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A Review of Approaches for Estimating Micro and Macro Nutrients in Paddy Leaves Using Digital Image Processing.

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ABSTRACT—

The efficient management of nutrient levels in paddy crops is crucial for maximizing agricultural productivity and ensuring food security. Traditional methods of nutrient assessment are often labor-intensive and time-consuming. In this study, we propose a novel approach for estimating micro and macro nutrient levels in paddy leaves through the application of digital image processing techniques. Digital images of paddy leaves are acquired using a high-resolution camera under controlled conditions. The images are then pre-processed to enhance their quality and reduce noise. Subsequently, feature extraction methods are employed to capture relevant information from the images, such as leaf morphology, color, and texture. Machine learning algorithms are trained on a dataset of labeled images to correlate these features with actual nutrient levels obtained through traditional laboratory methods.

Keywords-Nutrients, RGB, leaves, Extraction.

I. INTRODUCTION

In recent years, agriculture has witnessed a paradigm shift towards precision farming, leveraging technological advancements to enhance crop yield and optimize resource utilization. One crucial aspect of this evolution is the accurate assessment of plant nutrient status, particularly in staple crops like paddy (Oryza sativa). Nutrient deficiencies or imbalances can significantly impact crop growth, yield, and overall agricultural productivity.

Traditional methods of nutrient assessment often involve time-consuming laboratory analyses of plant samples, which may not be practical for real-time decision-making in the field. Recognizing the need for efficient and rapid nutrient estimation, this study introduces a novel approach: Estimating Micro and Macro Nutrients in Paddy Leaves Using Digital Image Processing.

Digital image processing offers a non-invasive, cost-effective, and timely means to evaluate the nutritional status of plants. By capturing high-resolution images of paddy leaves, we can extract valuable information related to both micro and macro nutrient levels. This approach aims to revolutionize nutrient assessment in paddy crops, providing farmers and agronomists with a more accessible and immediate tool for decision-making.

Macro Nutrients:

Nitrogen (N):

Use the Kjeldahl method or Dumas method for total nitrogen determination.

Digest the sample, distill the ammonia, and titrate it with a standardized acid or base.

Phosphorus (P):

Extract phosphorus from the leaves using an acid solution (e.g., HCl).

Use colorimetric methods like the molybdenum blue method to measure the concentration of phosphorus.

Potassium (K):

Extract potassium using a dilute acid or ammonium acetate.

Measure potassium concentration using flame photometry or atomic absorption spectroscopy.

Micro Nutrients:

Iron (Fe):

Extract iron using a strong acid (e.g., HCl).

Measure the iron concentration using colorimetric methods or atomic absorption spectroscopy.

Zinc (Zn):

Digest the sample using a strong acid (e.g., HNO3 or HCl).

Measure zinc concentration using methods like atomic absorption spectroscopy.

Copper (Cu):

Digest the sample using a suitable acid.

Measure copper concentration using atomic absorption spectroscopy or colorimetric methods.

Manganese (Mn):

Extract manganese using a dilute acid.

Measure manganese concentration using methods like atomic absorption spectroscopy or colorimetric analysis.

II. LITERATURE SURVEY

Normally, status in crops is measured by several chemical test methods.

A. Chemical Test Method

Kjeldahl method is a commonmethod for estimation of nitrogen content in leaves using chemical substances. This method is the most accurate and also the most time-consuming method. It may take as a week for testing, so this method is not suitable for rapid determination of nitrogen concentration in the leaf.

B. SPAD Meter(Subsystem Positioning Aid Device)

SPAD meter is a chlorophyll measurement device. The meter measures the transmission of 650 nm red lights which chlorophyll absorbs and transmission of 940 nm infrared light which chlorophyll does not absorb. The meter gives the relative value that has no unit but since the nitrogen quantity varies with the quantity of chlorophyll, there are many research studies on converting SPAD values to the nitrogen quantity in plant so the meter can be used to measure the nitrogen quantity in the plant too.

C. Review of literature

Vasudev B. Sunagar et al [1] have proposed image processing technique for estimation of nitrogen content in leaves based on color and texture. The image is acquired using digital camera having high resolution. The camera is located at a position normal to the object. After getting the image, then applied the pre-processing technique to remove the noise of the source image. The color and texture characters of soil are extracted. Color characters analyses using RGB and HSI model. Texture features are analyzed using entropy, energy, contrast and homogeneity. A relationship between extracted features and nitrogen content is developed.

V.K.Tewari et al [2] have proposed image processing technique using Regression Model for estimation of nitrogen content in paddy crop based on color. They have taken various color, features such as R, G, and B normalized “r” and normalized “g”. Regression models were developed and evaluated between various image features; they have observed minimum and average accuracy. Actual and predicted values of nitrogen percent were linearly correlated with R2 value; this showed that the plant nitrogen content can be successfully estimated by its color image feature.

Piti Auearunyawat et al [3] have proposed image processing technique using Regression Model for estimation of nitrogen content in Sugarcane leaf based on 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. Result showed that the terms R, G, B, G/B, G/R, R/B and ((IR-R) / (IR+R)) had the significant relationship with the nitrogen concentration in the sugarcane leaves.

M. M. Ali et al [4] have proposed image processing technique using Dark Green Color Index (DGCI) for estimation of plant chlorophyll and nitrogen contents in tomato leaf based on color. In this paper theyhave developed a diagnostic approach to detect plantCh and N levels using an image processing techniqueusing the RGB (Red, Green and Blue) color model. The experiment was conducted on tomato (Tommy Toy) in the field with three N treatments, where images leaf was collected using a handheld scanner. The proposed algorithm achieves better correlation with the value of Ch and N, measured in laboratory, compared with the existing non-destructive methods of SPAD 502 and Dark green Color Index (DGCI).

III. METHODOLOGY

A. Flow chart of the overall system

Figure 1 shows, input image from source, then applying Pre-processing technique to remove the noise of the input image, various features of color images and to transform color (RGB) images into normalized r, g, and b chromaticity coordinates. The composite color images were decomposed into red spectrum image (R), green spectrum image (G), and blue spectrum image (B) components. Subsequently, the images were also converted into hue, saturation, and intensity (HSI) coordinates to extract the intensity component. In order to extract the color information and to obtain different features, the entire image features were segmented from its background using an automatic segmentation technique based on a modification of Otsu's algorithm. The automatic threshold technique selects a threshold to segment the background from the object. Thus segmented images were used to calculate the mean values of images. Four image features like mean, variance, average energy, and entropy from each normalized 'r' and 'g' segmented image histogram of soil was calculated. Figure 1 shows the flow chart for extracting the color image features.

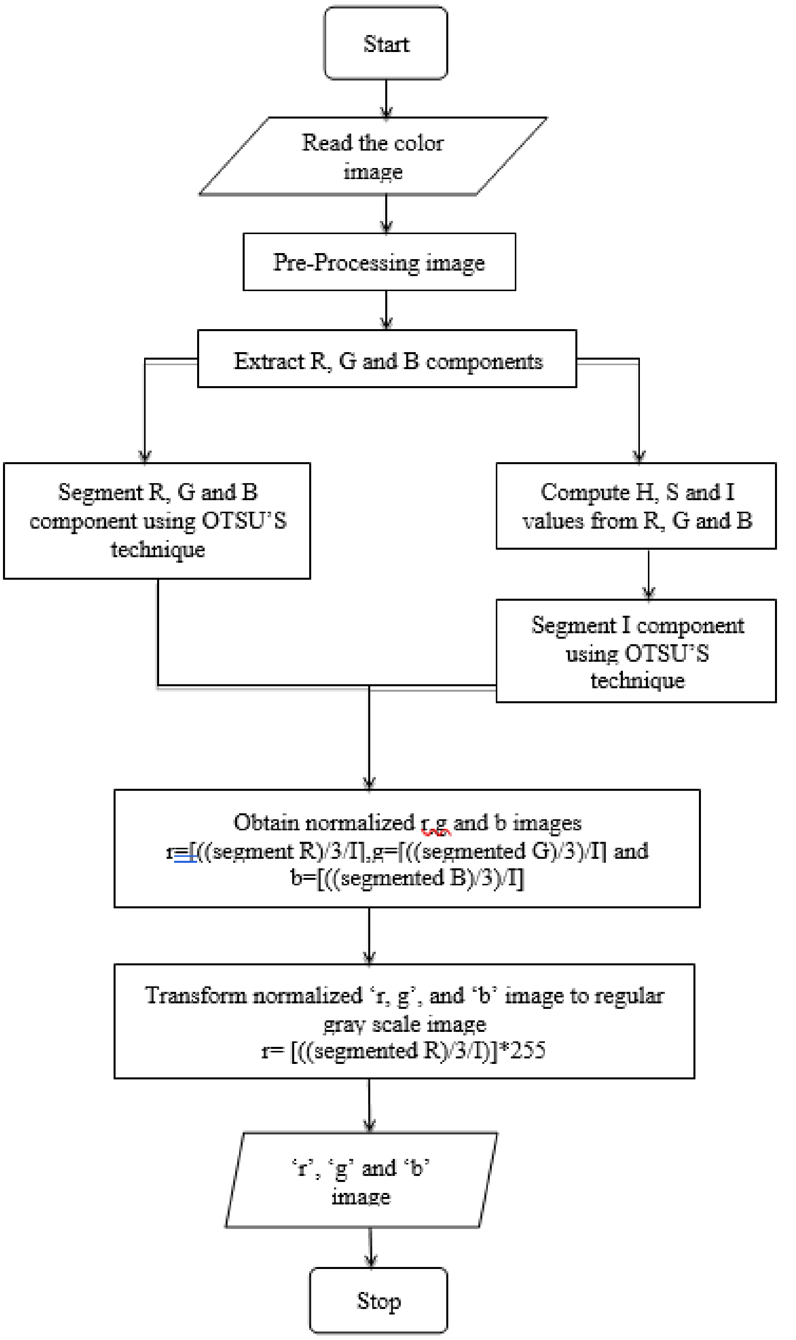

Figure 1 Flow chart of the overall system

B. Texture features

Texture features like Entropy, Mean, Variance and Average energy.

i. Entropy

E = entropy(I) returns E, a scalar value representing the entropy of gray scale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

$$E=\sum_i p * (log2(p)) \quad (1)$$

ii. Mean

The mean is the average of the numbers,

$$\bar{x} = \frac{\sum x}{N} \quad (2)$$

Where:

$\bar{x}$(Sometimes call the x-bar) is the symbol for the mean.

$\sum$ (The Greek letter *sigma*) is the symbol for summation.

x is the symbol for the scores.

N is the symbol for the number of scores.

iii. Variance

The variance measures how far each number in the set is from the mean. Variance is calculated by taking the differences between each number in the set and the mean, squaring the differences (to make them positive) and dividing the sum of the squares of the number of values in the set.

$$S^2 = \frac{\sum_{i=1}^{n}(X_i - X_{avg})^2}{n-1} (3)$$

iv. Average Energy

$$\sum_{i.j} p(i,j)^2 \ (4)$$

Returns the sum of squared elements in the GLCM (Gray Level Co-occurrence Matrix).

Conclusion

This research was basically undertaken to estimate the status of the plant nitrogen content / chlorophyll content in the field condition, so as to avoid the intricacies involved in other method such as chemical analysis. Digital image processing was selected as the tool to estimate plant nitrogen content in field. An experimental setup was developed to fulfill both the requirements in field condition; this was able to produce the constant illumination (artificial) and a uniform background for the image. Various image features such as RGB, normalized ‘r’ and normalized ‘g’ were taken. These features were correlated with SPAD reading, which represent nitrogen / chlorophyll content of plant. R, G and normalized ‘r’ and ‘g’ were found to be the most closely related with SPAD readings, normalized ‘r’ was found to have the highest value of R2. Regression model were developed between various image feature and the plant nitrogen content. When this model was tested, the minimum accuracy was found to be 65% with an average accuracy of 75%, actual and predicted values of nitrogen percent were linearly correlated with R2 value (0.948). These results show that the plant nitrogen content can be successfully estimated using its color image feature

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