Vol.2 Issue-7, MAR 2022 (e-ISSN: 2582-8223)

Remote Sensing: A Tool of Plant Disease Management

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ARTICLE ID: 031

Introduction

Remote sensing is a quick and efficient technique which can obtain and analyze spectral properties of earth surfaces from different distances, ranging from satellites various platforms. This modern technology can prove to be a boon for crop production including crop protection. Variability in the reflectance spectra of disease affected compared to healthy plant, allows their identification using remote sensing data. Using various specific parameters of sensors like spatial, spectral, radiometric and temporal resolution and imaging techniques like visible, infrared, multispectral, hyperspectral imaging and thermal sensors etc. have been studied for the detection of plant diseases. Several of these techniques have great potential in phytopathometry. Remote sensing technologies will be extremely helpful to greatly specialize diagnostic results and thereby rendering agriculture more sustainable and safe, avoiding expensive use of pesticides in crop protection.

What is remote sensing?

- It simply referred collection of information an object without coming into physical contact**.**
- Remote sensing is defined as the technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the object of investigation.
- The output of a remote sensing system is usually an image representing the scene being observed.

History of Remote Sensing

- ✓ The technology of modern remote sensing began with the invention of the camera more than 150 years ago.

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- ✓ The idea and practice of looking down at the Earths surface emerged in the 1840s when pictures were taken from cameras bind with balloon for purpose of topographic mapping.
- ✓ Aerial photography is the original form of remote sensing (using visible spectrum) started in 1909.
- ✓ Colour infrared photography began 1931, and then was widely used in agriculture and forestry.
- ✓ The terms "Remote Sensing" first used in the United State in the 1950s by Ms. Evelyn Pruitt.
- ✓ Satellite remote sensing can be traced to the early days of the space age (both Russian and American programs) and actually began as a dual approach to imaging surfaces using several types of sensors from spacecraft.
- ✓ After the first man-made satellite (Sputnik 1) was launched on 4 October 1957 by Soviet
- ✓ Colwell (1956) first used remote sensing technique for monitoring stem rust of wheat.

Type of remote sensing

1. **Active remote sensing: -** The use of sensors that deduct reflected responses from object that are irradiated from artificially generated energy sources such as Radar.
2. **Passive remote sensing: -** The use of sensors that deduct the reflected or emitted electromagnetic radiation from natural sources.

Objectives of remote sensing in plant pathology

1. Assessment of disease over a vast area
2. To know the relationship of diseases and environment
3. For detection, identification, of plant disease
4. Management of plant disease
5. Miscellaneous

Assessment of disease over a vast area

Remote sensing technology can provide spatial distribution information of diseases and pests over a large area with relatively low cost. The presence of diseases on canopy surface causes changes in pigment, chemical concentrations, cell structure, nutrient, water uptake, and gas exchange. These changes result in differences in color and temperature of the canopy,

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and affect canopy reflectance characteristics, which can be detectable by remote sensing (Raikes and Burpee 1998). Colwell (1956) first used remote sensing technique for monitoring stem rust of wheat.

To know the relationship of diseases and environment

- **Indian stem rust rules** - The spread and deposition of stem rust pathogen of wheat is influenced by definite synoptic weather conditions.
- **Late blight of potato** - e.g. Dutch rules in potato – Everdingen **,** The sensing of the pathogen and environmental conditions is a very promising tool to support decision-making regarding fungicide use.
- **Sensing of Host–Pathogen Interactions**:- Host–pathogen relationships may be investigated using spatial resolution for metabolic changes. Temporal resolution use for understanding host pathogen interactions.

  High spatial resolution of imaging sensors enables time-series measurements of host–pathogen interactions at the tissue scale. These images may be used to visualize and quantify pathogen effects on host metabolism with high spatial resolution, contributing to the understanding of tolerance mechanisms in host genotypes.
- **Thermal sensors:-** Infrared Thermography (IRT) assesses plant temperature and is correlated with plant water status, the microclimate in crop stands and with changes in transpiration due to early infections by plant pathogens.

For Detection, Identification, of Plant Disease

Remote sensing includes the sensor-based methods for the detection, identification of plant diseases. Sensors are expected to be objective, accurate, precise, rapid, and available 24 hours a day, 7 days a week (24/7). Systematic observation of a crop by technical sensors can allow the operator to intervene when infections are detectable or exceed action threshold levels. Its helps in quantifying the severity of the disease.

For management of plant disease

- The decision whether or not to apply a fungicide to control a sensitive pathogen depends on not only the presence of a symptom but also whether the disease severity exceeds the action threshold level calculated from economic considerations
- In Monocyclic pathogens do not need control at the time of the first appearance of symptoms, as the damage is already done (e.g., smut fungi). In contrast, the frequency

of first disease symptoms caused by polycyclic pathogens is often low and the expected increase in disease severity from the next generations of the pathogen may be controlled to prevent disease severity from exceeding the economic threshold level, provided effective fungicides are available.

Miscellaneous uses

- In the food industry, postharvest sensing of the quality and checking ripeness, colour, and suitability for storage.
- Sensors of plant diseases may be used in quality control (e.g., by the food industry or quarantine authorities) once, or they may be integrated into autonomous systems for the continuous monitoring of crops for plant diseases, i.e., checking and keeping a continuous record of the crop health status.

Case studies of remote sensing in plant disease management

- ✓ Nilsson *et al*. observed that the flag leaves of oats infected by barley yellow dwarf virus were 3-4°C warmer than visually healthy leaves.
- ✓ Smith *et al*. reported that stripe rust on wheat initially reduced stomata closure and disrupted the cuticle.
- ✓ Colwell (1956) demonstrated the potential of aerial photography using panchromatic and infrared films to detect and quantify crop diseases such as cereal rusts and virus diseases of citrus.
- ✓ Southern corn blight watch project in the USA (*Helminthosporium maydis*) demonstrated the efficacy of large-scale application of aerial IR-photography to crop disease surveillance.
- ✓ Evapo - transpiration from the leaves increased and the infected leaves were 0.2-1.0 °C cooler than the controls during early disease development.
- ✓ Clark *et al.* (68) used aerial IR-photography to estimate damage by diseases such as spot blotch of barley, crown rust and barley yellow dwarf virus of oats (BYDV), and powdery mildew of wheat in field plot experiments.
- ✓ In the early 1930s infrared plate-films were used in studies of virus diseases of potatoes and tobacco (Bawden).
- ✓ Blazquez & Edwards used IR-color photography and spectral reflectance for studies of tomato and potato diseases.

Examples of studies on plant diseases detection by different optical sensors (Mahlein, 2016)

Sensor	Crop	Disease/Pathogen	Reference
RGB	Cotton	Bacterial angular (*Xanthomonas campestris*)	Camargo and Smith (2009)
		Ascochyta blight (*Ascochyta gossypii*)	
	Sugar beet	Cercospora leaf spot (*Cercospora beticola*),	Neumann *et al.* (2014)
		Sugarbeet rust (*Uromyces betae*)	
	Grapefruit	Citrus canker (*X. axonopodis*)	Bock *et al.* (2008)
	Tobacco	Anthracnose (*Colletotrichum destructivum*)	Wijekoon *et al.* (2008)
Spectral sensors	Barley	Net blotch (*Pyrenophora teres*),	Kuska *et al.* (2015)
		Brown rust (*Puccinia hordei*),	
	Wheat	Head blight (*Fusarium graminearum*),	Bravo *et al.* (2003), Moshou *et al.* (2004)
		Yellow rust (*Puccinia striiformis* f. sp. *tritici*)	
	Sugarbeet	Cercospora leaf spot (*C. beticola*),	Mahlein *et al.* (2010, 2012) Bergstrasse *et al.* (2015)
		Sugarbeet rust (*U. betae*)	
	Tomato	Late blight (*Phytophthora infestans*)	Wang *et al.* (2008)
Thermal sensors	Sugarbeet	Cercospora leaf spot (*C. beticola*)	Chaerle *et al.* (2004)
	Cucumber	Downy mildew (*Pseudoperonospora cubensis*)	Oerke *et al.* (2006), Berdugo *et al.* (2014)
Fluorescence imaging	Wheat	Leaf rust (*Puccinia triticina*),	Burling *et al.* (2011)
		Powdery mildew (*Blumeria graminis* f.sp. *tritici*)	
	Sugarbeet	Cercospora leaf spot (*C. beticola*)	Chaerle *et al.* (2007); Konanz *et al.* (2014)

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