DRONE TECHNOLOGY: A NOVEL APPROACH IN PRECISION INSECT PESTS MANAGEMENT

Abstract

Drones, also known as Unmanned Aerial Vehicles (UAVs), have shown promising potential in revolutionizing pest control methods, offering enhanced precision, efficiency, and sustainability. By critically analyzing existing literature, we aim to provide valuable insights into the evolving landscape of drone-based pest management strategies. Global food grain output is declining mostly as a result of biotic stressors brought on by pests and diseases, which are well recognized to cause catastrophic harm. Therefore, to prevent the crops from being destroyed by these pests, careful observation and real technological capsules are required. Drones, which offer immense promise for agricultural planning and pest management, are semi-automated equipment that are steadily moving toward completely automatic gadgets. The pest control solutions facilitated by drones show significant potential and represent a possible alternative to traditional pest control methods. They ought to be strongly encouraged for effective use as a component of integrated pest management strategies in Indian agricultural research and technology development. We delve into the various applications of drones in pest management, highlighting their advantages, challenges, and future prospects.

Keywords: UAVs, Agricultural Research, Technology Development, Drones.

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I. INTRODUCTION

The field of pest management plays a crucial role in ensuring the health and productivity of agricultural crops, natural ecosystems, and urban environments. The constant challenge of combating pest infestations and minimizing their detrimental impacts has driven the exploration of innovative and sustainable solutions. In recent years, the emergence of drone technology, also known as Unmanned Aerial Vehicles (UAVs), has sparked significant interest and potential in revolutionizing pest management practices. Drones offer a powerful combination of mobility, accessibility, and versatility, making them an ideal tool for addressing various challenges faced by traditional pest control methods. Equipped with cutting-edge sensors, cameras, and payload systems, drones are capable of performing a wide range of tasks with unmatched precision and efficiency. As a result, they have found applications across multiple stages of pest management, from early detection and surveillance to targeted intervention and data-driven decision-making. This paper aims to provide an in-depth review of drone technology in pest management, examining its transformative impact on the agricultural and environmental sectors. By exploring the diverse applications, advantages, and limitations of drones in pest control, we seek to shed light on how this technology has the potential to enhance the effectiveness and sustainability of pest management strategies. In the following sections, we will delve into the various applications of drones in pest management, including aerial surveillance for pest detection and monitoring, precision application of pesticides, data collection for predictive modeling, and dissemination of beneficial organisms for biological control. Moreover, we will assess the advantages of using drones over conventional methods, such as improved efficiency, reduced environmental impact, and cost-effectiveness. While the potential benefits of drone technology in pest management are undeniable, there are also challenges to address, including battery life constraints, regulatory compliance, data processing, and privacy concerns. We will critically evaluate these obstacles to provide a comprehensive understanding of the current state and future prospects of drone-based pest management. The integration of drone technology into pest management practices holds immense promise for revolutionizing how we approach pest control and monitoring. By harnessing the capabilities of drones, we can develop more sustainable, precise, and data-driven strategies that effectively mitigate pest-related risks while minimizing the environmental impact. As we explore the potential of this cutting-edge technology, collaboration between researchers, industry stakeholders, and regulatory authorities will play a pivotal role in unlocking its full potential and ushering in a new era of pest management practices.

II. AGRICULTURAL DRONE

Drones are semi-automated gadgets that are moving steadily in the direction of being fully automatic. These tools offer great potential for agricultural planning and gathering associated spatial data. This method can be used for effective data analysis despite some inherent limitations (Grammatikis et al., 2020). Drones were initially developed as a military tool and were known under various names, including Unmanned Aerial Vehicles (UAV), Miniature Pilotless Aircraft, and Flying Mini Robots. It is used nowadays in a variety of industries, including business, infrastructure, farming, security, insurance claims, mining, entertainment, telecommunications, and transport. Small unmanned aerial vehicle (UAV) applications are expanding quickly in the agribusiness nowadays (Ramirez and Galvez, 2019; Devi et al., 2020; Giacomo et al., 2018).

III. TYPES OF DRONES

1. **Single Rotor Helicopter Drones:** They can be used to survey terrain, study storms, and map erosion brought on by global warming. They resemble tiny helicopters and are propelled by either gas or electricity.

2. **Multi-Rotor Drones:** Typically, they are among the tiniest and lightest drones available. These drones can typically fly for 20 to 30 minutes while carrying a small payload, like a camera.

3. **Fixed-Wing Drones:** They resemble regular airplanes, but instead of having rotors to produce lift, they have wings, which makes them far more effective. Typically, these drones run on fuel rather than electricity. Fixed-wing UAVs are employed by the military to conduct strikes, scientists to transport substantial amounts of equipment, and even non-profit organizations to bring food and other supplies to inaccessible regions.

4. **Fixed-Wing Hybrid VTOL Drones:** They have rotors that are mounted to the wings and combine fixed-wing and rotor-based drones. This technology combines a fixed-wing design's endurance with a rotor-focused strategy to provide consumers the best of both worlds.

5. **Working Principle of Sprayer Drone:** A drone is made up of Brushless Direct Current Motors (BLDC), Electronic Speed Control (ESC), flight controller, Camera, Transmitter, and Receiver. The pump and its controlling system are the primary components of any spraying system. The drone is controlled by an accelerometer, gyroscope, and GPS in the accessories. Estimating the payload is the first step in designing a drone for sprayer use. The drone's parts are chosen after the payload calculation. The current and voltage needs of the drone modules dictate the battery choice. Finally, the drone's frame is created based on the quantity of arms and payloads. The first unmanned aerial vehicle (UAV) for applying pesticides was created in 1983 by Yamaha Motor Co. Ltd. in Shizuoka, Japan.

IV. APPLICATIONS IN INSECT PEST MANAGEMENT

Precision insect pest management is attractive because drone-based remote sensing technologies have several advantages. The coverage of vast areas is likely possible with sensing drones compared to handheld, ground-based devices. Specific biotic pressures, such insect pest infestations, cause physiological plant responses, alter the plant's capacity for photosynthesis, and consequently alter the spectrum range of the leaf reflectance. A drone can be fitted with either a hyper-spectral sensor with hundreds of narrow spectral bands or an RGB (red, green, blue) sensor, which is a multispectral sensor with between 3 and 12 wide spectral bands for aerial remote sensing (Keller and Shields, 2014). It is crucial to remember that remote sensing does not find bugs directly, but rather patterns of canopy reflectance that show plant stress brought on by pest insects. The presence of particular insect pests still has to be confirmed through field observations.

1. **Drone Mediated Aerial Photography:** Aerial imagery taken by drones has made it possible to monitor plant pests through the clustering of wireless sensors and networks and precision agricultural planning. Farmers that use drone technology can get a

wonderful aerial perspective of their fields and use that information to solve problems by making important management decisions. Drone photographs are sent to a cloud data center where they are processed using spectrum analysis software to determine the extent of pest damage. (Gao *et al.,* 2020).

2. **Drone Mediated Insect Pest Sampling:** A device that may be attached to a drone and be used to catch flying insects in either position-fixed or freely mobile traps is offered for the sampling of insect pests. In order to provide an attractive force to attract insects that penetrate the electric field, a DD-screen (double-charged dipolar electric field screen) is attached with the drone. Because of how powerful the electric field is, the imprisoned insects cannot escape the trap. (Takikawa *et al.* 2020).

3. **Drone Mediated Precision Application of Insecticides:** By applying pesticides at varying rates, an actuation drone could aid with pest control at hotspots in a farm area. New drone designs that can be used as commercial drones and are equipped with crop dusters and/or sprayers are currently being developed in various parts of the world. Along with precision monitoring, precision pesticide administration could lower the overall number of sprays, resulting in less pesticide use, less insect resistance development, and more natural enemies in the field.

4. **Drone Mediated Precision Releases of Natural Enemies:** Drones are now an effective tool for augmentative biological management, which relies on the widespread deployment of natural enemies to eradicate pests immediately. They might disperse the natural enemies precisely where they are required, which might raise the effectiveness of the bio-control agents and lower the cost of distribution.

5. **Drone Mediated Sterile Insect Technique (SIT) and Mating Disruption:** The introduction of sterile insects is yet another potential application for drones in pest control. Codling moth populations have been successfully managed by experimental drone-released sterile bug programs in the USA, New Zealand, and Canada. Additionally, sterile insects dropped by drones as part of experimental initiatives to control Mexican fruit flies and cotton pink boll worms in citrus have been successful in the USA.

V. ADVANTAGE

1. **Precision and Targeted Application:** Drones enable precise and targeted application of pesticides and beneficial organisms. They can deliver treatments to specific areas affected by pests, minimizing off-target effects and reducing chemical wastage. This precision helps protect non-target organisms and promotes environmentally friendly pest management practices.

2. **Reduced Environmental Impact:** By delivering pesticides and biocontrol agents only where necessary, drone-based pest management reduces the overall use of chemicals. This, in turn, minimizes the potential negative effects on beneficial insects, wildlife, and water bodies, fostering sustainable and ecologically sensitive pest control practices.

3. **Increased Efficiency and Speed:** Drones significantly enhance the efficiency and speed of pest management operations. They can cover large areas in a short time, enabling swift

pest detection and intervention. The rapid response to pest outbreaks helps prevent further spread and reduces the risk of significant crop losses.

4. **Accessibility to Remote and Challenging Areas:** Drones can access hard-to-reach or hazardous locations, such as steep terrain, dense forests, or tall structures, where pests may thrive or be difficult to monitor. This accessibility ensures comprehensive pest surveillance and control, leading to more effective pest management strategies.

5. **Data-Driven Decision Making:** Equipped with various sensors, drones collect valuable data on pest distribution, crop health, and environmental conditions. The data collected can be analyzed using advanced algorithms and integrated with geographic information systems (GIS) to provide valuable insights. Data-driven decision making enhances the accuracy and effectiveness of pest control efforts.

6. **Cost-Effectiveness:** Although initial investments in drone technology may be significant, the long-term cost-effectiveness of drone-based pest management is often favorable. Reduced pesticide usage and improved resource utilization contribute to cost savings in the long run.

7. **Safe and Labor-Saving:** Drones eliminate or reduce the need for manual labor in hazardous tasks, such as climbing tall trees or navigating rough terrains. This minimizes the risk of accidents and injuries, ensuring safer working conditions for pest management professionals.

8. **Real-Time Monitoring and Response:** Drones equipped with live video feeds and telemetry data provide real-time monitoring of pest infestations. Pest control operators can make immediate decisions and adjust their strategies based on the real-time information, enabling more efficient and adaptive pest management.

9. **Integration with Advanced Technologies:** Drones can be integrated with cutting-edge technologies, such as artificial intelligence, machine learning, and autonomous navigation systems. These technologies enhance the drones' capabilities, allowing for autonomous pest detection, targeted interventions, and optimized flight paths.

10. **Scalability:** Drone-based pest management is scalable and can be adapted to various scales of operations, from small-scale farms to large commercial agricultural fields. It offers versatility in managing pest issues across different landscapes and sectors.

VI. LIMITATIONS

1. High prices
2. Calls for expert labor to operate
3. Data collection, analysis, and interpretation challenges
4. Cannot be used in poor weather conditions
5. Only appropriate for large-scale spraying
6. Drone Accidents

VII. FUTURE PROSPECTS

After 2017, drone use for precision agriculture will increase. This is brought on by the decrease in weight, increase in UAV cost, and expansion of cargo capacity. Multicopter and fixed-wing drones are the most common varieties employed in agricultural health monitoring and livestock detection. Each day, these drones' size and price continue to decrease. Multispectral cameras are replacing RGB cameras, and operations have moved from semi-controlled to completely automated systems. However, the development of drone technology is still in its early stages, and there may be room for both technological and agricultural application advancement. Cost of technology, drone battery life limitations, vision loss, end-user technological literacy, and flaws are the main challenges.

VIII. CONCLUSION

Precision insect pest management strategies are increasingly including drones. Drones equipped with sensors are used as remote sensing equipment to map agricultural performance variability, track pest outbreaks, apply insecticides, and release natural enemies. Despite advancements in drone-mediated technology for precision agriculture over the past ten years, only a few nations, notably the United States, China, Japan, and South Korea, have commercially used drones in agricultural fields or forests. The pest management drone-mediated technologies show great potential and offer a promising alternative to traditional pest management approaches. They should be widely supported for their effective use as a component of integrated pest management practices in Indian agricultural research and technology development.

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