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Sensing Techniques in Precision Agriculture for Pest and Disease Management †

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Abstract: Precision agriculture (PA) is a cutting-edge, comprehensive, and globally recognized method. PA entails the application of agronomic ideas and modern technologies to improve sustainability, agricultural output, and environmental quality. This article is mostly concerned with sensing techniques. Remote sensing is a useful technique in PA for spotting, predicting, and predetermining the levels of infestations, and for controlling pests and diseases on a variety of fruits and crops. Sensors also transform traditional farming methods into precision farming methods, which helps to cut back on unnecessary input costs and raises agricultural productivity. By using these techniques, the application of pesticides can be quickly and locally administered.

Keywords: precision agriculture; remote sensing; sensors; pest management

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1. Introduction

Precision agriculture (PA) technologies have been developed and used over the past four decades, opening up new possibilities for crop and animal management by utilizing contemporary information technology. The current PA research also focuses on the creation of sensors that enable remote real-time crop and soil property detection, which includes remote sensing, digital image analysis, and biosensors. Therefore, a broader concept of PA encompasses all agricultural activities that use modern information technologies, including animal and plant production, precision livestock agriculture (PLA), soil fertility and water quality management, and raw material processing after harvest. PA technology also helps farmers control plant diseases and pests [1,2]. According to Zhang and his coworkers, PA is a creative, comprehensive, and globally standardized strategy for sustainable agriculture that seeks to improve resource use efficiency while reducing risks and management decision ambiguity [3]. It is a tactic that simultaneously addresses the requirements of both people and animals in terms of safety and well-being [4]. Precision agriculture applies artificial intelligence (AI), wireless communication, and information technologies, e.g., the Internet of Things (IoT), to agriculture for precisely managing the fertilization, plant pests in the fields, crop diseases, and irrigation [5]. The health monitoring of crops determines the farm's state regarding plant pests and is seen to be the primary application of smart agriculture [6,7].

2. Remote Sensing (RS) Systems

The use of remote sensing is now crucial for managing agriculture sustainably. Fitzgerald found that color shifts and subsequent changes in the canopy's appearance may be utilized to identify early mite infection in cotton fields using multispectral remote sensing.

For the IPM context in many agricultural techniques, remote sensing offers useful information. For instance, several airborne remote sensing techniques, such as multispectral and hyperspectral sensors, were employed for agricultural applications. The availability of imaging is made possible by the employment of either single-band cameras or video with appropriate filter lenses in these systems. Numerous writers looked at the use of airborne remote sensing for the analysis and detection of insect pest damage in the field. Additionally, it has been used to map agricultural diseases and evaluate their effects on crop yield [8,9].

3. Sensors

With the use of intelligent sensors, precision farming can increase agricultural output by giving farmers precise information and assisting them in making better decisions. Sensors involved in PA include green seekers or the Normalized Difference in Vegetative Index (NDVI) sensors, nano-biosensors, atomic dots (QDs), tiny barcodes, etc. [10] (Figure 1). Sensing technologies make it possible to record details on crop symptoms, ambient circumstances, or the physical traits of an insect pest or disease. Sensing techniques record ambient variables and pictures. Field sensors, spectroradiometers, and microscopes are the three different types of sensors employed to record the data in image form [11]. The next section explains each image recording category of sensors.

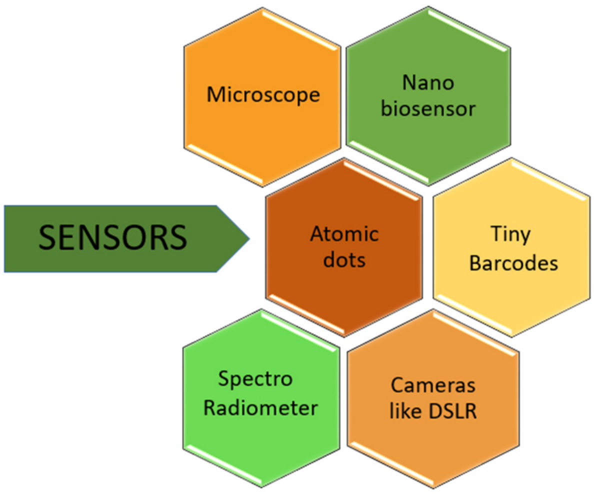

Figure 1. Different types of sensors.

- Field sensors: Ambient temperature sensors, image capture, soil-moisture sensors, humidity sensors, and water sensors are used to identify and manage diseases. The soil is also observed using environmental humidity, temperature, and moisture sensors. The findings demonstrated that the crop output is increased with prompt diagnosis and ongoing observation by using advanced techniques.
- Spectroradiometer: An experiment was carried out from 70 to 90 days after seeding that employed a spectroradiometer to identify and quantify the harm caused by T. tobacco (Lind). SVIs were calculated based on the reported canopy reflectance. Remote sensors were used to assess the relationship between a whitefly infestation and biotic stress. In the spectral range of 350–2500 nm at 1 nm, they employed a spectroradiometer with various sample intervals. To ascertain the correlation between the degree of damage caused by the whitefly infestation and chlorophyll content, the chlorophyll concentration was evaluated.
- Microscope: In natural settings, Rothe and Rothe utilized a DSLR camera and a Leica Wild M3C microscope to identify the presence of Myrothecium, Alternaria, and bacterial leaf blight [11].

4. Conclusions

The goal of PA research is to eliminate decision uncertainty brought on by unrestrained spatial and temporal variation. The secret to the successful future of PA, however, is not by simply gathering pertinent data, but also turning these data into knowledge that can be used to make choices and thoroughly weigh the risks and rewards of those actions. In the domain of sensors, cameras and outdoor sensors such as temperature and humidity sensors are the most popular types of sensors. Applications for remote sensing in agriculture are expanding and evolving, particularly in the management of pests and plant diseases. Remote sensing data are now viewed as general-purpose data for a large user population with potentially varied needs.

5. Future Outlooks

- Create prediction algorithms to determine the times and locations of disease and insect invasions.
- Prescriptive models should be used to specify methods to manage illness and insect pests.
- Create a system of sophisticated traps made of pheromones to anticipate the invasion of pests.
- Create illness diagnosis models.
- Create models with many detections for disease or insect assaults.

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