Chlorophyll and Nitrogen Estimation of Grape Using Colour Image Processing

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Abstract: **Chlorophyll and Nitrogen are related to each other. Estimating one will give content of other. Many techniques are invented to estimate these two. Colour Image processing technique is proving to be effective for the estimation of both. The Colour Image Processing technique gives faster and accurate output. In this paper, some of the techniques are reviewed and a method is proposed to estimate Chlorophyll and Nitrogen for Grape using Matlab. The function developed in this method shows the satisfactory correlation with both and gives coefficient of 0.7307 and -0.3 with RMSE of 0.05551 and 0.1302 for Ch and N, respectively. The Chlorophyll and Nitrogen estimated with above shows the average error of -0.38 and -1.08 percent for all samples. Also, the correlation coefficient for estimated values of Ch and N is 0.9426 and -0.7253, respectively.**

Keywords: **Colour Image Processing, MATlab, Grape.**

I. INTRODUCTION

1.1 Measuring Chlorophyll and Nitrogen:

Chlorophyll and Nitrogen are important components, which are present in plant leaf. Lower or unhealthy productions will occur, if these are deficient proportion. To avoid this, various fertilizers are available in market which proportionate the quantity of these components. These fertilizers are applied to plants. However, sometimes application of fertilizer would not be proper. Means, there may be higher or lower quantity of fertilizer applied by farmers. Most of farmers, apply fertilizer on the basis of predetermined date of seeding. They do not consider the actual need of crop. So, there is possibility of lower production. Therefore, measurement of the quantity of actual content of Chlorophyll and Nitrogen would be useful. If we measure the content and apply fertilizer according to actual need of the plant; then it will be beneficial to crop as well as to farmer.

1.2 Conventional Techniques used for estimating Ch and N:

As Chlorophyll and Nitrogen are related to each other; there are various method discovered, which includes determination of both. A multi-spectral imaging system[12] was used to determine spectral reflectance and estimate top-view surface area. A non-destructive method [18] of determining chlorophyll content and concentration in field-grown spinach is investigated. A hyperspectral index named area under curve normalized to a maximal band depth between 650-720nm is developed [13] to estimate chlorophyll content of the Norway spruce crown. Chlorophyll is also estimated using the hyper spectral data through the inversion method of linked leaf level and canopy level radiative transfer model.

Using remote sensing, Vegetation indices computed from remote sensing data containing the red edge region (690-730 nm) can be used to predict plant nitrogen (N) status [14]. They have conducted to assess whether simulated RapidEye™ data could match the capacity of narrow band, hyperspectral data to predict mid-season N status of dark northern spring wheat. Leaf area index (LAI) and canopy chlorophyll content can be mapped in heterogeneous Mediterranean grassland from canopy spectral reflectance measurements [15]. Reflectance indices of pigment content of wheat crop, Ch and N content and Leaf Area Index [19] are calculated and great correlation between these indices. A light absorbance technique [17] was developed to estimate Ch of whole tomato.

Before discovery of SPAD 502; CCM-200 device was used by researchers. Leaf Ch and N is estimated by using CCM-200 [20] is also time and resource saving technique. The regression models were developed with destructively measured parameters as the dependent variable and a parameter derived from CCM-200 as the independent variable (CCI) to estimate Ch and N of Rosa damascene[22][25]. Chlorophyll-a vertical profile, water column photosynthetic parameter and underwater irradiance parameter are used to develop an algorithm [21]. Chlorophyll estimation using MODIS sensor with in-situ Ch measurements [23] is compared with present study and ANN model give good result. QuickBird satellite imagery data was also used for data collection instead of SPAD, but high cost and cloud interference limits its use.

1.3 Image processing Techniques used for estimating Ch and Ni:

The techniques cited above are time consuming and costly. Image processing technique is now becoming an effective tool for analysing parameters. Because; it is faster, low cost and gives more accurate results than above techniques. Relationship between chlorophyll content of various functions [6] derived from red, green and blue wavelengths are examined. Leaf color diagnosis with video camera is an effective, easy and low cost operation for use with individual plants or a large field. A rapid analysis and data storage[1] at minimal cost is developed and it does not require any technical or laboratory skills. Their method analyses leaf color images obtained from a digital scanner that requires minimal calibration. The algorithm they have developed; produces superior correlations with the true value of foliar chlorophyll content measured in the laboratory.

Another method in which color image analysis was performed to estimate sugar beet leaf chlorophyll status[9] is developed. Chlorophyll level of the leaves was measured by a SPAD-502 chlorophyll meter. To estimate chlorophyll status, a neural-network model was developed based on the RGB components of the color image captured with a conventional digital camera. The coefficient of determination (R^2) and mean square error (MSE) between the estimated and the measured SPAD values, which were obtained from validation tests, appeared to be 0.94 and 0.006, respectively.

CIE chromaticity diagram[3] is used in which leaf color information in RGB is transformed into wavelength (in nm). Light exposure time (τ) is chosen as environmental change, is varied. Each day sample from different exposure time is taken, its color is recorded and its chlorophyll content is obtained from absorption spectrum measured using Spectrophotometer and the information from the spectrum is calculated using Arnon method. Based on these results an empirical relation between concentration of chlorophyll *a Cc-a* and its wavelength λ average can be formulated. This method is more accurate than remote sensing and NN model. RGB color image processing based method[6] was proposed for nitrogen estimation in veraison. The Green index Igreen showed strong positive correlation with coefficient of 0.90 and other index Ikaw showed strong negative correlation with coefficient factor -0.88. The correlation between chlorophyll and nitrogen showed positive correlation. The method proposed is cost effective and less time consuming.

The health of a plant is estimated using various non-destructive Image Processing Techniques. Chlorophyll content was detected based on color Image Processing. The Haar transform [29] is applied to get size of leaf and the parameters. The relationship between chlorophyll content of the leaf and healthiness of plant, with the help of various techniques, is determined. A manually operated four wheel test trolley [4] was designed and developed for acquiring outdoor color images of plant under controlled illumination to predict crop nitrogen content in field. The results were compared with the chlorophyll content of the crop measured by SPAD meter and the chemical analysis of plant leaf. Various features such as R, G, B, normalized ‘r’ and normalized ‘g’ were analyzed for both the processes. An automatic nitrogen estimation method[5] is developed in a plant based on leaf color. Here, sugarcane leaf images are captured by a portable camera and then relationships between nitrogen content and leaf colors in red (R), green (G), blue (B) and near infrared (IR) are examined. The terns R, G, B, G/B, G/R, R/B and ((IR-R)/ (IR+R)) had the significant relationship with nitrogen concentration in the sugarcane leaves.

Image processing techniques were developed by Gautam R.K. and Panigrahi [7] to extract statistical and textural features from multi-spectral bands of aerial images. Along with the conventional image bands of red, green, and near-infrared; normalized difference vegetation index (NDVI) and green vegetation index (GVI) were derived. The extracted image features were used as input to the neural network models.

Brendon J. Woodford and Nikola K. Kasabov [10] Wearing proposed wavelet based image processing technique and neural network to develop a method of on line identification of pest damage in pip fruit in orchards. Fast wavelet transform with special set of Doubenchies wavelet was used to extract the important features. A prediction approach based on support vector machines for developing weather based prediction models of plant diseases is proposed by Rakesh & Amar [11]. It was concluded that SVM based regression approach has led to a better description of the relationship between the environmental conditions and disease level which could be useful for disease management. This paper proposes the method to estimate Chlorophyll and Nitrogen from the RGB color images with RGB plane functions.

II. METHOD AND MATERIAL

2.1 Sample Collection:

Sample collection consists of Image Acquisition of Grapes leaves of various species (e.g. Thompson, Sharad, Sonaka). Grape farms are situated in Solapur, Maharashtra, India. Grape leaves are collected after April Pruning. Every fifth or sixth leaf is collected as a sample from different plants in each field. At least, 20 leaves from each farm are collected. First leaves are cut and cleaned to remove the dust or pesticides from its surface.

Sample collection is made by capturing images of grape leaf during early morning on black background is kept to reduce illumination effect. Sony DSC-H100 CCD sensor camera is used. Camera is positioned at 7 inches above. At the same time, Chlorophyll readings were taken using Ch-meter (atLEAF+), which were taken as reference for comparison. Then, petioles are separated from the leaf and given for the laboratory analysis.

2.2 Laboratory Analysis:

Petioles of samples were analysed in laboratory for Nitrogen estimation using Kjeldhal digestion method. The laboratory analysis gives the value of Nitrogen, in which 20 petioles are considered as 1 sample. These values of Nitrogen are also used as reference values for comparison..

2.3 Image Analysis:

Images are cropped for getting the leaf blade area. R, G, B planes of image are separated. Using these R, G and B values different combinations of functions of these planes are calculated. Next, statistical parameters (e.g. Average, Min, Max, Standard Deviation and Variance) are calculated.

The correlation of these functions is taken with reference Ch and N values. Among these parameters we found average values of functions have greater correlation with average values of both. Table 1 shows correlation between functions and Chlorophyll and Nitrogen ; where, R_ch and R_N shows the correlation coefficient with Ch values taken from Ch meter and N values taken from laboratory.

TABLE 1: Correlation between functions and Chlorophyll and Nitrogen

Function	R_Ch	R_N
G/(R+B)	-0.70271088	0.34269
2B/(R+G+B)	0.70931294	-0.28038
B/G	0.73071491	-0.30071
(R+2G)(R+G)/2B(R-G)	0.73107113	0.132654

Next, Regression analysis is applied to the function with greater correlation coefficient, so as to get the regression equation. Using regression equation, Ch and N are estimated as shown in Table 2 as Ch-est and N_est. In this Study, 15 field samples were collected and brought to statistical analysis. The curve fitting tool of Matlab is used for the analysis and curve fitting. Figure shows the Fitted Curve for both Chlorophyll and Nitrogen.

TABLE 2: Chlorophyll and Nitrogen Estimation

B/G	CH-meter	Ch_est	N_lab	N_est
0.76116711	43.495	31.46	1.13	1.19
0.80512388	36.51	35.03	1.05	1.14
0.95978563	48.635	58.32	0.87	1.00
0.94459573	44.425	54.74	1.04	1.00
0.98530541	61.56	65.50	1.01	1.00
0.99295952	69.725	68.01	0.9	1.00
0.91865442	48.025	49.56	0.86	1.02
0.9427347	46.955	54.34	0.97	1.00
1.04315654	92.33	90.87	1.12	1.09
1.02824086	88.52	82.62	0.92	1.05
0.85327101	54.645	40.01	1.3	1.08
0.97142551	51.66	61.39	0.96	1.00
0.97288978	60.885	61.80	1.21	1.00
0.96421524	56.55	59.45	1.08	1.00
0.97852042	78.225	63.42	1.15	1.00

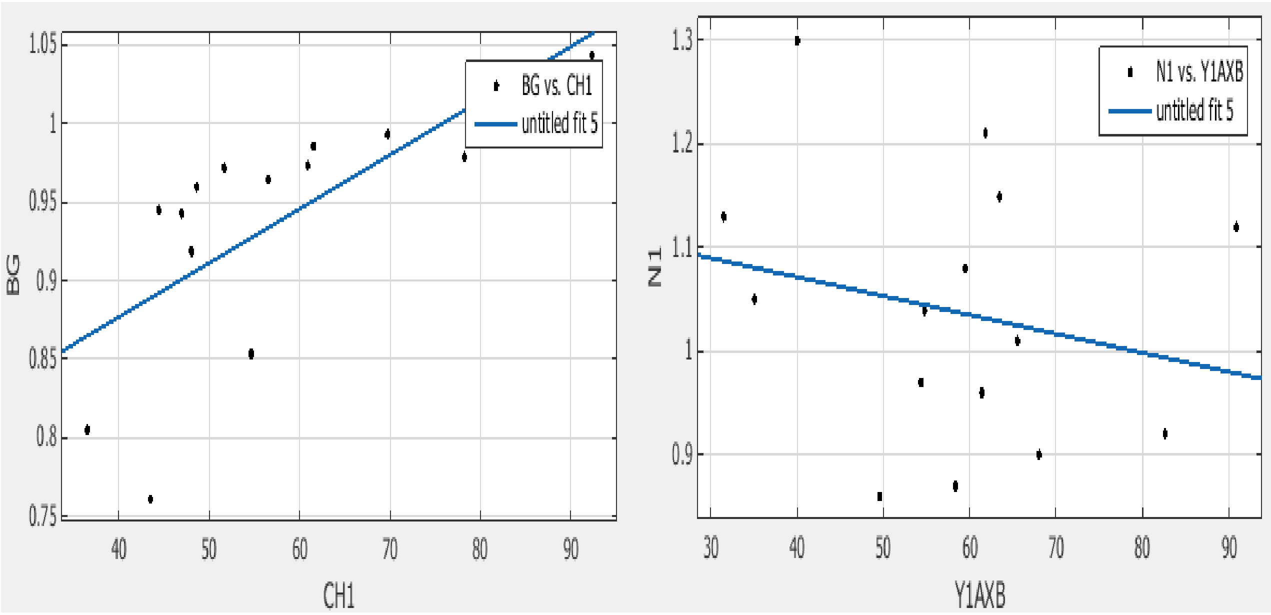

Fig. 1 : Fitted Curves for Chlorophyll and Nitrogen

III. RESULTS AND DISCUSSIONS

After experimentation with various functions of R, G and B almost all functions showed significant correlation with Chlorophyll values about -0.702 to 0.731 and with Nitrogen values about -0.30 to 0.34. The functions 2B/(R+G+B), B/G and (R+2G)(R+G)/2B(R-G) showed positive correlation with Chlorophyll, whereas G/(R+B) and (R+2G)(R+G)/2B(R-G) showed positive correlation with Nitrogen. Among all functions, B/G function showed better accuracy than other functions on application of linear and non- linear regression analysis for estimation. So, this function is used for further calculations. Using LABfit software, regression analysis is done. First, B/G function values and values of Ch_meter are plotted and from that we got the regression equation,

$$Y_1 = \frac{1}{(Ax+B)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, A= -0.0736856, B= 0.0878699, Y_1 is Chlorophyll value and x is value of function B/G at that sample.

e.g.TocalculateY$_{1=}$1/(-0.0736856 *0.76116711 + 0.0878699) = 31.46

Where, 0.76116711 is the value of x i.e. first value of B/G in table 2. See table 2, 1st value in third column (Ch_est) which is nothing but the Chlorophyll value of sample 1. Likewise, all the values of Ch for particular sample were calculated. Again, the Y_1 values and lab values of N are plotted and from that we got the regression equation,

$$Y_2 = \frac{Ae^{Bx}}{x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, A = 22.538 and B = 0.0162645, Y_2 is Nitrogen value and x is the value of function Y_1 at that sample.

e.g. To calculate Y_2 =(22.538 * exp (0.0162645*31.46))/ 31.46 = 1.19

Where, 31.46 is value of Y_1 for sample 1. See table 2, 1st value in fifth column (N_est) which is nothing but the Nitrogen value of sample 1. Likewise, all values of N for particular sample were calculated.

Next, the same operation is done using MATLAB curve fitting tool. After regression analysis of both Ch and N, we got the same linear regressing equation. The regression equation is P_1*x+P_2, which gives best fitted curve having R^2 of 0.5339 and 0.05101 for Ch and N; RMSE of 0.05551 and 0.1302 for Ch and N. You can see the table 2 for estimated values of Chlorophyll and Nitrogen, where estimated values are near about same compared with reference values. The Chlorophyll and Nitrogen estimated after regression analysis shows the average error of -0.38 and -1.08 percent for all samples. Also, the correlation coefficient for estimated values of Ch and N is 0.9426 and -0.7253, respectively.

IV. CONCLUSION

Image processing technique is proving to be the best solution for Ch and N estimation and the concept of precision farming is fulfilled by using it. The output of techniques used previously; may change or could be inaccurate as these were made manually, but IP technique will be accurate every time.

The proposed method will be helpful for farmers who grow grapes. The method comes under non-destructive methodology, so it saves cost and time. In this method, the image acquisition is done natural condition. It shows significant correlation with Chlorophyll and nitrogen. Also, the estimation of these two is done with greater accuracy.

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