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Remote Sensing Technology in Entomology

Burjikindi Madhuri[1*], Kolli Bharghavi[1], Koosari Supriya[2], Satwika Maharaj[3], Gummudala Yashaswini[4] and Sravanthi Erla[5]

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Corresponding Author
Burjikindi Madhuri
e-mail: madhuriburjikindi2016@gmail.com

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Abstract

Remote sensing is a technology that is used to collect information and examine an object, place, or phenomenon without making any physical contact with it. The spectral behavior of features on the earth is essential in the applications involving remote sensing. These days, it's a useful tool for managing plant diseases and insect pests on various crops and fruit orchards through forecasting, detection, and control. The primary goals of this use was to reduce the amount of chemical pesticide pollution in the environment and to gather data that aids in decision-making for insect pest management. For controlling insect pests and weed detection, aerial remote sensing has proven to be a helpful and promising technique. In order to minimize pest damage and management expenses, remote sensing can offer quick and precise forecasts of specific insect pests.

1. Introduction

Remote sensing is the science of deriving information about an object or phenomena through analysis of data acquired by a device that is not in contact with the object or phenomena under investigation. Remote sensing is the examination or the gathering of information about a place from a distance. Such examination can occur with devices (e.g., cameras) based on the ground, and/or sensors or cameras based on ships, aircraft, satellites or other spacecraft.

The visual detection of plant responses to biotic stresses with acceptable levels of accuracy, precision and speed is difficult. These responses affect the amount and quality of electromagnetic radiation reflected from crop canopies. Hence, remote sensing is the technique involving instruments that measure and record the changes in electromagnetic radiation and provides better means of objectively quantifying biotic stresses in comparison to visual assessment methods besides repeated used to collect sample measurements

Author's Address

[1]Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad, Karnataka, (580 005), India
[2]Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (444 104), India
[3]Acharya N.G Ranga Agricultural university, Andhra Pradesh (522 034), India
[4]Dr. Rajendra Prasad Central Agricultural University, Bihar (848 125), India
[5]Assam Agricultural University, Jorhat, Assam (785 013), India

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non-destructively and non- invasively. Remote sensing techniques are useful in detecting crop stresses like nutrient deficiency, pest infestation, disease development and to monitor drought. It improves spatial and temporal resolution compared with traditional methods for pest monitoring (Acharya and Thapa, 2015).

2. Principle of Remote Sensing

Every object reflects/scatters a portion of electromagnetic energy incident on it depending on its physical properties. In addition, objects emit radiation depending on their temperature and emissivity. The reflectance/emittance of any object at different wavelengths follow a pattern which is characteristic of that object, known as spectral signature.

In general, the healthy plants give a higher reflectance in the near infrared region and a lower one in the visible region and opposite is the situation with the infected plants. The plant stress usually results in an increase in visible reflectance due to decrease in chlorophyll and resulting decrease in absorption of visible light.

3. Components of Remote Sensing

1. Energy Source or Illumination
2. Radiation and the Atmosphere
3. Interaction with the Object
4. Recording of Energy by the Sensor
5. Transmission, Reception and Processing
6. Interpretation and Analysis
7. Application

4. Types of Remote Sensing

4.1. Based on Source of Energy

➢ *Passive remote sensing*: The remote sensing systems, which use natural energy form sun.

➢ *Active remote sensing:* The remote sensing systems which provide their own source of energy.

4.2. Based on Range of EMS

➢ *Optical Remote Sensing:* Remote sensing in visible, near-infrared (NIR), mid-infrared (MIR) ranging from 0.3 to 3.0 μm. Measure the radiations reflected by the target.

➢ *Thermal Remote Sensing:* Acquisition, processing and interpretation of data acquired primarily in the thermal infrared (TIR) region of electromagnetic spectrum. Measure the radiation emitting from the target.

➢ *Microwave Remote Sensing:* In the range of 1 mm to 1 m, in frequency interval from 40,000 Hz to 300MHz. Radar transmits a microwave (radio) signal towards the target and detects the backscattered portion of the signal.

Conventional remote sensing is of two types: i) Aerial photography, and ii) Satellite imagery.

➢ *Aerial photography:* Photographs shot from an airplane with the aerial camera's axis kept vertical, horizontal, or oblique. Vertical pictures, on the other hand, are ideal for attaining uniform coverage in environmental surveys. The images were shot from an aircraft that was flying at a specific altitude (Baumann, 2014). The applications of aerial photography in biosphere reserve administration make this sort of remote sensing extremely significant. Its advantages include higher spatial resolution, relative ease of photography and film processing, cheap cost equipment, and the ability to provide a significant amount of information. However, film emulsion technology limits the sensitivity range to the visible and near infrared ranges (o.4 to 1m).

➢ *Satellite Imagery:* Many satellites now monitor the Earth's surface using various remote sensing equipment. These satellites and their remote sensing operations can be traced back to the CORONA and Land sat missions. CORONA was a covert military reconnaissance program that is still in use today via advanced Keyhole satellites, while Landsat was an open Earth resources program that is still in use today via more advanced Landsats and other satellite resource monitoring programs. Satellites can cover far more land than planes and can regularly monitor locations. With technological advances, visuals became digital rather than analog. The digital format enabled computers to show and analyze imagery; sensors that recorded the Earth's surface concurrently in several different sections of the electro-magnetic spectrum were becoming available.

The satellites' multispectral scanners scan the earth line by line in several discrete light quality ranges (spectrum bands) in the visible and thermal regions of the spectrum (0.3 to 14.0 m). A scan line is made up of many measurement results that indicate the energy reflected or emitted by discrete blocks of surface area. The values are recorded on magnetic tapes and can be analyzed directly in a computer. A computer can handle multispectral data at the same time and use statistical algorithms to identify surface features.

5. Concept of Spectral Vegetation Index

A vegetation index (VI) can be defined as a dimensionless, radiation-based measurement computed from the spectral combination of remotely sensed data. These VIs are quantitatively and functionally related with canopy parameters such as the leaf area index (LAI), aboveground biomass, chlorophyll and other leaf pigment content and vegetation fraction and have potential applications in agriculture in general and for monitoring pests and diseases in particular (Pena and Altman, 2009).

The normalized difference vegetation index (NDVI) is the most commonly used ratio based vegetative indexes which differs from plant to plant and also within the same plant depending on the varieties, DAS, fertilizer application etc.

NDVI: (NIR-RED)/(NIR+RED) (NIR: Near Infra-Red spectrum, RED: Red spectrum of visible light energy)

The higher the NDVI value, the healthier the green vegetation

6. Applications of Remote Sensing in Pest Monitoring, Detection, Early Warning and Management Aspects in the Field of Agriculture Pest Management

i. Survey of ecological conditions and forecasting locusts

Desert Locust control tactics have evolved from curative efforts to an emphasis on prevention, i.e. locating and controlling infestations before they develop huge hopper bands and swarms. This necessitates continuous monitoring of locust breeding locations as well as the ability to quickly mount small-scale control efforts in several of the Desert Locust's 60 impacted countries. Remote sensing imagery can aid in the discovery of green vegetation, guiding ground survey crews. For the past four decades, the utilization of satellite remote sensing technologies has created many hopes for locust surveillance. The combined use of remote sensing data and RAMSES locust data during a 43-year period (1965-2008) proved critical. These locust data assisted in prioritizing the various areas based on their interest in locust ecology. They enabled researchers to concentrate their efforts solely on regions of high priority for the species' prevention (Lazar et al., 2015).

ii. Assessment of crop infested with insect pests

Several remote sensing approaches have been developed to identify stress in rice production induced by BPH infestation using visible and infrared imagery. The use of remote sensing to detect insect infestations will spread, allowing for precision farming practice. ENVI 4.8 and SPSS software are used to conduct analysis on the Normalized Difference Vegetation Index (NDVI), Standard Difference Indices (SDI), and Ratio Vegetation Index (RVI). These indices, when used as indicators, can help to define the threshold for zoning epidemics (Ghobadifar et al., 2014).

To estimate LAI across multiple ecosystems, the normalized difference vegetation index (NDVI) has been a popular indicator with certain drawbacks. Cotton farmed as a monoculture in the Andhra Pradesh districts of Guntur and Prakasham was badly plagued by the white fly, *Bemisia tabaci*, during the kharif season of 1985. The cotton crop's condition was assessed using Landsat-5 (MSS & TM) false color composites. Regions with 50-80% pest damage might be easily detected.

iii. Early detection of wild hosts and reducing the population build up

In Mississippi State, USA, wild radish, winter peas, wild mustard, vetch, and curly duck attract insects that subsequently attack cotton and soybean. Remote sensing has been utilized to detect wild host plant locations early in the season, as well as pest infestations within cotton fields and crop maturity levels associated with these pest infestations throughout the cropping season (Acharya and Thapa, 2015).

iv. Early detection of insect pests

Early detection of insect infestations may reduce overall pesticide treatments utilizing variable rate application technology, saving the producer money. Tarnish plant bugs eat and reproduce on broad leaf wild host plants during non-cropping months. Broad leaf hosts and non-host grasses were distinguished using remote sensing and spectro-radiometry. For remote sensing diagnosis of agricultural disease stress, high spectral resolution remote sensing images with more bands and smaller bandwidth is necessary (Acharya and Thapa, 2015).

v. Locating hot spots of pest infestation in crops

In 1999, preliminary remote sensing indicated spider mite infections in cotton fields as reddish hot spot patterns that could be distinguished from healthy and drought stressed cotton. This information could help with precision pesticide application targeting. Because spider mites and aphids are found in a variety of fields, it is likely that these "hot spots" can be distinguished from other causes of variation by using NIR wavelengths.

vi. Monitoring conditions favourable for pest outbreak

Earth observation systems are valuable for monitoring weather and environmental conditions that favor agricultural pests and illnesses. Temperature, humidity (moisture), sunshine hours (light), and wind all have a significant impact on pest population densities and natural enemies. Among the weather parameters that can be remotely sensed, the most easily retrievable are cloud type, cloud extent, and cold cloud duration (a surrogate for rainfall). Phytopathologists used this information to examine wheat rust illnesses (Das, 2013).

vii. Remote sensing of individual species of insects

Locusts: Remote sensing (satellite data) appears to be a viable tool in locust monitoring. Satellite data are increasingly being utilized to monitor and forecast the desert and Australian plague locusts (Latchininsky, 2013).

Moth flight: Until now, entomological radar observation programs have been heavily focused on large insects (moths, migratory grasshoppers) flying at night under stable boundary layer conditions (Wood et al., 2008). RADAR observations of *Spodoptera exempta* have revealed that this species is an obligatory windborne migratory, at least in its gregarious phase, and that the aggregation of flying moths, particularly by storm front outflows, is a crucial element in caterpillar outbreaks. In India, *Heliothes armigera*, on the other hand, exhibits minimal proclivity for long-distance migration above the altitude where wind speed surpasses flying speed.

Aphids and spider mites: NIR wavelengths were fair to fairly reliable predictors of aphid and mite infestations in cotton. Airborne aphid concentrations have been identified up to 1200 m above sea level using highly powerful 10 cm RADARS (Acharya and Thapa, 2015).

Plant hoppers and leaf hoppers: The brown planthopper (BPH), *Nilaparvata lugens* (Stal.), was detected by Prasannakumar et al. (2013) in India using hyperspectral remote sensing on rice plants in both glasshouse and field conditions. They found that the variation in plant reflectance caused by BPH damage was smaller at shorter wavelengths (350-730 nm) and larger at longer wavelengths, i.e., NIR (740-925 nm) followed by mid infrared (MIR) (926-1800 nm). This suggested the possibility of detecting BPH stress on rice and subsequently providing stakeholders with timely warning.

viii. Survey of insect pests of crops and fruit trees

The presence of the sweet potato white fly, *Bemicia tabaci* Glover, and the corn leaf aphid, *Rhopalosiphum maydis*, has been detected by sooty mold. Using computerized area estimating methods and photographic enhancements, different degrees and regions of infestation were successfully measured in a study that involved taking images from a height of 2000 meters. Photographs taken from 2000 meters showed well-resolved mold growth patterns, while sooty mold caused by white flies could be seen growing on cotton at a distance of 300 meters. Numerous insect pests, such as citrus grove-infesting soft scale (*Coccus hesperidium*), citrus mealy bugs (*Phenococcus citri*), citrus black flies (*Aleucocanthes woglumi*), and citrus mealy bugs, create honey dew, which acts as a host medium for the sooty mould fungus. This type of mould turns leaves black, which serves as a hint for prompt insect identification through aerial photography.

ix. Mapping of geographical distribution of pests along with GIS

GIS is another useful technique for mapping the geographical distribution of pests and designating hotspot zones. GIS approaches are classified into two categories: remote sensing and digital cartography. GIS approaches, at their core, build data abstractions to explain real-world living by carefully classifying features into a series of thematic layers. Each layer can be evaluated independently, or features from two or more layers can be examined concurrently. Remote sensing has also been used in conjunction with GIS to monitor crop condition changes. NCIPM has created district-level geographic maps of rice and cotton pests (Acharya and Thapa, 2015).

x. As an aid in precision farming

Precision Farming (PF), also known as Precision Agriculture (PA) or site specific crop management (SSCM), is "an integrated information- and production-based farming system designed to increase long-term, site specific, and whole farm production efficiency, productivity, and profitability while minimizing unintended effects on wildlife and the environment" (Acharya and Thapa, 2015). The ability to differentiate multiple crop features, such as nutrients, water, pests, diseases, weeds, biomass, and canopy structure, has been transformed by aerial hyperspectral photography. Precision agriculture has a lot of potential for merging historical remote sensing data with real-time data for better agricultural management.

xi. Rainfall and outbreak of pests

Convergent winds associated with rainstorms concentrate flying moths of the east African armyworm, *Spodoptera exempta*, and the subsequent mass laying of the aggregated moths results in enormous outbreaks of damaging caterpillars. Remote sensing of rainstorms in appropriate locations allows for the quick detection of potential epidemics.

xii. Survey of habitats of insect vectors of animal diseases

Remote sensing imagery (from high-resolution aerial photography to coarse-resolution satellite imagery) when paired with GIS spatial analysis tools can play a vital role in existing vector surveillance and control programs. We can determine the root cause of disease infection and the source of infection by using remote sensing and GIS techniques to map vector habitats, vector presence, abundance, and density, estimate the risk of vector-borne diseases, disease transmission, and spatial diffusion. With the availability of multispectral, multitemporal, and real-time satellite data products, GPS-assisted geo-referenced epidemiological data are being integrated under the umbrella of GIS software for mapping the distribution of vector-borne diseases (such as malaria, *Japanese encephalitis*, filariasis, schistosomiasis, Ross river virus disease etc).

7. Conclusion

The integration of remote sensing technology in entomology provides a holistic approach to pest management, enabling timely and targeted interventions while minimizing environmental impact and optimizing resource use. It has been widely applied in pest management, offering rapid and non-destructive approaches to plant screening, monitoring habitat characteristics, and providing early warning systems for potential problems in agriculture. It has also played a significant role in precision agriculture, pest detection and crop monitoring, contributing to improved pest management results.

8. References

Acharya, M.C., Thapa, R.B., 2015. Remote sensing and its application in agricultural pest management. The Journal of Agriculture and Environment16, 43–61. https://doi.org/10.3126/aej.v16i0.19839

Baumann, P.R., 2014. History of remote sensing, Aerial Photography Part I. Available: http://www.oneonta.edu/faculty/baumanpr/geosat2/ RS%20History%20I/ RS- History Part 1.html (Retrieved on 15 April 2015).

Das, H.P., 2013. Sattellite-Based Agro-Advisory Service. In: Satellite Remote Sensing and GIS Applications in Agricultural Meteorology, 347–355.

Ghobadifar, F., Wayayok A., Shattri M., Shafri H., 2014. Using SPOT-5 images in rice farming for detecting BPH (Brown Plant Hopper). 7th IGRSM International Remote Sensing & GIS Conference and Exhibition. IOP Conf. Series: Earth and Environmental Science, 20, 10.

Latchininsky, A.V., 2013. Locusts and Remote Sensing: a review, Special Section On Advances In Remote Sensing Applications For Locust Habitat Monitoring And Management. Journal of Applied Remote Sensing 7(1), 075099.

Lazar, M., Diongue, A., Yang, J.T., Bahia, D.M., Michel, L., 2015. Location and characterization of breeding sites of solitary desert locust using satellite images Landsat 7 ETM+ and Terra MODIS. Advances in Entomology 3, 6–15. http://dx.doi.org/10.4236/ae.2015.31002

Pena-Shaff, J.B., Altman, W.S., 2009. Case-based instruction using asynchronous online discussions: A synthesis. Journal on Excellence in College Teaching 20(3), 97–121.

Prasannakumar, N.R., Chandar, S., Sahoo, R.N., Gupta, V.K., 2013. Assessment of brown plant hopper (*Nilaparvata lugens*) [Stal], damage in rice using hyperspectral remote sensing. International Journal of Pest Management 59 (3), 180–188. http:// dx.doi.org/10.1080/09670874.2013..808780.

Wood, C.R., O'Connor, E.J., Hurley, R.A., Reynolds, D.R., Illingworth, A.J., 2008. Cloud-radar observations of insects in the UK convective boundary layer. Meteorological Applications, 1–10 Available : www.interscience.wiley.com (Retrieved 15 April 2015).