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Remote Sensing: A Promising Prospect in Plant Pathology

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SUMMARY

Plant diseases and pests pose a huge threat to agriculture and forestry around the world. Plant protection might be considerably aided by the deployment of non-contact, highly efficient, and cost-effective systems for detecting and monitoring plant diseases and pests over large areas. Different types of remote sensing (RS) systems have been introduced in this regard for identifying and monitoring plant diseases and pests in a variety of ways. This article discusses the various sensing systems used in disease-pest diagnosis of infected plants, including visible and near-infrared spectral sensors (VIS-NIR), fluorescence and thermal sensors, synthetic aperture radar (SAR), and light detection and ranging (Lidar), as well as different challenges of remote sensing applications.

INTRODUCTION

Remote sensing is the acquisition of information about an object or area by a recording device which is not in direct contact with the object under study. Basically, it is a process of observing and detecting the different characteristics of an area/object by measuring its reflected and emitted radiation at a distance using satellite or aircraft. In this method of remote sensing we use thermography, fluorescence imaging and spectral techniques that allows us to monitor almost all plants or entire field area repeatedly in no time. It helps to minimize the number of fungicides to be sprayed by applying it only where it is needed, so that we can reduce hazardous environmental effects as well as resistance development in the pathogen. Plant disease and pest remote sensing can be thought of as a type of "radio-diagnosis" for plants, allowing for noncontact and spatially constant monitoring of diseases and pests. The first studies and applications in this area can be found in the 1980s. Riley (1989) stated that it is possible to identify damaged areas due to plant diseases and pests by visual interpretation of aerial or satellite photos. Studies on sensing systems, feature extraction, and algorithms have been conducted at numerous scales during the previous few decades, indicating new potential in remotely monitoring plant diseases and pests.

Different Principles Involved For Monitoring Plant Diseases:

Different plant diseases and pests cause a variety of symptoms and damages when observed in pathogen and host interactions, which form the physical basis for their remotely sensed monitoring. As a result, the presence of a specific response that can be detected by a specific sensor or sensor system is a key prerequisite in identifying and monitoring plant diseases and pests via remote sensing. Different types of disease symptoms associated with remote sensing are-

Lesions or pustules due to infection:

The most common signs are lesions or pustules, which are sori or necrotic tissues caused by infections of the pathogen. The colour and shape of lesions and pustules differ between diseases and pests. It's worth noting that the distribution and abundance of these lesions and pustules in the canopy can have a big impact on their detectability (Cao *et al.*, 2013).

Destruction of pigment systems:

In many circumstances, disease infection or insect attack can destroy chloroplasts or other organelles, resulting in pigment content variations (e.g., chlorophyll, carotene, and anthocyanin). To detect this type of response, hyperspectral RS measurements are usually necessary(Grisham *et al.*, 2010)

Wilting:

Dehydration-induced rigidity loss is a rare indication of plant diseases and pests, and it's readily confused with drought stress. Plant wilting is caused by the piercing and sucking activities of various pests (such as beetles or aphids). Furthermore, in some cases of severe infection, the damaged vascular system will limit water flow in plants, resulting in dehydration of the entire plant (Calderón*et al.*, 2013).

Remote Sensing Systems Available For Monitoring Plant Diseases and Pests:

There are a range of RS systems available that can be used to identify and monitor plant diseases and pests. These RS devices can collect data from gamma rays to microwaves and work with both passive and active radiation. Some of these systems are:

VIS-NIR Systems:

Multiple RS platforms (i.e., ground-based, aerial-based, and satellite-based platforms) have Visible and Near-infrared spectral sensors (VIS-NIR) sensors, which are potentially ideal for monitoring plant diseases and pests. Various signs and physiological changes of diseases and pests (e.g., pigment degradation, cellular damage, scab, etc.) display unique reactions in spectrum reflectance in the VIS-NIR spectral domain (Mahlein*et al*., 2013). The hyperspectral sensor's high spectral resolution allows it to capture some weak or inconspicuous spectral changes, which is critical for early detection and monitoring of plant diseases and pests in complex circumstances (Thomas *et al*., 2018).

Fluorescence and thermal systems:

Plant respiration and photosynthetic processes can be tracked using thermal infrared and fluorescence RS systems, allowing for pre-symptomatic surveillance of plant diseases and pests. Laser-induced fluorescence (LIF) is the most promising technology for obtaining plant fluorescence responses. Römer*et al*. (2011) used fluorescence spectra over 370–800 nm to identify wheat leaf rust and found that the pre-symptomatic disease diagnosis was 93% accurate. Falkenberg*et al*. (2007) successfully differentiated biotic (root rot) and abiotic (drought) stress in cotton using thermal imaging.

SAR and Lidar systems:

Plant traits and their habitats may be plotted using Synthetic Aperture Radar(SAR) and Light detection and ranging (Lidar), which could be useful in disease and pest monitoring. SAR has been used to retrieve plant water content, soil properties, and some structural aspects of the plant canopy since the emergence of high resolution imaging (Pichierri*et al*., 2018). These findings may be useful in identifying the habitat characteristics of plant diseases and pests. The Lidar system has the ability to collect precise canopy morphology data. The three dimensional canopy structure may be reconstructed using point cloud data obtained by Lidar sensors, which can reveal damages or biomass loss due to diseases or pests. For example, *Sclerotinia* blight of peanut, causes alternation of plants' canopy morphology significantly and could be potentially detected by Lidar sensors (Butzler*et al*., 1998).

Challenges in Application of Remote Sensing:

Improved detection of disease at an early stage – To attain this goal, more research on the practicality of fluorescence, thermal, and hyperspectral imaging, as well as fusing them with unmanned aerial vehicles (UAVs), such as drones and satellite photography, is needed.

Accurate detection of specific disease under realistic field conditions – Currently, the majority of monitoring investigations are carried out in controlled laboratory settings with prior knowledge of diseases and other stressors. It is difficult to obtain trustworthy and accurate monitoring data without this preceding information. Deep learning algorithms can be used to solve this challenge by establishing a data base regarding the history and characteristics of that specific disease under different conditions.

Continuous track of the dynamics of the disease at close range – Bad weather and uneven topography are the biggest roadblocks to collecting data at every stage of the disease's progression. To solve this, a remote sensing system must be combined with high-resolution satellite photos gathered with the help of a UAV.

Data and information sharing – Since plant disease epidemics are global phenomena, multinational collaboration is critical for study and application in order to share experimental data and ideas for global research.

CONCLUSIONS

Monitoring plant diseases and pests across large regions in a reliable, fast, and efficient manner is critical for plant protection evaluation and management. Various RS techniques for monitoring plant diseases and pests have been established during the last few decades, and have shown considerable promise in augmenting traditional laborious inspection. Thus extensive research is required in this area that can provoke new thoughts and promote the development of efficient techniques that can be used in future for successful diagnosis of plant diseases.

REFERENCES

Butzler, T. M., Bailey, J., &Beute, M. K. (1998). Integrated management of Sclerotinia blight in peanut: utilizing canopy morphology, mechanical pruning, and fungicide timing. *Plant Disease*, *82*(12), 1312-1318.

Calderón, R., Navas-Cortés, J. A., Lucena, C., &Zarco-Tejada, P. J. (2013). High-resolution airborne hyperspectral and thermal imagery for early detection of Verticillium wilt of olive using fluorescence, temperature and narrow-band spectral indices. *Remote Sensing of Environment*, *139*, 231-245.

Cao, X., Luo, Y., Zhou, Y., Duan, X., & Cheng, D. (2013). Detection of powdery mildew in two winter wheat cultivars using canopy hyperspectral reflectance. *Crop Protection*, *45*, 124-131.

Falkenberg, N. R., Piccinni, G., Cothren, J. T., Leskovar, D. I., & Rush, C. M. (2007). Remote sensing of biotic and abiotic stress for irrigation management of cotton. *Agricultural water management*, *87*(1), 23-31.

Grisham, M. P., Johnson, R. M., & Zimba, P. V. (2010). Detecting Sugarcane yellow leaf virus infection in asymptomatic leaves with hyperspectral remote sensing and associated leaf pigment changes. *Journal of virological methods*, *167*(2), 140-145.

Mahlein, A. K., Rumpf, T., Welke, P., Dehne, H. W., Plümer, L., Steiner, U., &Oerke, E. C. (2013). Development of spectral indices for detecting and identifying plant diseases. *Remote Sensing of Environment*, *128*, 21-30.

Pichierri, M., Hajnsek, I., Zwieback, S., &Rabus, B. (2018). On the potential of Polarimetric SAR Interferometry to characterize the biomass, moisture and structure of agricultural crops at L-, C-and X-Bands. *Remote Sensing of Environment*, *204*, 596-616.

Riley, J. R. (1989). Remote sensing in entomology. *Annual review of entomology*, *34*(1), 247-271.

Römer, C., Bürling, K., Hunsche, M., Rumpf, T., Noga, G., &Plümer, L. (2011). Robust fitting of fluorescence spectra for pre-symptomatic wheat leaf rust detection with support vector machines. *Computers and Electronics in Agriculture*, *79*(2), 180-188.

Thomas, S., Kuska, M. T., Bohnenkamp, D., Brugger, A., Alisaac, E., Wahabzada, M., ... &Mahlein, A. K. (2018). Benefits of hyperspectral imaging for plant disease detection and plant protection: a technical perspective. *Journal of Plant Diseases and Protection*, *125*(1), 5-20.