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Study of detecting Plant diseases using Non-Destructive Methods: A Review

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Abstract: ***Plant diseases are majorly responsible for losses in production and economy of the agricultural industries worldwide. Monitoring and identifying the diseases in plants in early stages become very important, needs an effective management for caring of plants from the diseases. Traditional way of identifying disease symptoms visually on plant is getting limited. The present review recognized the Non-destructive techniques to identifying various diseases on plants. Non-imaging, and imaging techniques provide rapid way for identify diseases in plants. Use of Vegetation indices for studying plant health which depends on various atmospheric and other intrinsic factors.***

Keywords: Spectroscopic techniques, Imaging techniques, Fieldspec, Vegetation indices, Remote sensing

1. INTRODUCTION

The bacterial, fungal, viral and diseases spread by the insect's damages the plants, causes the reduction in the plant yield. An expert person required for visually identified diseases on plants. Diseases caused by microorganism which cannot be seen through the human eyes. And also some micro level changes happened in the plant due to diseases which is not visible to human eye. That time this traditional method of analyzing plant disease visually failed many times. After observing the symptoms on plant verified disease on plant using disease detection technique.

1.1 Remote Sensing for Plant disease Assessment

For the plant disease assessment use of remote sensing started many decades ago. In the late 1920s, Aerial photography was used in detecting cotton root rot disease [1]. In the early 1980s, Toler, et al., used aerial color infrared photography was used to detect root rot of cotton and wheat stem rust disease [2]. Airborne cameras were used in most of these studies which involved the use of that record the reflected electromagnetic energy on analogue films for covering broad range of spectral bands. The reflectance data was found to be capable of detecting pathogen-induced biophysical changes in the plant leaves and canopy. Since then, however, remote sensing technology has advanced significantly. The modern sensors have superior spectral, spatial and radiometric resolutions, thereby offering enhanced capabilities to detect and map disease symptoms on plants.

1.2 Use of Vegetation Indices for study of plant health

In the field of remote sensing applications, vegetation indices (VI) quantitatively and qualitatively evaluating vegetative covers using spectral measurements. Moreover, the VI is affected by spatial-temporal variations of the atmospheric condition [3].Remote sensing of vegetation is mainly performed by considering the electromagnetic wave reflectance information. It is well known that the reflectance of light spectra from plant changes with change in the plant type, water content within tissues of plant and other intrinsic factors [4].The reflectance of electromagnetic spectrum from the plant is determined by chemical and morphological characteristics of the surface of organs or leaves [5].The following light spectra's considered for vegetation studies: (i) the ultraviolet region (UV), which ranges from 10 to 380 nm; (ii) the visible spectra, which are combined of the blue (450–495 nm), green (495−570 nm), and red (620–750 nm) wavelength regions; and (iii) the near and mid infrared band (850–1700 nm) [6,7].

Vegetation indices used in following applications [8].

- For the crop discrimination
- In Land cover applications
- Use for the identification of canopy species in tropical forest
- For detecting leaf and plant biophysical and biochemical property.
- For detecting plant stress and diseases.

VI also be useful to examine effects of Air pollution on plant leaves content such as chlorophyll content, water content, carotenoid content, anthocyanin content [9]. Biochemical content such as phosphorus, nitrogen, potassium etc. can be identified. These contents are important for metabolic processing which balance plant health [10].
This review paper describes Non-destructive methods for identifying plant diseases.

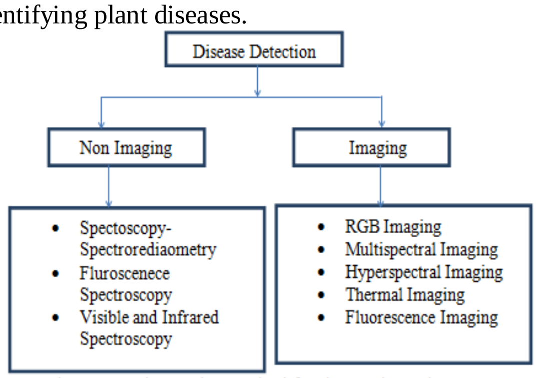

Figure 1 Non- destructive Methods to detect Plant Diseases

2. DISEASE DETECTION TECHNIQUES FOR IDENTIFYING DISEASES ON PLANT

2.1 Molecular Techniques

Now a days the molecular techniques uses like ELISA (enzyme-linked immunosorbent assay), which is based on proteins produced by pathogen. Another method PCR (Polymerase chain reaction) which is based on specific DNA (deoxyribose nucleic acid) sequence of the pathogen [11].
Molecular techniques has some limitations. It is time consuming required a detailed procedure specially during the sample preparation to get the accurate result. The molecular techniques require large number of samples and also time consuming process. The Non-destructive methods can be rapid method than the molecular techniques for identifying diseases on plant.

2.2 Imaging Techniques

By the time that it displays visible symptoms of diseases, a plant can already be adversely affected. Current imaging techniques allow pre-symptomatic (before the appearance of visual symptoms) monitoring of changes in the physiological state of plants nondestructively. Can also detecting disease related changes in the pattern of light emission from plant leaves. These techniques can be applied on scales ranging from microscopic observation to airborne remote sensing. Using these for plant monitoring would allow us to alleviate stress at an early stage, so avoiding irreversible damage and thus substantially reducing yield losses. Several imaging techniques have been used for disease detection of plant like RGB imaging, Multispectral imaging, Hyperspectral imaging etc.

2.3 Spectroscopic Techniques

Spectroscopy is the branch of science concerned with the investigation and measurement of spectra produced when matter interacts with or emits electromagnetic radiation.
The spectroscopy technique can provide information about disease at early stages which control over the spread of plant diseases. For identifying stress levels and nutrient deficiencies in plants this technology is very helpful. In the context of plant disease detection Spectroscopic technology has been successfully applied for identifying plant stress detection by considering water stress and nutrient stress. It also be useful in significant applications such as monitoring the quality of fruits and vegetables. Spectroscopic Techniques includes Fluorescence spectroscopy, Visible infrared spectroscopy etc.

3. LITERATURE REVIEW

Many papers describes detection of the diseases and methods suggesting the implementation ways as illustrated there are some explained here shortly.
Burling et. al. they used fluorescence spectroscopy to identify Leaf rust on wheat. In this study experiment were conducted in controlled environment cabinet four leaf rust susceptible and three leaf rust resistant plants of wheat were observed. Discriminant analysis done between resistant susceptible wheat plants at 3rd day. Leaf rust identified in spectral range 440,500,530 nm [12].
Belasqueet .al. they have used fluorescence spectroscopy technique to detect stress caused by citrus canker and mechanical injury. Samples of citrus leaves collected from field and greenhouse plants. Three ratios are used ration between i) fluorescence intensity 452-735 nm ii) fluorescence intensity 685-785 nm iii) fluorescence intensity 452-685 nm. Fluorescence of citrus leaves was taken and monitored for 60 days under four different conditions: leaves with no stress, leaves with mechanical stress, leaves with disease, and leaves with disease and mechanical stress. The study done by Belasque et. al. results the potential of fluorescence spectroscopy for disease detection and discrimination between the diseased and mechanical stress [13].
Graeff et. al. In this study experiment was conducted for identify changes in leaf spectral reflectance of wheat plants during infection by powdery mildew and take-all disease for the evaluation of leaf reflectance measurements as a tool to quantify and identify disease severity and to discriminate between different wheat diseases. Wheat plants were inoculated under controlled conditions in different intensities with powdery mildew or take-all. Leaf reflectance was measured with a digital imager under controlled light conditions in various wavelength ranges which covers the visible and the near-infrared spectra (380-1300nm). Visual estimates of disease severity were made for each of the infected plants daily from the onset of visible symptoms to maximum disease severity. Reflectance within the ranges of 490-780 nm, 510-780nm and 540-1300 nm shows the strongest relationship with infection levels of both powdery mildew and take-all disease. Among all evaluated spectra's the range of 490-780nm showed most sensitive response to damage caused by powdery mildew and take-all infestation [14].
Yang et.al. they studied brown planthoppers and leaf-folder infestations in rice plants. They used spectroradiometer with reflectance range 350-2400 nm under the field condition for the collection of rice plant data. Plants were ranked on the basis of level of infection. The spectral range 426 to 1450 nm showed the maximum correlation intensity [15, 16].
Huang et.al. have used a portable spectrometer, sample measurements of diseased and healthy leaves were collected from celery leaves in the field. Raw and transformed spectral data both were used in Partial Least Squares regression models development. Disease on celery can predicted using the raw spectra and the first and second derivative data by cross validation results. Diseased on celery leaves find in the spectral range 698-936 nm [17].
Delwiche and Kim's study was undertaken to explore the possibility of detecting scab-damaged wheat by hyperspectral imaging system, possessing a wavelength range of 425 to 860 nm. Group of 32 normal and 32 scab infected wheat were studied. Step discrimination and discriminant analysis was carried out. Disease found at spectra 568,715 nm [18].
E. Bauriegelet. al**.** studied wheat plants were analyzed using a hyper-spectral imaging system under laboratory conditions. Principal component analysis (PCA) was applied to differentiate spectra of diseased and healthy tissues in the wavelength ranges of 500–533 nm, 560–675 nm, 682–733 nm and 927–931 nm, respectively. During the development

stages Head blight could be successfully recognized. However, the best time for disease determination was just after start of flowering. Diseases identified at spectral range 500-533, 560-675 nm [19].

For detecting citrus canker and other damages on the citrus fruits hyperspectral images were obtained by Qin et.al.in the wavelength range 450–930 nm. They used a spectral information divergence (SID)-based classification method increases about 96% classification accuracy for discriminating the diseased, damaged, and healthy fruits. Diseased found at spectra553, 677, 718 and 858nm [20].

Del Fiore et.al. have used hyperspectral imaging-based method to detect toxigenic fungi on maize, and to discriminate between healthy and diseased. A desktop spectral scanner equipped with an imaging based spectrometer ImSpector working in the visible-near infrared spectral range (400–1000 nm) was used. The results show that the hyperspectral imaging based method able to rapidly discriminate maize infected with toxigenic fungi at spectral range 500-700nm [21].

M. Prabhakar et.al. Spectroradiometer Fieldspec 3(spectral range: 350–2500 nm) were used to collect cotton plant data. In this study stress on cotton were identify by observing sensitive bands due to Leaf Hopper and derived hyperspectral indices for this pest. Regression analysis of several ratio indices formulated with two or more sensitive bands and developed new index LHI (Leaf Hopper Index).Effect on Chlorophyll and water content estimated from plant. Broad band comparison of mean reflectance spectra between healthy and leaf hopper infected plants significant decrease in blue (450 to 520 nm), red (630 to 690 nm) regions, while reflectance significantly increased in the NIR region (760 to 900 nm) [22].

M. Prabhakaret. al. have used Spectroradiometer Fieldspec 3(spectral range: 350–2500 nm) to collect cotton plant data. Different levels of mealybug infestation were identified. Mealybug Stress Indices (MSI) were developed using two or three wavelengths, tested using multinomial logistic regression (MLR) and compared with other indices. Reflectance sensitivity identified at spectral range 492, 550, 674, 768 and 1454 due to mealybug damage [23].

Davoud Ashourloo et. al. have used Spectroradiometer (spectral range: 350-2500 nm) to collect wheat data. Along with spectral data RGB image also used for extracting symptoms of leaf rust disease. Extracted symptoms used as input to the Spectral Mixture Analysis (SMA).Then, the spectral reflectance of the different disease symptoms estimated using SMA and least square method. Two spectral disease indices were developed Leaf Rust Disease Severity Index 1(LRDSI_1) and Leaf Rust Disease Severity Index 2(LRDSI_2) [24].

Ranjitha G used Portable spectroradiometer for collecting cotton data on field. They done analysis of damage caused by Thrips tabaci. At the end of study they found the reflectance was decrease in near infrared (770-860 nm) while blue (450-520 nm), green (520-590 nm) and red (620-680 nm) reflectance increased compared to undamaged plants. On the basis of spectral indices and pest damage and a relationship between pest damage Linear regression equations were developed and VIs was established [25].

Ranjitha G used Hyperspectral radiometer to collect cotton plant data damaged by aphids and Aphis Gosypii. NDVI, RVI and GRVI these Vegetation Indices were calculated. From sensitive band analysis and linear correlation intensity analysis results that wavelength of 758 nm (NIR band) and Ratio Vegetative Index were found more sensitive to aphid damage [26].

Daniel Atherton et.al .have used handheld hyperspectral spectoradiometer to collect Potato plant data. Data were taken at two different stages of growth of plant to analyses the early blight disease. The spectra were analyzed using principal component analysis (PCA) and spectral change (ratio) analysis. PCA successfully distinguished more heavily diseased plants from healthy and minimally diseased plants using two principal components. Spectral change analysis found optimal wavelengths 505, 510, 640, 665, 690, 750, and 935 nm which were most sensitive to early blight infection [27].

Mahlein A.K. et. al. they have used handheld hyperspectral spectroradiometer to collect Sugerbeet plant data. Cercospora leaf spot, powdery mildew and rust disease analyzed by studying the spectral signature. Spectral vegetation indices related to physiological parameters were calculated and correlated to the severity of diseases. The spectral vegetation indices Normalised Difference Vegetation Index (NDVI), modified Chlorophyll Absorption Integral (mCAI) and Anthocyanin Reflectance Index (ARI) differed in their ability to assess the different diseases before first symptoms became visible or even at early stage of disease development [28,29].

Sreekala G. Bajwaet. al. they have used Spectrometer to collect soybean plant data. Soybean cyst nematode (SCN) and sudden death syndrome (SDS) these two common diseases on soybean. Disease conditions were created with introducing four disease treatments as - control (no disease), SCN, SDS, and SCN+SDS. The correlation shows between disease rating and selected vegetation indices (VI) were evaluated. Bands of wavelength with the most disease discrimination capability were identified with stepwise linear discriminant analysis (LDA), logistic discriminant analysis (LgDA) and linear correlation analysis of pooled data [30].

Table 1: Summary of Literature Review

Plant	Disease	Statistical Method	Spectral Range	Reference
Spectroradiometry				
Cotton	Leafhopper	Regression Analysis	376, 496, 691, 761, 1124and 1457 nm	[22]
Cotton	Solenopsismealybug	Linear discriminate analysis (LDA) and multivariate logistic regression (MLR)	492, 550, 674, 768 and 1454 nm	[23]
Wheat	Leaf Rust	SMA and Least Squares Method.	605, 695 and 455nm	[24]
Cotton	Thripstabaci	Regression Analysis	496,691 and 710 nm	[25]
Cotton	Ahid, Aphis Gosypii	Regression Analysis	758nm	[26]
Potato	Early Blight	PCA	505, 510, 640, 665, 690, 750, and 935 nm	[27]
Sugar Beet	Cercospora leaf spot, powdery mildew and rust	Analysis of variance, correlation and regression Analysis	500-700,400-530, 500-670 nm	[28,29]
Soybean	Soybean cyst nematode and sudden death syndrome	Discriminant Analysis	694 nm, 688 nm	[30]

Fluorescence Spectroscopy				
Wheat	Leaf rust	Discriminant analysis	440,500, 530 nm	[12]
Citrus	Citrus canker	Discriminant analysis	452, 685 and 735nm	[13]
Visible and Infrared Spectroscopy				
Wheat	Powdery mildew and take-all disease	Analysis of variance, correlation and regression analysis	490-780,510-780 and 540-1300 nm	[14]
Rice	Brown planthopper and leaffolder infestation	Linear regression	426 nm	[15,16]
Imaging techniques				
Celery	Sclerotinia rot	PLS regression Analysis	698-936 nm	[17]
Wheat	Scab	Discriminant analysis	568, 715 nm	[18]
Wheat	Fusarium infection	PCA	500-533, 560 -675 nm	[19]
Citrus	Citrus Canker	SID	553, 677,718 and 858 nm	[20]
Maize	Toxigenic Fungi	PCA	500-700 nm	[21]

4. CONCLUSION

This study summarizes some of the noninvasive techniques that have been used for plant disease detection. In remote sensing Vegetation Indices plays important role for determining health of plant. In spectroscopic method electromagnetic spectrum has to be considered. Reflectance curve is studied i.e. spectral signature. It is well known that the reflectance of light spectra from plant changes with change in the plant type, water content within tissues of plant and other intrinsic factors. Found that spectroscopic techniques are best nondestructive method for analyzing plant diseases and various plant characteristics than the traditional approach.

5. ACKNOWLEDGEMENT

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References

[1] Taubenhaus, J.J., Ezekiel, W.N., and Neblette, C.B. (1929). “Airplane photography in the study of cotton root rot”. Phytopathology, Vol. 19, pp.1025-1029.

[2] Toler, R.W., Smith, B. D., and Harlan, J.C. (1981) “Use of aerial color infrared photography in the study of cotton root rot”. Plant Disease, Vol. 65, no.1, pp.24-31

[3] A. Bannari, D. Morin ,F.Bonn , A,R. Huete.1995.A Review of Vegetation Indices. Remote Sensing Reviews, 1995, Vol. 13, pp. 95-120.

[4] L. Chang, S. Peng-Sen, and Liu Shi-Rong, “A review of plant spectral reflectance response to water physiological changes,” Chinese Journal of Plant Ecology, vol. 40, no. 1, pp. 80–91, 2016.

[5] C. Zhang and J. M. Kovacs, “The application of small unmanned aerial systems for precision agriculture: a review,” Precision Agriculture, vol. 13, no. 6, pp. 693–712, 2012.

[6] H. R. Bin Abdul Rahim, M. Q. Bin Lokman, S. W. Harun et al., “Applied light-side coupling with optimized spiral-patterned zinc oxide nanorod coatings for multiple optical channel alcohol vapor sensing,” Journal of Nanophotonics, vol. 10, no. 3, Article ID 036009, 2016.

[7] B. A. Cruden, D. Prabhu, and R. Martinez, “Absolute radiation measurement in venus and mars entry conditions,” Journal of Spacecraft and Rockets, vol. 49, no. 6, pp. 1069–1079, 2012.

[8] Pooja Vinod Janse and Ratnadeep R. Deshmukh , ”Hyperspectral Remote Sensing for Agriculture: A Review,” International Journal of Computer Applications (0975 –8887) Volume 172 –No.7, August 2017.

[9] Archana R. Mate, Dr. Ratnadeep R. Deshmukh, ”Analysis of Effects of Air Pollution on Chlorophyll, Water, Carotenoid and Anthocyanin Content of Tree Leaves Using Spectral Indices”, ISSN 2321 3361 © 2016 IJESC Volume 6 Issue No. 5, May 2016.

[10] Sushma D Guthe and Dr. Ratnadeep R Deshmukh , ”Prediction of Phosphorus Content in Different Plants: Comparison of PLSR and SVMR Methods” International Journal of Computer Applications Technology and Research,Volume 6–Issue 8, 410-416, 2017.

[11] Ruiz-Ruiz, S., Ambrós, S., Carmen Vives, M., Navarro, L., Moreno, P., Guerri, J., 2009.Detection and quantification of Citrus leaf blotch virus by TaqMan real-time RT-PCR. Journal of Virological Methods 160 (1–2), 57–62.

[12] Burling ,K. Hunsche, M., and Noga, G.2011. “Use of blue-green and chlorophyll fluoroscence measurements for differentiation between nitrogen dificiency and pathogen infection in wheat”. J. plant Physiol. 168:1641-1648.

[13] Belasque, L., Gasparoto, M.C.G., Marcassa, L.G., 2008. “Detection of mechanical and disease stresses in citrus plants by fluorescence spectroscopy”. Applied Optics 47(11), 1922–1926.

[14] Graeff, S., Link, J., Claupein, W., 2006. “Identification of powdery mildew (Erysiphegraminis sp. tritici) and take-all disease (Gaeumannomycesgraminis sp. tritici) in wheat (Triticumaestivum L.)by means of leaf reflectance measurements”. Central European Journal of Biology 1, 275–288.

[15] Yang, C.M., Cheng, C.H., 2001. “Spectral characteristics of rice plants infested by brown planthoppers”. Proceedings of the National Science Council, Republic of China.Part B, Life Sciences 25 (3), 180–186.

[16] Yang, C.M., Cheng, C.H., Chen, R.K., 2007. Changes in spectral characteristics of rice canopy infested with brown planthopper and leaffolder. Crop Science 47,329–335

[17] Huang, J.F., Apan, A., 2006. “Detection of Sclerotiniarot disease on celery using hyperspectral data and partial least squares regression”. Journal of Spatial Science 51(2), 129–142.

[18] Delwiche, S.R., Kim,M.S., 2000. "Hyperspectral imaging for detection of scab in wheat".Proceedings of SPIE 4203, 13–20
[19] Bauriegel, E., Giebel, A., Geyer, M., Schmidt, U., & Herppich, W. B. (2011). "Early detection of Fusarium infection in wheat using hyper-spectral imaging". Computers and Electronics in Agriculture, 75, 304–312.
[20] Qin, J., Burks, T.F., Kim, M.S., Chao, K., Ritenour, M.A., 2008. "Citrus canker detection using hyperspectral reflectance imaging and PCA-based image classification method". Sensing and Instrumentation for Food Quality and Safety 2, 168–177.
[21] Del Fiore, A., Reverberi, M., Ricelli, A., Pinzari, F., Serranti, S., Fabbri, A. A., et al. (2010)."Early detection of toxigenic fungi on maize by hyperspectral imaging analysis". International Journal of Food Microbiology, 144(1), 64–71.
[22] M. Prabhakar , Y.G. Prasad, M. Thirupathi, G. Sreedevi, B. Dharajothi, B. Venkateswarlu .,2011. Use of ground based hyperspectral remote sensing for detection of stress in cotton caused by leafhopper (Hemiptera: Cicadellidae). Computers and Electronics in Agriculture 79 (2011) 189–198.
[23] Mathyam Prabhakar , Yenumula G. Prasad, Sengottaiyan Vennila, Merugu Thirupathi ,Gudapati Sreedevi, G.Ramachandra Rao, Bandi Venkateswarlu .,2013. Hyperspectral indices for assessing damage by the solenopsismealybug (Hemiptera: Pseudococcidae) Pseudococcidae) in cotton. Computers and Electronics in Agriculture 97 (2013) 61–70.
[24] Davoud Ashourloo, Mohammad Reza Mobasheri ,Alfredo Huete., Developing Two Spectral Disease Indices for Detection of Wheat Leaf Rust., 2014. (*Pucciniatriticina*)., *Remote Sens.*2014, *6*, 4723-4740.
[25] Ranjitha G, MR Srinivasan and Abburi Rajesh.,2014. Detection and Estimation of Damage Caused By Thrips *Thripstabaci*(Lind) of Cotton Using Hyperspectral Radiometer. Agrotechnol 2014, 3:1.
[26] Ranjitha G.,Srinivasan M.R ,Abburi Rajesh.,Detection and estimation of damage caused by aphid, aphis gossypii (glover) in cotton using hyperspectral radiometry.,2014.International Journal of Recent Scientific Research Vol.5, Issue, 4,PP..750-753, April, 2014.
[27] Daniel Atherton, Ruplal Choudhary, Dennis Watson.,2017. Advanced detection of early blight (Alternariasolani) disease in potato (Solanumtuberosum) plants prior to visual disease symptomonology.,2017. International Journal of Agriculture and Environmental Research Volume:03, Issue:03 "May-June 2017"
[28] Mahlein, A.K., Steiner, U., Dehne, H.W., Oerke, E.-C., 2010. "Spectral signatures of sugar beet leaves for the detection and differentiation of diseases". Precision Agriculture 11 (4), 413–431.
[29] T. Rumpf , A.K. Mahlein , U. Steiner , E.C. Oerke , H.W. Dehne , L. Plumer.(2010)."Early detection and classification of plant diseases with Support Vector Machines based on hyperspectral reflectance". Computers and Electronics in Agriculture 74 (2010) 91–99
[30] Sreekala G. Bajwa, John C.Rupe ,JohnnyMason. (2017). "Soyabean Disease Monitoring with Leaf Reflectance",Remote Sensing. 2017, *9*(2), 127.

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