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Integration of Precision Agriculture Techniques for Pest Management †

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Abstract: Horticultural crops have a special impact on a nation's economy due to their significance in raising the living standards of farmers. The traditional method for crop protection is becoming ineffective with an increase in climate change effects. Precision Agriculture (PA) presents a solution to this issue through the precise monitoring and forecasting of pests, which improves productivity and guarantees environmental sustainability. The productivity of the existing plant production system can be increased by using precision agriculture techniques. Various PA technologies that enable farmers to monitor the pest include remote sensing, the Internet of Things, geographical information systems, and artificial intelligence. The PA technique assists with pest forecasting and the management of pests and diseases in plants. The content of this article was gathered through a literature review of recent research. The approaches used in PA for pest forecasting, monitoring, and management are the main topic of this study. In the long term, this study will help farmers to manage insect pests in a way that is both affordable and environmentally beneficial.

Keywords: precision agriculture; pest forecasting; pest monitoring; pest management

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1. Introduction

The yield and quality of citrus and olive crops are significantly harmed by insect infestation. Different parts of the plant are inhabited by insect pests, hampering the productivity and survival of plants. Therefore, to prevent pest attacks and production losses, the pest management techniques need to be updated regularly to ensure better output and environmental sustainability [1]. Remote Sensing (RS), the Internet of Things (IoT), Geographic Information Systems (GIS), and Artificial Intelligence (AI) are just a few of the PA technologies that give farmers the ability to monitor pests. According to Moses-Gonzales, N and M.J. Brewer, [2], sensing drones along with sensors can detect and identify pest-caused damage, pest habitat, and pest presence. This study is being carried out to gather information about the main citrus and olive [3] orchard pests that exist worldwide. This study investigated the major PA tools available for pest management. Furthermore, this study reviewed the literature about monitoring and forecasting approaches available for citrus and olive pest monitoring and forecasting.

2. Methodology

A review of secondary published data was conducted to retrieve authentic information for this investigation. To gather relevant information about the pest management system,

various research papers, books, web-based publications, and initiatives were reviewed. The study utilises recent data about the integration of PA in pest monitoring, forecasting, and management.

3. Role of Precision Techniques in Pest Management

Forecasting pest activity is made easier by precision farming techniques. According to automatic pest control systems, pests can be identified by using infrared sensors, thermal sensors, audio sensors, and image-based categorisation. To increase crop productivity and sustainability, sensors and software are used to interpret the data. High-resolution crop photos from satellite or aerial platforms (manned or unmanned) were processed to extract more information, i.e., employed for making pest control decisions.

4. Major Precision Approach for Monitoring Pests

For the effective production of the crop, pest surveillance and management are crucial as described in Figure 1. A pest monitoring program is thought to be crucial for identifying various pests on a large scale. Modern monitoring tools for pest monitoring include GPS, Global Navigation Satellite System (GNSS), and AI.

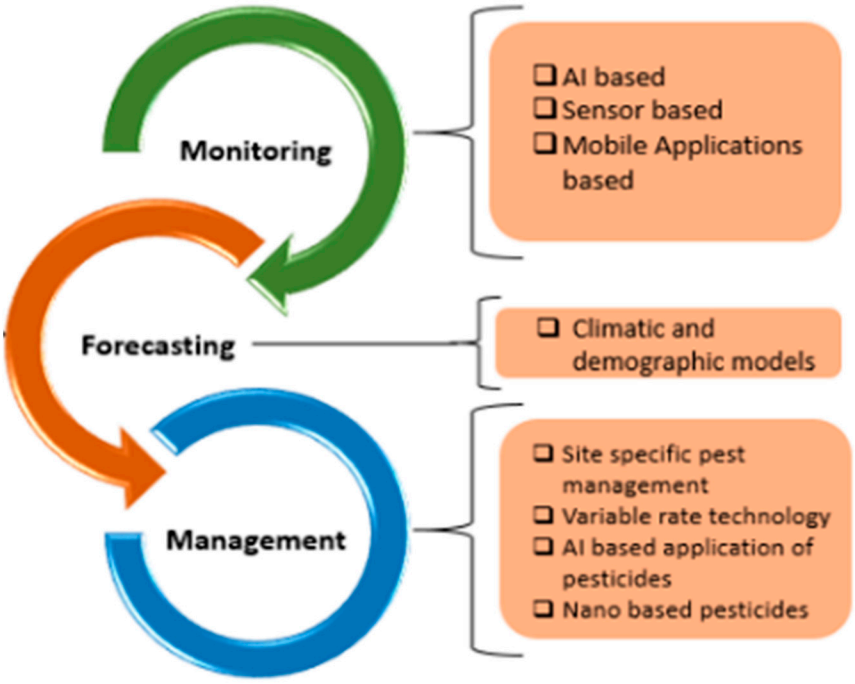


Figure 1. Precision Pest Management.

i. AI-based monitoring of pests: With its stringent skill set, AI has emerged as a crucial tool for addressing many issues in agriculture. Deep learning (DL) models for AI assist in identifying pests [4].
ii. Sensors-based monitoring of pests: The use of sensor-based PA technologies in field surveys of various pests has recently begun. Some of the examples include the use of radar to track the migration of pests, thermal infrared imaging, GNSS for telemetry of wildlife, video equipment to monitor flying insects, chemiluminescent tags to track insect movement at night, detection of larval movement through echo-sounding and habitat mapping.
iii. Mobile app for monitoring pests: Different smartphone applications are available for automated management and control of agricultural pests. The most popular are Trapview System, Plantix-Mobile App, Agri-App, and Kheti-Badi [5].

5. Role of Precision in the Forecasting of Pests

The prediction of pests helps farmers in reducing pesticide usage, avoiding blanket pesticide treatments, and providing high-quality outcomes by advising them on the biology and timing of insect occurrence [6]. The use of forecasts and early warnings based on biophysical techniques allows the management of near-pest assaults, which improves pest control, lowers crop loss, and lowers cultivation costs.

5.1. Climatic Model for Forecasting the Pest Attack

Climate influences both insect abundance and the number of natural enemies, which is a crucial organic component in pest population management. Climate models may be a useful tool for predicting the spectrum of potential changes on a global scale when paired with the environmental needs of a specific pest species.

5.2. Other Models for Forecasting the Attack

Pest forecasting mostly utilizes an embedded system and an intelligent system for plant protection and pest management [7]. The important techniques used in pest forecasting are:

1. The use of machine learning (ML) techniques enables users to handle complicated information and conduct trend analysis for a variety of applications (such as data mining, image processing, and predictive analytics). A machine learning (ML) model was used to forecast the appearance of the summer generation of pests.
2. Physiologically based demographic models (PBDMs) might be utilized effectively in the context of climate change. A PBDM model is utilized to observe the weather pattern, the location, and the abundance of pests.

When examining the insect population dynamics, the most important aspect is to consider both the local weather conditions and worldwide climate indicators. Moreover, the combined effects of exogenous (such as regional climate conditions) and endogenous (such as intrinsic population dynamics) components are also examined and modelled for pest forecasting [3].

6. Management of Insect Pests Using Precision Agriculture Tool

The goal of pest control in agricultural production is to keep pest populations or damage at levels that are both socially acceptable and economical. Some of the management techniques include:

1. Site-specific insect pest management: This technique involves the management of pests at a specific location, rather than treating the entire region. The advancement of AI helps us to manage pests at a specific location.
2. Variable rate technologies (VRT): Variable rate technologies allow farmers to apply pesticides at a specific location by utilizing AI and GIS techniques. This reduces the negative impact of pesticides on the environment and preserves beneficial insects.
3. AI-based application of pesticides: Artificial intelligence is the most recent technique employed to manage pests. The most common AI-based technologies used in pest management are unmanned aircraft systems. The first unmanned aerial vehicle (UAV) to be used for commercial purposes was developed by Yamaha Motor Co. Ltd. in Shizuoka, Japan, to monitor pest attacks in orchards.
4. Nano-bio-pesticides: Nanotechnology improves pest management through the effective utilization of pesticides. The size and dimensions of the nano pesticides allow the farmers to apply them precisely on crops.

7. Future Perspectives of PA for Insect-Pest Management

The broad literature review reveals the following research gaps in pest control that must be appropriately addressed if accurate findings are to be anticipated:

- A few prediction models for pests are not researched;

- The use of sensors for pest prediction has not yet been properly investigated;
- The information on weather-related pest occurrence in rain-fed crops is insufficient;
- Farmers do not receive the most recent forecast information timely.

8. Conclusions

The review shows that remote sensing (sensors), a precision tool, is used to assess agricultural variability, monitor crop health, and identify insect outbreaks. As early identification and correction to inadequate abiotic conditions may avoid significant pest outbreaks, they might act as decision support aids. Engineers, ecologists, and agronomists must collaborate on multidisciplinary research for this approach, which has huge market viability.

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