Ch vs. $\frac{\frac{255}{R+B}-\frac{255}{R-B}}{3}$

TABLE I. CORRELATION OF IMAGE PROCESSED BASED ALGORITHM WITH LAB CH

S.NO	Equation	Correlation coefficient
1	(R-B)/(R+B)	- 0.483382567
2	G/(R+G+B)	- 0.618612932
3	R/(R+G+B)	- 0.785669365
4	G/R	- 0.576726434
5	R+G	- 0.595969437
6	(G-(R/2)-(B/2))	- 0.303705329
7	$logsig\ \frac{G-\frac{R}{3}-\frac{B}{3}}{255}$	- 0.245668717
8	$\frac{\frac{255}{R+B}-\frac{255}{R-B}}{3}$	- 0.848556746

IV. CONCLUSION

Several studies have recently pioneered image processing techniques as a method to detect chlorophyll content in the leaves. Most of the study utilize digital camera, hand held scanners they are time consuming and practically not applicable for hectares and hectares of land. To overcome this issue we used drones to acquire images. The image obtained from the drone after segmentation is utilized for detection of chlorophyll status whose results are similar to those obtained from digital camera, hand held scanners. Correlation value of -0.84 is obtained in our study for Karthika et al.[21] algorithm.

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