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Imaging Technique to Measure Leaf Area, Disease Severity and Chlorophyll Content: A Survey Paper

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***Abstract*-An agricultural production system is the outcome of a complex interaction of seed, water and agro-chemicals including fertilizers and pesticides. Therefore, careful management of all inputs is essential for the sustainability of such complex system. The focus on enhancing the productivity without considering the ecological impacts of the input resources has resulted into environmental degradation. Fertilizers are pesticides are the major contributor of production cost and environmental degradation. Efficient use of that contributor is possible by monitoring leaf area, leaf disease and assessing chlorophyll content. Recent advances in agriculture using image processing tool have resulted in significant improvement in the areas of agriculture by increasing crop production, with good quality, low operating cost and without environmental degradation.**

I. Introduction

India is an agriculture based country, wherein seventy percent of the population depends on agriculture. Diverse nature of India, uncertainty in rainfall, effect of pests, diseases and stress on the crop can cause decrease in crop production. To increase the average yield per acre with minimum cost, an alternative solution is to adapt the 'Hard' Precision Agricultural (PA) concept. This concept uses advanced technologies to maximize the effectiveness of the crop inputs including soil testing, seed selection, disease monitoring, weed controlling, application of fertilizers and pesticides and controlling of Irrigation. The PA uses data from GPS, GIS, and Remotely Sensed Images for monitoring, analyzing and controlling the stress, diseases and other issues [1].

In rural areas it is difficult to access these types of data and in India 91 % farmers are marginal farmers so the cost of these tools is not affordable to those farmers for farm management. In this case the alternative solution is to use the CCD images as a data for crop management.

Image Processing:

Digital Image Processing is nondestructive method that can capture, process and analyze information from images. Using currently available image collection equipments like cameras, computers, scanners and image analysis programs. It is possible to acquire hundreds of quality images per hour, which can be analyzed later with a great degree of automation at the observer's convenience. Other than these, digital images can be stored and used as and when required for a possible future application [2, 3].

Farmers usually are aware that their fields have variable yield across the land space. These variations can be traced by management practices, soil properties and environment characteristics. The factors that affect the yield are input parameters like seed quality, irrigation water, fertilizer and environmental parameters includes weeds, insects and diseases. Finally by testing the maturity of crop it sends to market. In market there is tremendous variation in rate, depends on the quality and quantity of crops available [4].

To provide the better understanding of application of image processing in agricultural, the article presents the recent development of agricultural, specifically; the discussion is focused on wide literature survey of importance of leaf area, leaf disease severity, leaf chlorophyll measurement of the plant.

A.Leaf area measurement:

In overall growth of the plant, leaves are treated as photosynthetic engines of the plant, producing the food that is stored in the stalks. In plant leaves are attached to the nodes and forms two alternative ranks on either side of the stem or branches. Leaf size, length and number depend on variety and generation of the plant and it is different in plant to plant [5].

The leaf area monitoring is an important tool in studying physiological features related to the plant growth, photosynthesis and transpiration process. Also being helpful parameter in evaluating, damage caused by leaf diseases and pastes, to find out micronutrients deficiencies, water and environmental stress, need of fertilization, for effective management and treatment [6].

Leaf area determination can be done by direct methods, which involves the measuring of all the individual leaf areas or indirect methods, which are based on the relation of some plant characteristics with the true leaf area obtained in destructive tests.

Precision agriculture production adapting rapid and accurate methods to measure plant leaf area. Present leaf area measuring methods are grid counting method. In this method leaf is placed on standard grid area and corresponding grids are counted to determine the leaf area. This has simple principals and high accuracy, but time consuming.

In Paper weighing method leaf outline is cut out from graph paper, which is called paper sample weight (W) is weighed in electronic analytical balance. Standard graph paper weight is weighed in electronic analytical balance and it is known (S), so paper weight per unit area is D=G/S then the area formula of paper weighing method is S=G/D, this is also time consuming method.

In Leaf area meter method leaf area, leaf maximum length width is measured, but its final is the average of five measure values. Means repetitions of readings are essential. The plani-meter offers a less time consuming technique, but the precision is limited and high cost. Particularly in sugarcane leaf, size of midrib creates a problem in measuring by all these methods.

In leaf area measurement of coffee plants by using digital image analysis, used two models, one based on the height and width of the canopies and other based on the area of digital image of a tree. Here the images were corrected by frequency histograms and for segmentation thresholding was done by Otsu method the results were compared with real area of the leaves using digital scanner, they found 0.82 and 0.91 correlation [6].

In other non destructive leaf area measurement, used Hough Transformation to acquire the coordinates of quadrangle corner points in distorted image and thresholding was used for image segmentation. To eliminate the effect of holes in the leaf, contour extraction approach was used where pixel scanning from one side to opposite side was implemented in four directions to extract contour and leaf area was measured by pixel number statistic, they found absolute error 2.88 [7].

In leaf area measurement of cucumber using image processing method they used reference object and picture pixel number statistic to calculate the leaf area ,found coefficient of variation of 3.99 [8]. In two new leaf area determination methods using digital photographs processed in Matlab and computer Aided software they found 99% accuracy [9]. The shape of leaf is also important parameter affecting the leaf area measurement and to evaluate environmental stress [10].

In leaf area measurement of sugarcane using digital image processing, the results of the experiments are compared with graphical area measurement method. The calculated accuracy in this experiment is 99 % [11]

B.Leaf disease severity measurement:

Plant disease symptoms can be estimated or measured in various ways that quantify the intensity, prevalence, incidence and severity of disease.

a. Disease intensity is a general term used to describe the amount of disease present in population.

b. Disease prevalence is the proportion of fields, countries, states etc. where the disease is detected and reveals disease at grander scale than incidence.

c. Disease incidence is the proportion or percent of plants diseased out of a total number assessed.

d. Disease severity is the area (relative or absolute) of the sampling unit (leaf or fruit) showing symptoms of disease. It is most often expressed as a percentage or proportion [12].

Generally plants are attacked by a number of diseases. Fungi-caused diseases are the most predominant diseases which appear as spots on the leaves. These spots prevent the vital process of photosynthesis to take place, hence to a large extent affects the growth of the plant and consequently the yield. In case of severe infection, the leaf becomes totally covered with spots. If not treated on time, a whole plantation can become infected; the plant completely withers down and eventually dies resulting in severe loss.

Excessive uses of pesticide for plant diseases treatment increases the danger of toxic residue level on agricultural products and also pesticides are among the highest components in the production cost. The use of pesticides must be minimized by finding severity of disease and target the diseases places, with the appropriate quantity and concentration of pesticide.

The naked eye observation method is generally used to in the production practice but results are subjective and it is not possible to measure the disease extent precisely. Grid counting method can be used to improve the accuracy but this method has cumbersome operation process and time consuming.

Image processing technology in the agricultural research has made significant development. To recognize and classify sugarcane fungi disease an automated system has been implemented using algorithm such as chain code technique, bounding box method and moment analysis [13].To measure severity of Rust disease on Soybean, disease spot have segmented by Sobel operator to find out spot edge and plant disease severity has measured by calculating the quotient of disease spot area and leaf area [14].

Many researchers have been conducted on this. Rust and infected area due to rust on soybean can be find out by using multispectral CCD Camera. Under natural light collect infected plant images and develop three steps, like seperation of the infected leaflets using image processing, lesion color identification and rust severity quantification as shown in Figure 1.[15].

Earlier severity of attack of herbivorous insects on leaves have been calculated using video digitizer for pesticide application [16].Extent of color patches due to micronutrient deficiency or fungal disease on leaves have calculated by color thresholding method [17].

Color image processing used to count the insects on a leaf, image enhancement techniques viz. Red – Green - Blue to hue saturation, intensity conversion, adaptive histogram median filtering, thresholding and morphological operation these operation are used to count the insects on the leaf [18]. These operations are as shown in Figure 2.

Figure 1: Illustration of a Soybean plant infected by Rust pathogen.

In particular disease color as well as shape of leaves also changes that have measured by using HSV color space, Speeded Up Robust Features (SUFR), Scale Invariant and Feature Transformation (SIFT)[5].By choosing color difference due to fungal infection and lookup table it is possible to distinguish the healthy area from diseased one [20].

Disease severity can be measured in three different ways that are Visual Rating, Image Analysis and Hyper spectral Imaging [21].Using multispectral images thresholding operation Ratio of Infected Area (RIA), Lesion Color Index

(LCI) and Severity Index of Soybean rust have been calculated [22].Similarly using reflectance value in the green and NIR regions, same time the SWIR domains, orange rust of sugarcane has detected [23].

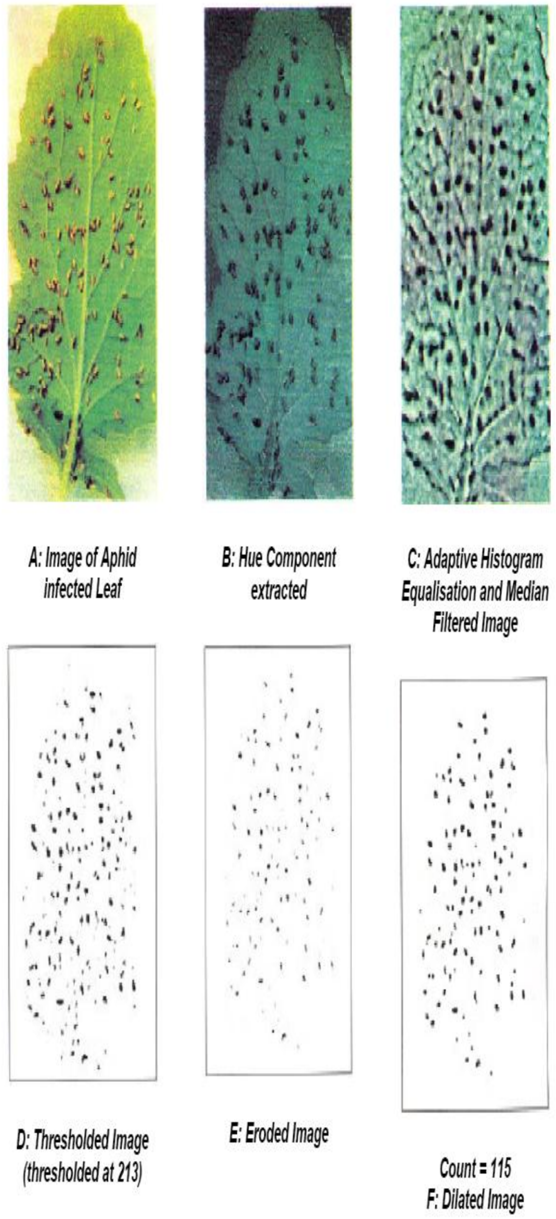

Figure 2: Image processing and analysis for quantification of A: image of aphid-infected

Leaf, B-F: various images processing operation as indicated in the captions done before obtaining the final count.

This spectral reflectance value is also useful to determine chlorophyll index which is helpful for sugarcane infected plots detection monitoring from Satellite imagery [24].Usually observed disease in wheat plant has detected in early stage using spectral reflectance of plant and neural network [25].

C.Chlorophyll measurement:

Plant leaf color is commonly used as an indication of health status of plants. The chlorophyll is a green pigment found in almost all plants, which allows plants obtain energy from light. The loss of chlorophyll content of leaves occurs due to nutrient imbalance, excessive use of pesticide, environmental changes and aging [26, 27].

Various kinds of color plates for comparison and chlorophyll meter, which give an arbitrary value, have been developed to estimate leaf color or chlorophyll content. These tools, which utilize methods that represent various alternatives to the chemical analysis of chlorophyll, are widely used as a basis for fertilizer management [28].

Research has been conducted to estimated chlorophyll content of leaves using a portable color video camera and personal camera. Relation between chlorophyll content and various functions derived from red, green and blue wavelengths are examined. Although red-blue and green-blue wavelengths show the highest correlation with chlorophyll content under limited range of metrological condition, the normalized difference (red-blue)/ (red + blue) is the most applicable function which can be use data collected under different metrological conditions and accuracy is improved by correcting with solar radiation data [27].

In nondestructive method for measurement of chlorophyll precisely and efficiently of grapes leaves, a relation was established between chlorophyll content and the red-edge chlorophyll index, based on reflectance in the red-edge (710-720nm) and near-infrared (755-765nm) spectral ranges and the algorithm for chlorophyll retrieval was calibrated, the calibrated algorithm was capable of accurately predicating grape leaf chlorophyll with RMSE less than 30 mg m^2[29, 30, 31, 32].

Research have been also conducted for estimation of chlorophyll content of leaves using portable digital camera to prove that the RGB color indices of R,G and R+G+B, R-B, R+B, R+G and the lab space parameter L, a and b had the significant relation with chlorophyll content [33].

In a non destructive method of determining chlorophyll content and concentration at the individual plant level in spinach. A multispectral imaging system was used to determine spectral reflectance and to estimate top view surface area. The relation between the reflectance, estimated biomass and laboratory measured chlorophyll content and concentration were investigated. Estimate chlorophyll concentration per unit leaf mass was poor (r2=0.30) [34].

The color image analysis is useful tool to estimate sugar beet leaf chlorophyll status. 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 conventional digital camera. The coefficient of determination (R2) and mean square error (MSE) between the estimated and he measured SPAD values are 0.94 and 0.006 respectively [35].

II.CONCLUSION

Thus going through different research papers it is concluded that image processing play vital role in Precision Agricultural. It helps to farmer from selection of seeds, caring of crops from weed, biotic and Abiotic stresses, insects, detecting nutrient deficiency.

Particularly, monitoring of leaf area and measurement of the chlorophyll content is useful for fertilizer and irrigation rate control. Leaf disease severity measurement is very useful to decide the quantity and concentration of pesticide that reduces the production cost and environmental degradation.

Thus, image processing technique can be effectively implement with high accuracy, low cost and less technical expertise in Precision Agricultural and hence it is worship to farmer**.**

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