International Journal of Engineering Research and Reviews ISSN 2348-697X (Online)
Vol. 2, Issue 4, pp: (33-41), Month: October - December 2014, Available at: www.researchpublish.com

Chloropyll and Nitrogen Estimation Techniques: A Review

Prajakta Patane[1], Anup Vibhute[2]

[1,2]Department of Electronics and Telecommunication Engineering, Brahmadeodada Mane Institute of Technology, Solapur, India

Abstract: **Chlorophyll and Nitrogen are related to each other. Estimating one will give content of other. Many techniques are invented to estimate these two. Remote sensing, hyperspectral data, multi spectral imaging data, vegetation indices, light absorbance technique are some of the estimation techniques. Some tools also used say, RapidEye, QuickBird, MODIS sensor, SPAD meter, CCM 200 meter. These techniques are divided in two categories- Non destructive and Destructive. However, Image processing technique is proving to be effective among all these; which come under non destructive method. In this paper, some of these techniques are reviewed**.

Keywords: **Estimation techniques, Non-destructive, Image processing.**

I. INTRODUCTION

1.1 What is Chlorophyll and Nitrogen?

Chlorophyll (Ch) is a key biochemical component in the molecular apparatus that is responsible for photosynthesis in which the energy from sunlight is used to produce oxygen. In the photosynthetic reaction below, carbon dioxide is reduced by water, and chlorophyll assists this transfer.

$$6\ CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Chlorophyll a is the most abundant form of chlorophyll within photosynthetic organisms and, for the most part, gives plants their green color. There are other forms of chlorophyll, coded b, c, and d, which enlarge the overall fluorescent signal. These types of chlorophyll, including chlorophyll a, can be present in all photosynthetic organisms but vary in concentrations. Nitrogen (N) is also a main structural component present in plant leaf. More the quantity of Nitrogen more the healthier plant is.

II. REASONS TO MEASURE CHLOROPHYLL AND NITROGEN

As explained above, Chlorophyll and Nitrogen are important components, which are present in plant leaf. Deficiency of these two may cause lower or unhealthy productions. To avoid this, various fertilizers are available in market which proportionates 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 yield.

Measuring the quantity of actual content of Chlorophyll and Nitrogen would be useful in this case. 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. There are various techniques have been developed by many researchers. Some of these are discussed here.

III. CHLOROPHYLL AND NITROGEN MEASURING METHOD

1.2 Spectrophotometry

It is a Lab based method. In this method, large quantity of water is taken and filtered to concentrate the chlorophyll containing organism. Cells are then ruptured. The extraction of Chlorophyll from disrupted cell into Acetone is done. The extract is then analyzed by spectrophotometric method. It includes Transmittance and reflectance of light, which gives the chlorophyll content.

1.3 Normalized Difference Vegetation Index (NDVI)

It is simply a numerical indicator. It uses visible & near infrared bands of electromagnetic spectrum for observing whether target contain live green vegetation or not. From this, we get Chlorophyll content. Also, we get Nitrogen status indirectly.

1.4 Chlorophyll meter

This is a Chlorophyll measuring device. It is a Minolta, which measures transmission of 650 nm red light which chlorophyll absorb it and transmission of 940 nm infrared light which chlorophyll does not absorb. It gives Ch value in a particular range. An exponential relationship exists between SPAD (Soil Plant Analysis Development) value and Ch content (micromol/m^{-2}). It uses average of at least 5 readings. So, it is time consuming. It is reliable method than other. SPAD-502 meter is widely used by researchers. It is suitable for medium area of farm.

1.5 Leaf Colour Chart

It is a simple colour chart, consists of many shades of leaf colour from light green to dark green. It is used mainly for Nitrogen estimation. For N estimation, Leaf is cut and it is compared with colour in the chart. Different species crop uses different chart. This is the easiest but also the least accurate method and is suitable for medium area.

IV. TECHNIQUES USED FOR ESTIMATING Ch AND Ni

Chlorophyll and Nitrogen are related to each other. So there are various method discovered, which includes determination of both. A multi-spectral imaging system [12] was used to determine spectral reflectance and to estimate top-view surface area. An ultrasonic distance sensor provided vegetation height estimates. Surface area estimates and height data were combined to estimate plant biomass. The relationships between reflectance, estimated biomass, and laboratory measured chlorophyll content and concentration were investigated. The product of biomass estimate and normalized difference vegetative index ($NDVI_{680}$) provided the best estimate of chlorophyll content per plant while estimates of chlorophyll concentration per unit leaf mass were poor. A non-destructive method [32] of determining chlorophyll content and concentration in field-grown spinach is investigated. Biomass was estimated with percent vegetation coverage based on images taken with a multispectral imaging system. Chlorophyll yield was estimated using reflectance-based NDVI from a Green Seeker hand-held optical sensor and a multispectral imaging system. Strong correlations were found between reflectance-based NDVI and chlorophyll yield, between NDVI and biomass, and between biomass and projected plant area. Combined parameter estimators of chlorophyll concentration had low correlation

Ch estimation in open canopy tree crops is done using hyperspectral indices and model simulation [13]. They used hyperspectral optical indices related with leaf Ch content for testing different modelling assumptions. They captured images and calculated indices. Also, tested results for more accuracy and developed relations between indices. They demonstrated that various components like Soil, shadow and crown reflectance in open canopy case affects the readings when pixel size aggregates the scene components. Also, hyperspectral indices are more sensitive to open canopy conditions. A hyperspectral index named area under curve Normlised to maximal band depth between 650-720nm is developed [14] to estimate chlorophyll content of norway spruce crown. The result showed that RMSE between calculated indices is two times higher than real and $ANMB_{650-720}$ estimated concentrations.

Remote sensing is also useful for Weed detection. Vegetation indices computed from remote sensing data containing the red edge region (690-730 nm) can be used to predict plant nitrogen (N) status [15]. 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. Data is converted into reflectance of RapidEye™. Various indices such as Modified Chlorophyll Absorption Ratio Index/Modified Triangular Vegetation Index (MCARI/MTVI) are calculated. Their results suggest that the MCARI/MTVI index computed from RapidEye™ data is a potentially useful predictor of mid-season wheat N status. Hyperspectral remote sensing is a useful tool [42] that can be used to estimate foliar chlorophyll and nitrogen concentrations, which can serve as proxies for understanding photosynthesis and biogeochemical cycling. His study indicated that no single SVI is optimal for estimating variations in Ch and N concentrations for each of the species throughout a growing season. Also, SVIs are most useful in predicting the Ch and N concentrations of deciduous species and trees inhabiting peatlands, as well as estimating the Ch and N concentrations of mosses and all species grouped together into plant functional types.

A hyperspectral remote sensing technique is used to estimate Ch in rice leaves [20]. In their study they found there is a correlation between the chlorophyll concentration and spectral reflectance of the rice leaves. Also, the strong correlation between the wavelength of the Red Edge inflection point and the chlorophyll concentration of the rice leaves was found by them. A conceptual model was developed [23] for estimating Ch estimation of maize and soya bean canopies using remote estimation. This new technique showed great potential for remotely tracking the physiological status of crops, with contrasting canopy architectures, and their responses to environmental changes.

Ch concentration in higher plants leaves changes throughout different stages of plant development and affects to vegetation when exposed to natural or anthropogenic fertilizers. Anatoly [16] introduced an algorithm, which will estimate Ch concentration with minimum error and could be applied to different species. They exhibit more than 6 times wider dynamic range than widely used the NDVI. Nitrogen is the most important nutrient in growing potatoes [33] a deficit or excess in its supply can affect yield and quality, resulting in economic losses. The green index (IV) could be a valuable method to assess N sufficiency. The chlorophyll meter is an appropriate tool to determine the nutritional status in potato crops. The IV and ISN-IV values showed that the crop achieved maximum yields when N levels are above the threshold values found in this research.

Leaf area index (LAI) and canopy chlorophyll content can be mapped in heterogeneous mediterranean grassland from canopy spectral reflectance measurements [17].This method can provide a useful exploratory and predictive tool for mapping and monitoring heterogeneous grasslands. Nitrogen deficiency effectively reduces the wheat yield [34]. As it is related with Ch; estimating one will indirect give presence of other. Reflectance indices of pigment content of wheat crop are calculated. Also, Ch and N content and Leaf Area Index are calculated. They found great correlation between these indices. So, they concluded that, optical techniques offer a potential to assess N content. A.K. van den Berg [36] evaluated the ability of the same meter to estimate both Ch and N content in Sugar maple leaves by same procedure followed by Aparna. He found same results as that with Aparna. In the same study, Fernando [37] used all species and leaf stages. A strong non-linear relationship was found between the chlorophyll content index (CCI) and leaf chlorophyll content per unit area. In all species, the slope of the CCI-chlorophyll content relationship varied during leaf development, suggesting that caution should be exercised when using the CCM-200, since the interpretation of CCI readings should be limited to samples of similar leaf age. Evaluation of the performance of optical methods [41], which are based on the absorbance or reflectance of certain wavelengths of light by intact leaves, is done. Ch a, Ch b, and total Ch content of paper birch leaves are measured using standard extraction techniques. These values were compared with the nominal Ch index values obtained with two hand-held Ch absorbance meters and several reflectance indices correlated with foliar Ch. The noninvasive optical methods all provided reliable estimates of relative leaf Ch.

A light absorbance technique [19] was developed to estimate Ch of whole tomato.The relationship between optical measurements of whole tomato and pigment content was studied. The difference between the absorbance's (A) at 710 and 780 nm [AA (710-780 nm)] correlated significantly (I= 0.98) with chlorophyll contents of 0.3-l 3.4 pg/g fresh weight (gfw). The AA (570-780 nm) correlated significantly (I = 0.97) with lycopene contents of 0.2-46.7 pg/gfw. The AA (550-580 nm) correlated significantly with the p-carotene, content (I = 0.95). The reflectance measurements correlated with the chlorophyll and lycopene contents, but the coefficients were lower and the standard errors were larger than those observed with the absorbance measurements.

Spectral absorption indices are developed [30] for prediction of leaf chlorophyll concentration based on blue/yellow/red/ edge absorption spectrum. Several indices BEACI, YEACI, REACI were calculated from elected absorption wavelength positions. Correlation between them is calculated from which Ch content is calculated.

Spectral reflectance [21] was evaluated for its usefulness as a nondestructive estimation of chlorophyll content from three cultivars of sweet potato with green, yellow, and purple leaves. For green and yellow leaves, the reciprocal reflectance (R^{-1}) and derived indices incorporating near infrared (NIR) reflectance, $[(R\lambda)^{-1}$ - (RNIR)-1] and $[(RNIR/R\lambda)^{-1}]$, in the green and red edge spectral ranges were shown to be strongly correlated with the chlorophyll content. For leaves with high levels of anthocyanins, the correlation between [1 - (Rλ/RNIR)] and the chlorophyll content remained strong in the green spectral range, and the RMSE was minimal. Corn leaf Ch concentration [22] was measured from leaf and canopy reflectance. They have selected the wavelength which is sensitive to Ch concentration, simulated the canopy reflectance and detected Ch status.

Non-destructive measurements of both reflectance and area of a single leaf [41] can be used to accurately estimate total Ch content in a maize canopy. They calibrated and validated a reflectance-based nondestructive technique to estimate leaf Ch in maize; quantified the relative contribution of each leaf Ch to the total Ch in the canopy; and established a relationship between leaf Ch content and total Ch in a maize canopy.

Leaf N and chlorophyll concentrations of cotton are important indicators of plant N status measurements of leaf reflectance [49] may provide a rapid and accurate means of estimating leaf N and Ch. Reflectance at 556 and 710 nm increased significantly as N fertilizer rate decreased leaf reflectance can be used for real-time monitoring of cotton plant N status and N fertilizer management in the field. Leaf nitrogen and leaf surface area influence the exchange of gases between terrestrial ecosystems and the atmosphere, and play a significant role in the global cycles of carbon, nitrogen and water. E. Boegh [31] has studied the field-based and satellite remote-sensing-based methods to assess leaf nitrogen pools. REGFLEC (REGularized canopy reFLECtance), an advanced image-based inverse canopy radiative transfer modelling system is used by them.

Before discovery of SPAD 502; CCM-200 device was used by researchers. Leaf Ch and N is estimated by using CCM-200 [24] is also time and resource saving technique. Data from this device is correlated with data obtained by DMSO and Kejeldal methods. It gives better results. 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 [27]. The non destructive Ch meter is now becoming more effective and valuable tool for researchers than other techniques [35]. They studied different plants with varying photosynthetic pathways. They have used Ch meter CCM-200. The significant correlation between chlorophyll content index and extracted chlorophyll is found by them. A chlorophyll meter can conveniently estimate foliar chlorophyll and nitrogen (N) contents in tea plant leaf [29]. The chlorophyll and nitrogen contents and chlorophyll meter (SPAD) readings of tea leaves in August were greater than in November, and plot-scale values were greater than field-scale values. SPAD readings could estimate the chlorophyll content of tea leaves regardless of temporal and spatial considerations. However, they found that; space and time must be considered when using SPAD readings to estimate the nitrogen content of tea leaves. Correlation between extractable leaf Ch concentration and portable nondestructive leaf greenness meter readings [39] also help out to measure N status. They experimented on Citrus and took readings of SPAD 502, CCM 200, observer; these readings correlated with each other. But, regression models found different readings with these meters reading.

The relationship between SPAD readings and leaf nitrogen concentration (LNC) in sweet sorghum [40] established after examining the relationship between SPAD readings and LNC in sweet sorghum in a two-year study; and the effects of leaf thickness on the relationship. But the correlation was weaker when the data for the two growth stages were pooled. This correlation improved when the specific leaf area was introduced as a second independent variable in the multiple regression analysis. The results suggest that the regression equation developed can help in optimizing nitrogen fertilization for sweet sorghum production. The feasibility of using SPAD-502 chlorophyll meter and plant visual aspect for N management [46] in drip fertirrigated tomato plants under unheated greenhouse is checked. The results indicate that a SPAD meter can provide a quantitative measure of the N requirement of the tomato plants as long as appropriate SPAD critical values are established.

Chlorophyll-a vertical profile, water column photosynthetic parameter and underwater irradiance parameter are used to develop an algorithm [26]. Jyh- Horng [25] tried to establish a simple and reliable method for bamboo chlorophyll extraction. Chlorophylls in moso bamboo epidermis were extracted with acetone, DMF and DMSO using three methods, including ultrasonics, centrifugation and grinding. Different forms of chlorophyll a concentration quantification are compared spectrophotometry, fluorimetry and spectrophotometry after high performance liquid chromatography separation (HPLC). From two environments (Lobo and Salto Grande Reservoir), 120 samples had been used to compare these methods. Although they have a very great correlation, two of them, spectrophotometric and fluorimetric, had overestimated chlorophyll concentration. This overestimate was more significant in the Lobo reservoir.

Chlorophyll estimation using MODIS sensor with in-situ Ch measurements [38] is compared with present study. Their analysis showed overestimation of Ch, using MODIS. Also, RMS log error was high. They developed ANN model, which gives satisfying results.

Nitrogen management is critical in optimizing potato yield [43] and quality and reducing environmental pollution. Six N rates from 34 to 270 kg ha_1, and different timing of N application were used in a 3-year field experiment to contrast SPAD-502 chlorophyll meter and QuickBird satellite imagery data against the conventional petiole sampling technique for assessing canopy N status the ability of the SPAD meter to detect treatment differences varied with growth stage and growing season. Severe N deficiency was detected about 1 month after emergence with SPAD readings, but as early as 2 weeks after emergence with petiole NO3-N concentrations. Cloud interference and high cost of images could limit the use of QuickBird data in making timely management decisions.

As an alternative to chemical analysis, chlorophyll meter readings and N-NO3 concentration determination [44] in petiole sap were proposed, but these assays are not always satisfactory. The study was based on evaluation of the possibility and the accuracy of the estimation of tomato leaf nitrogen concentration performed through a rapid, portable and non-destructive system, in comparison with chemical standard analyses, chlorophyll meter readings and N-NO3 concentration in petiole sap. The correlation between predicted values from spectral reflectance analysis and the observed chemical values showed in the independent test highly significant correlation coefficient.

One of the most difficult challenges facing farmers is to determine the appropriate fertilizer nitrogen application rate [45]. The problem is basically one of synchronizing soil N availability (from all N sources) with crop N needs. This task is complicated because it is difficult to accurately predict climatic variables that influence crop growth, soil microbial activity, and NO3 leaching.

V. 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 analyzing parameters. This is because; it is faster, low cost and gives more accurate results than above techniques. Plant leaf color is commonly used as an index for nutrient diagnosis [6]. Relationship between chlorophyll content of various functions 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. They had developed a low cost diagnostic method that is easy to use to assess the nutrient status of the plants, based on the estimation of chlorophyll content of leaves using camera and PC.

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 compared as it has its one light source and the angle and distance between light and leaf are constant. The algorithm they have developed; produces superior correlations with the true value of foliar chlorophyll content measured in the laboratory compared with existing non-destructive methods when applied to three different species of crops. Correlation coefficients got in their experiment are greater than other algorithms.

Another method in which color image analysis was performed to estimate sugar beet leaf chlorophyll status [9] is developed. The experiment was carried out in a phytotron and nitrogen was applied at 6 levels to the sugar beet grown in pots. 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 results showed that the neural network model is capable of estimating the sugar beet leaf chlorophyll with a reasonable accuracy. The coefficient of determination (R2) 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, which normally should be about 12 hours/day, 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 is Spectrophotometer after it is rinsed in 85 % acetone solution and the information from the spectrum is calculated using Arnon method. It has been observed that average wavelength of leaf color λ average is decreased from 570.55 nm to 566.01 nm as is measured for 1 - 10 days with 9 hours/day, but chlorophyll concentration C is increased from 0.015 g/l to 3.250 g/l and from 0.000 g/l to 0.774 g/l for chlorophyll *a* and *b*, respectively. Other value of τ gives similar results. 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.

Plants need a certain amount of macronutrients (nitrogen, phosphorus, etc.) and micronutrients (Zinc, Boron, etc.) to grow and stay healthy [2]. These Nutrients alter and regulate the functioning of plant and produce qualitative and quantitative changes in plant yield. RGB color image processing based method 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 on the basis of Igreen index is cost effective and less time consuming. The changes in correlation may occur according to different soil conditions and plant varieties.

Plant nutrients in proper proportion keep the plant healthy and it is less susceptible to the pests [18]. The nutrient analysis by invasive and non invasive methods has their own advantages and disadvantages. They have proposes method using color image analysis for estimation of nitrogen for grapes. The function used to estimate shows significant correlation and gives the coefficient of determination of 0.89 with mean square error of 0.08935. The proposed method has advantage of time and cost effectiveness compared to conventional methods.

The health of a plant is estimated using various non-destructive Image Processing Techniques. Chlorophyll content was detected based on colour Image Processing. The Haar transform [48] is applied to get size of leaf and the parameters. This method proves to be an easy and simple one. The relationship between chlorophyll content of the leaf and healthiness of plant, with the help of various techniques, is determined. This can be used to determine the chlorophyll content instead of going for destructive methods that involves various chemical methods. One can avoid the damage of plants and can use this non destructive method.

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. This set up consists of a camera to capture the plant image, four lights to control illumination and a laptop for processing the signal. The developed unit was evaluated rigorously for paddy crop for four observations at fifteen days interval after transplantation. The results were compared with the chlorophyll content of the crop measured by SPAD meter and the chemical analysis of plant leaf. The processing of the color plant image was done in MATLAB program. Various features such as R, G, B, normalized ‘r’ and normalized ‘g’ were analyzed for both the processes. Regression models were developed and evaluated between various image feature and the plant nitrogen content and observed that, the minimum accuracy was found to be 65% with an average accuracy of 75% (Standard Deviation ±1.9), actual and predicted values of nitrogen percent were linearly correlated with $R2$ value (0.948), this showed that the plant nitrogen content can be successfully estimated by its color image feature.

An automatic nitrogen estimation method [5] is developed in a plant based on leaf color. The main is focus on sugarcane. 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, two additional image bands, normalized difference vegetation index (NDVI) and green vegetation index (GVI) were derived. Two neural network architectures, multilayer perceptron and radial basis function were applied to develop twenty neural network (NN) models for predicting leaf nitrogen content of corn plants in field conditions. The extracted image features were used as input to the neural network models. Performance of the neural network models were evaluated based on simultaneous comparison of root mean square error of prediction (RMSEP), minimum prediction accuracy (MPA), and correlation coefficient. The optimum NN model was based on the radial basis function architecture and used textural image features as its inputs. The radial basis function based on green vegetation index texture (RBGvT) provided an RMSEP of 6.6%, MPA of 88.8%, and correlation coefficient of 78% for predicting leaf nitrogen content infield conditions.

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. Three pests that are prevalent in orchards were selected as the candidates for this research: the leaf-roller, codling moth, and apple leaf curling midge. Fast wavelet transform with special set of Doubenchies wavelet was used to extract the important features. To retrieve the related images, the search is done in two steps. The first step matches the images by comparing the standard deviations for the three color components. In the second step, a weighted version of the Euclidean distance between the feature coefficients of an image selected in the first step and those of the querying image is calculated and the images with the smallest distances are selected and sorted as matching images to the query.

Weed infestation rate (WIR) in synthetic images using Gabor filtering and results of wavelets were compared in [47] Daubechies, Symlet, Coiflet, Meyer, Biorthogonal, R-biorthogonal wavelets were used for image decomposition and reconstruction. Results of these and global confusion matrix were used to classify crop and weed into true and false categories. Daubechies 25 wavelet and the Meyer wavelets give better result than Gabor filtering at the cost of average time in both synthetic and real images.

A prediction approach based on support vector machines for developing weather based prediction models of plant diseases is proposed by Rakesh & Amar [11]. The performance of conventional multiple regression, artificial neural network (back propagation neural network, generalized regression neural network) and support vector machine (SVM) was compared. 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.

VI. CONCLUSION

From above review, it is clear that image processing technique is proving to be the best solution for Chlorophyll and Nitrogen estimation. As this technique comes under non destructive methodology; it saves cost and time. Also, one can get the result in shorter time. The concept of precision farming is fulfilled by using this technique. Although, there are various techniques developed; they are time consuming. Thus, we can conclude that; image processing was effective technique for estimation. It is more accurate than other techniques.

REFERENCES

[1] Mahdi M. Ali, Ahmed Al-Ani "A New Image Processing Based Technique to Determine Chlorophyll in Plants" IDOSI Publications, 2012

[2] Anup Vibhute & S. K. Bodhe "Color Image Processing approach for Nitrogen Estimation of Vineyard" Vol. 3, Issue 3, Aug 2013, 189-196

[3] Muhammad Abdul Hakim Shibghatallah, Siti Nurul Khotimah "Measuring Leaf Chlorophyll Concentration from Its Color:A Way in Monitoring Environment Change to Plantations" physics.bio 26 July 2013

[4] V. K. Tewari, Ashok Kumar Arudra"Estimation of plant nitrogen content using digital image processing"AgricEngInt: CIGR, vol.5 no. 2 Journal July, 2013

[5] Piti Auearunyawat, Teera sit Kasetkasem "An Automatic Nitrogen Estimation Method inSugarcane Leaves Using Image ProcessingTechniques" International Conference on Agricultural, Environment and Biological Sciences (ICAEBS'2012) May 26-27, 2012 Phuket

[6] Shigeto Kawashima and Makoto Nakatani, "An Algorithm for Estimating Chlorophyll Content in Leaves Using a Video Camera" Annals of Botany 81: 49-54, 1998

[7] R.K. Gautam and S. Panigrahi,"Leaf nitrogen determination of corn plantusing aerial images and artificial neural networks"S. 2007.

[8] AnupVibhute and R.S.Bodhe "Applications of Image Processing in Agriculture: A Survey", International Journal of Computer Applications (0975 – 8887) Volume 52– No.2, August 2012

[9] Parviz Ahmadi Moghaddam, Mohammadali Haddad Derafshi,"Estimation of single leaf chlorophyll content in sugar beet using machine vision" Turk J Agric For35 (2011) 563-568

[10] Brendon J. Woodford , Nikola K. Kasabov and C. Howard Wearing[1999] "Fruit Image Analysis using Wavelets" , Proceedings of the ICONIP/ANZIIS/ANNES.

[11] Rakesh Kaundal, Amar S Kapoor and Gajendra PS Raghava, "Machine learning techniques in disease forecasting: a case study on rice blast prediction", BMC Bioinformatics. 2006

[12] Carol L. Jones, Niels O. Maness, "Chlorophyll Estimation Using Multi-spectral Reflectance and Height Sensing", ASAE/CSAE Annual International Meeting, 2004.

[13] P.J.Zarco-Tejada, J.R.Miller, "Hyperspectral indices and model simulation for Chlorophyll Estimation in open canopy tree crops", Science direct, 22 Jan 2004.

[14] Zbynek Malenovsky, Christin Ufer, "A new hyperspectral index for chlorophyll estimation of a forest canopy: area under curve normalized to maximal band depth between 650-725 nm", SARsel eProceedings 5, 2006

[15] Jan Eitel and Dan Long, "Predicting Wheat Nitrogen Status with Remote Sensing", 2007.

[16] Anatoly Gitelson and Mark, "Remote sensing of chlorophyll concentration in higher plant leaves", Adv. Space Res. Vol.22 no. 5 pp.689-692, 1998

[17] R. Darvishzadeh, A. Skidmore, "Estimation of leaf area index and chlorophyll for a Mediterranean grassland using htperspectral data" Commission VII, WG VII/3.

[18] Anup Vibhute, S.K.Bodhe and B.M.More, "Nitrogen Estimation for Grapevine (In Veraison) Using RGB Color Image Processing", Research and Reviews: Journal of Botanical Sciences, 26 Dec 2013.

[19] Alley E. Watada, Karl H. Norris, "Estimation of chlorophyll and carotenoid contents of whole tomato by light absorbance technique",JOURNAL OF FOOD SCIENCE- Volume 41 1976.

[20] Shufa Chen and Shiping Zhang, "Quantitative Estimation of Rice Chlorophyll Concentration Based on Hyperspectral Remote Sensing Technology, International Conference on Agricultural and Biosystems Engineering Advances in Biomedical Engineering Vols. 1-2, 2011

[21] Wen-Dar Huang, Kuan-Hung Lin, "Eliminating interference by anthocyanin in chlorophyll estimation of sweet potato (Ipomoea batatas L.) leaves", Botanical Studies 2014.

[22] C. S. T. Daughtry, C. L. Walthall, "Estimating Corn Leaf Chlorophyll Concentration from Leaf and Canopy Reflectance" Elsevier Science, 2000

[23] Anatoly A. Gitelson, Andres Vina,"Remote estimation of canopy chlorophyll content in crops" GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L08403, 2005

[24] Mostafa Ghasemi, Kazem Arzani, "Estimate of Leaf Chlorophyll and Nitrogen Content in Asian Pear (Pyrus serotina Rehd.) by CCM-200" , Notulae Scientia Biologicae, 2011

[25] Jyh-HorngWU, ShengYang Wang, "Extraction and determination of chlorophylls from moso bamboo (Phyllostachys pubescens) culm", J. Bamboo and Rattan, Vol. 1, No. 2, pp. 171–180, 2002

[26] Eko Siswanto, Joji Ishizaka, "Estimating Chlorophyll-a Vertical Profiles from Satellite Data and the Implication for Primary Production in the Kuroshio Front of the East China Sea", Journal of Oceanography, Vol. 61, pp. 575 to 589, 2005

[27] Probir Kumar Pal, Rakesh Devsharan Singh, "Non-destructive estimation of chlorophyll and nitrogen content in leaf of Rosa damascena (Mill)" Soil Science and Plant Nutrition 58, 604—610, 2012

[28] Dos Santos, A.C.A., CalijuriI ,"Comparison of three methods for Chlorophyll determination: Spectrophotometry and Fluorimetry in samples containing pigment mixtures and spectrophotometry in samples with separate pigments through High Performance Liquid Chromatography." Acta Limnol . Bras. , 15(3) :7- 18, 2003

[29] Z.A. Liu, J.P. Yang, "Using a chlorophyll meter to estimate tea leaf chlorophyll and nitrogen contents Journal of Soil Science and Plant Nutrition", 12 (2), 339-348, 2012

[30] Jinheng Zhang, Chao Han, "Absorption spectrum estimating rice chlorophyll concentration: Preliminary investigations", Journal of Plant Breeding and Crop Science Vol. 1(5). pp. 223-229, July, 2009

[31] E. Boegh1, R. Houborg, "Remote sensing of LAI, chlorophyll and leaf nitrogen pools of crop and grasslands in five European landscapes" Biogeosciences, 10, 6279–6307, 2013

[32] C. L. Jones, P. R. Weckler, "Remote Sensing to Estimate Chlorophyll concentration in Spinach using Multispectrl plant reflectance" American Society of Agricultural and Biological Engineers Vol. 50(6): 2267-2273 , 2007

[33] Claudia Marcela Giletto, Cecilia Díaz, “Green Index to estimate crop nitrogen status in potato processing varities”, CHILEAN JOURNAL OF AGRICULTURAL RESEARCH 70(1):142-149, 2010

[34] I.Fillella, L.Serrano,“Evaluating wheat nitrogen status with canopy reflectance and discriminant analysis”, Crop scince 35: 1400-1405, 1995

[35] Aparna Rathor, Yogesh Jasrai, “Evaluating chlorophyll content in selected plants with varying photosynthesis pathways using optiscinece CCM-200”, International journal of recent scientific research, vol. 4, 119-121, 2013

[36] A.K. van den Berg, T.D. Perkins “Evaluation of a portable chlorophyll meter to estimate chlorophyll and nitrogen contents in sugar maple (Acer saccharum Marsh.) leaves” Forest Ecology and Management 200 113–117 2004

[37] Fernando Silla, Ana Gonzalez-Gi, “Estimation of chlorophyll in Quercus leaves using a portable chlorophyll meter: e_ects of species and leaf age” Ann. For. Sci. 67, 2010

[38] Salman Mahiny, Fendereski, “A MODIS sensor estimation of chlorophyll a concentration using ANN model and in-situ measurements in southern Caspian sea” Inadian journal of Geo-marine sciences Vol 42, pp. 924-928, 2013

[39] John Jefon, James, “Growth environment and leaf antomy affect nondestructive estimates of chlorophyll and nitrogen in Citrus sp. Leaves” J.Amer Soc.Hort.Sci. , 152-158, 2005

[40] H. Uchino, T. Watanabe, “Calibrating chlorophyll meter(SPAD-502) reading by specific leaf area for estimating leaf nitrogen concentration in sweet sorghum” Journal of Plant Nutrition, Volume 36, Issue 10, 2013

[41] Andrew D. Richardson, Shane P. Duigan “An evaluation of noninvasive methods to estimate foliar chlorophyll content Phytologis153 : 185–194, 2002

[42] Veronica Ciganda, Anatoly Gitelson, ”Non-destructive determination of maize leaf and canopy chlorophyll content” Journal of plant physiology, 2008

[43] Mark Lalonde, “Using hyperspectral remote sensing to estimate foliar chlorophyll and nitrogen concentrations in an ombrotrophic peatland”

[44] Jindong Wu, Dong Wan, “Comparison of petiole nitrate concentrations, SPAD chlorophyll readings, and QuickBird satellite imagery in detecting nitrogen status of potato canopies” Field Crops Research 101 96–103, 2007

[45] Valentina Ulissi, Francesca Antonucci, “ Nitrogen Concentration Estimation in Tomato Leaves by VIS-NIR Non-Destructive Spectroscopy” Sensors11, 6411-6424, 2011

[46] D.D. Francis and W.P. Piekielek, “Assessing Crop Nitrogen needs with Cholophyll meters” SSMG-2012

[47] Paulo Cezar Rezende Fontes and Charles de Araujo, “Use of a chlorophyll meter and plant visual aspect for nitrogen management in tomato fertigation”Journal of Applied Horticulture, 8(1): 8-11, January-June, 2006

[48] J. Bossua, Ch. Géea, G. Jones, F. Truchetetb, “Wavelet transform to discriminate between crop and weed in perspective agronomic images”, Science Direct- computers and electronics in agriculture 6 5 (2009) 133–143,2009

[49] Abhinav Arora, R. Menaka ”Haar Transform based estimation of chlorophyll and structure of leaf” ICTACT JOURNAL ON IMAGE AND VIDEO PROCESSING, , VOLUME: 03, ISSUE: 04, MAY 2013

[50] Duli Zhao, K. Raja Reddy, “Selection of Optimum Reflectance Ratios for Estimating Leaf Nitrogen and Chlorophyll Concentrations of Field-Grown Cotton” Agron. J. 97:89–98, 2005