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Real-Time Automated Pest Monitoring: Making Pest Management Smarter in Horticultural Crops

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Horticultural farming is one of the most input-intensive and risk-prone sectors of agriculture. Farmers invest heavily in quality seedlings, fertilizers, irrigation, and plant protection to meet the high market standards demanded for fruits and vegetables. Yet, a single unnoticed pest outbreak can wipe out weeks of effort. Insect pests continue to be a major reason why horticultural crops often fail to deliver expected yields and profits, despite good agronomic practices. Traditionally, pest management decisions depend on periodic field scouting and manual observation of traps. While these methods have served agriculture for decades, they are increasingly inadequate under present conditions of labour scarcity, changing climate, and fast-multiplying insect populations. Farmers frequently detect pests only after visible damage appears, by which time control measures become costly and less effective. Real-time automated pest monitoring offers a practical and timely solution to this problem by enabling continuous pest surveillance and early warning, directly at the field level.

Why Continuous Pest Monitoring Is Necessary

Insect pests do not follow a fixed calendar. Their population build-up is influenced by temperature, humidity, crop stage, and surrounding vegetation. In horticultural crops, even short delays in pest detection can result in serious yield and quality losses. Pests such as *Helicoverpa armigera* in vegetables and fruit flies in orchards often increase rapidly without clear early symptoms on the crop. By the time damage is visible, larvae may already be inside fruits, making control difficult. Manual scouting has clear limitations. It depends on human availability, experience, and consistency. Traps installed in fields are often checked only once a week, and pest counts are recorded manually. This low frequency of observation misses critical changes in pest activity. Moreover, large orchards and clustered vegetable farms make regular monitoring labour-intensive and expensive. These gaps highlight the need for automated systems that monitor pests continuously, without depending on daily human presence.

What Is Real-Time Automated Pest Monitoring?

Real-time automated pest monitoring is a digital approach where pest activity is recorded automatically using smart traps equipped with sensors, and the data are transmitted instantly to farmers or advisory systems. Unlike conventional traps, which require manual counting, automated traps work continuously and provide up-to-date information on pest populations.

At the heart of these systems are sensor-based smart traps. These traps use pheromones or food attractants to lure specific pests, just like conventional traps. However, once an insect enters the trap, sensors detect its presence and record the event. Depending on the system, this detection may be done using optical sensors, cameras, infrared beams, or vibration sensors. The captured data are then processed and sent wirelessly through mobile or low-power networks (Roy et al., 2024)

For the farmer, this means pest activity can be monitored daily or even hourly, without physically visiting the field. Pest pressure is no longer a guess based on occasional observations but a continuously updated reality.

Key Components of an Automated Monitoring System

Smart Traps with Integrated Sensors

Smart traps are designed to identify and count insect activity automatically. Camera-based traps capture images of trapped insects, which are later analysed using image recognition algorithms. Other traps use entry-event sensors that record every time an insect enters the trap. These technologies are particularly effective for pests like fruit flies and moths, whose adult activity provides early signals of infestation (Aziz et al., 2025).

Environmental Sensors

Many automated traps also include sensors for temperature, humidity, and light intensity. These environmental parameters help explain pest behaviour and improve prediction accuracy. For instance, a rise in temperature combined with increased moth catches may signal an imminent outbreak.

Wireless Data Transmission

Collected data are transmitted automatically using GSM, LoRaWAN, or similar communication technologies. This removes the need for manual data collection and allows monitoring across multiple fields simultaneously. Even remote farms can be connected to advisory platforms through low-power networks.

Decision Support and Alerts

The true value of automation lies in decision support. Pest data are analysed and compared with threshold levels. When pest activity crosses a critical limit, alerts are generated and sent to farmers through mobile applications or SMS. This allows timely and targeted interventions rather than routine spraying.

How Automation Changes Pest Management Decisions

Automated pest monitoring shifts pest management from a reactive to a preventive approach. Instead of spraying insecticides based on fixed schedules, farmers can take action only when pest pressure is rising. For example, an increase in *Helicoverpa armigera* moth activity can warn farmers several days before larvae appear in fruits. Similarly, early detection of fruit fly activity enables timely deployment of bait stations or mass trapping, reducing the need for repeated cover sprays. This precision reduces unnecessary pesticide applications, lowers production costs, and minimizes pesticide residues on produce. It also helps preserve beneficial insects, which are often harmed by indiscriminate spraying.

Benefits for Farmers and the Horticulture Sector

Real-time automated pest monitoring offers multiple benefits:

- Early warning of pest outbreaks
- Reduced labour dependency for monitoring
- Lower pesticide use and input costs
- Improved timing and effectiveness of control measures
- Better compliance with food safety and export standards

For small and medium farmers, shared or community-based monitoring systems can further reduce costs and support area-wide pest management programmes.

Conclusion

As digital agriculture advances, automated pest monitoring is becoming more affordable and farmer-friendly. Integration with mobile advisory platforms and artificial intelligence will further improve pest prediction and management accuracy. In horticultural systems where quality and timing are critical, real-time automated pest monitoring is no longer a luxury but a necessary tool for sustainable and profitable production.

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