Revolutionizing Crop Health Management in Vikshit Bharat: A Drone-Enabled Approach for Precision Insecticide and Fungicide Applications in Disease and Pest Management

Shyam Narayan Patel[1]*, Ashish Kumar Verma[2] and Vikas Yadav[3]

[1,2,3]Research Scholar,
[1]Department of Plant Pathology, [2]Department of Agronomy,
[3]Department of Soil Science & Agril. Chemistry,
[1,2,3]Acharya Narendra Deva University of Agriculture and Technology,
Kumarganj, Ayodhya, Uttar Pradesh- 224229, India

Corresponding Author
Shyam Narayan Patel
Email: patelshyamnarain@gmail.com

OPEN ACCESS

Keywords

Vikshit Bharat, Precision Agriculture, Drone Technology, Insecticide, Fungicide

How to cite this article:

Patel, S. N., Verma, A. K. and Yadav, V. 2025. Revolutionizing Crop Health Management in Vikshit Bharat: A Drone-Enabled Approach for Precision Insecticide and Fungicide Applications in Disease and Pest Management. *Vigyan Varta* 6(6): 1-5.

ABSTRACT

The introduction of advanced technologies to improve farming methods is causing a revolution in the agricultural landscape of Vikshit Bharat (Developed India). In order to control pests and diseases in crops, this abstract explores a ground-breaking project under the Vikshit Bharat Programme that uses drone technology to apply fungicides and insecticides precisely and locally. Drones have great potential to revolutionize agriculture by promoting resource efficiency, sustainability, and increased crop yields. The suggested approach is the tactical use of unmanned aerial aircraft outfitted with cutting-edge spraying equipment that can apply fungicides and insecticides with previously unheard-of precision. This strategy guarantees that the agrochemicals efficiently reach their intended objectives while also reducing the environmental impact associated with conventional spray

approaches. The Vikshit Bharat Program's primary objectives, which emphasize technical improvements for comprehensive agricultural development, are well aligned with the use of drones in disease and pest management.

INTRODUCTION

India's lofty goal of becoming a developed, robust, and self-sufficient country by 2047 known as "Vikshit Bharat" makes modernizing its agricultural sector a key component of this change. More over half of India's workforce is employed in agriculture, which is the foundation of rural livelihood and food security and makes a substantial contribution to the country's GDP. However, issues like unpredictable weather patterns, the rise of new diseases and pests, declining landholdings, and the unsustainable abuse of agrochemicals are putting more and more burden on the industry. Traditional methods of pest and disease control, which mostly rely on broad-spectrum chemical applications, frequently applied without accurate diagnosis or dosage, are compromising crop health in particular. In addition to decreasing effectiveness, these antiquated techniques cause pest resistance, degradation of the environment, and health risks for both farmers and consumers (Gupta *et al*., 2022).

In this Fourth Industrial Revolution era, incorporating cutting-edge technologies into agriculture is not only a question of creativity; it is a necessity. Unmanned aerial vehicles (UAVs), also referred to as drones, are one of the most promising ways to support precision agriculture. Drones can map, monitor, and control crop health in real time when they are outfitted with multispectral sensors, high-resolution cameras, and intelligent spraying systems. By facilitating the early identification of pest infestations or disease outbreaks, they help farmers make evidence-based decisions about the sparing application of fungicides and insecticides. This improves the quality and safety of agricultural products, lowers production costs, and minimizes the abuse of chemicals. A paradigm change toward a more intelligent, environmentally friendly, and financially successful farming model in line with "Vikshit Bharat" objectives is represented by drone-enabled crop protection (Singh *et al*., 2021).

Drone use in crop health management has major ecological, financial, and agronomic advantages. In terms of agronomy, drones help with early intervention, which is essential to disrupting the life cycle of a disease or pest before it spreads over whole fields. Particularly useful in India's varied agricultural regions, they can reach marginal lands and challenging terrain. When it comes to cost, precision spraying greatly reduces labour and agrochemical costs while increasing crop quantity and quality. In terms of the environment, drone-assisted applications are an essential part of sustainable farming since they reduce chemical runoff into water bodies, soil compaction, and emissions from fewer tractor passes. Additionally, drone service models via FPOs (Farmer Producer Organizations), agri-startups, or government-led initiatives can democratize access to this technology without putting the entire financial burden on individual farmers in a nation where small and marginal farmers dominate the agricultural landscape (Mishra *et al.*, 2022)

Drone adoption in Indian agriculture is not without its difficulties, though. The broad use of drone-based solutions has been hampered by regulatory obstacles, high upfront costs, poor awareness, and a lack of technical expertise among farmers and extension agents. Implementation is made more difficult by airspace limitations, privacy issues, and the requirement for a strong data infrastructure. These difficulties are not insurmountable, though. The environment is gradually becoming more favourable for drone integration as a result of the Indian government's growing support for Agri-Tech through initiatives like the Digital Agriculture Mission, Sub-Mission on Agricultural Mechanisation, and the inclusion of drones under the Production-Linked Incentive (PLI) scheme. The gap between technological potential and practical reality can be closed through skill development programs, public-private partnerships, and targeted subsidies particularly if they are created with an emphasis on inclusivity and local flexibility.

Drones not only offer an effective means to apply chemicals in the context of managing pests and diseases, but they also open the door for integrated crop health systems. India can create a comprehensive and predictive agricultural health ecosystem by integrating drone monitoring with blockchain-based traceability, AI-powered decision support systems, and weather forecasting models. Improved adherence to international residue standards, prompt and accurate responses to hazards, and increased marketability of Indian produce internationally are all benefits of such integration. Global objectives like the Sustainable Development Goals (SDGs) of the UN, especially those pertaining to ending hunger, combating climate change, and promoting responsible production and consumption, are also in line with this shift (Patel *et al*., 2019).

"The significance of precision agriculture facilitated by drones in the future"

The future of sustainable and effective farming is represented by precision agriculture, which is frequently defined as the use of technology and data-driven decision-making to maximize crop yield. The need for food, fiber, and fuel is predicted to rise sharply as the world's population continues to grow, reaching almost 9 billion people by 2050. In today's resource-constrained and ecologically conscious society, traditional farming methods that depend on treating fields uniformly are no longer sufficient to address this challenge. Unmanned aerial vehicles (UAVs), sometimes known as drones, are essential to precision agriculture because they offer site-specific management capabilities, real-time crop monitoring, and high-resolution aerial imagery. Drones enable farmers to monitor soil moisture, identify pests and diseases, evaluate crop development, and measure plant health with surprising accuracy by capturing multispectral, thermal, and visual data. This fine-grained understanding makes it possible to go from reactive to proactive farm management, which lowers input waste, boosts yields, and preserves natural resources (Mishra *et al*., 2020).

Drone technology has a multifaceted impact on agriculture, influencing labor optimization, environmental sustainability, and economic efficiency. Precision agriculture, for example, reduces unnecessary expenditure on labor, water, and agrochemicals by applying treatments only where they are needed, rather than treating entire fields uniformly. This improves input efficiency and profitability, which is especially important at a time when input costs are rising and margins are shrinking. Environmentally, drones contribute to sustainable agriculture by reducing greenhouse gas emissions, minimizing chemical runoff into nearby ecosystems, and reducing soil compaction from heavy machinery. These environmental benefits are critical in an era of climate change, where agriculture must balance productivity with ecological responsibility. Moreover, drones offer labour-saving solutions in contexts where rural labor is either scarce or costly, automating tasks like spraying, monitoring, and mapping that would otherwise be time-consuming and labour-intensive.

Technologically speaking, farms are changing as a result of the incorporation of drones with other digital technologies like artificial intelligence, the Internet of Things (IoT), and geospatial analytics. Drones serve as eyes in the sky, gathering information that may be used to inform farm management through the use of AI and machine learning algorithms. With automated drone fleets or connected smart farming platforms, these insights can be utilized to anticipate yields, create prescription maps, and even make decisions on their own. Swarm drone technology may eventually allow several drones to cooperate and effectively and independently cover vast areas of land. To build a completely networked and intelligent agricultural ecosystem, these technologies may be combined with weather forecasting software, robotic harvesters, and intelligent irrigation systems. By avoiding the limitations of conventional automation, this type of technology gives emerging countries like India the chance to enter a new era of agricultural productivity (Gupta *et al*., 2022).

Looking ahead, precision agriculture made possible by drones is significant not only because it can boost agricultural productivity but also because it can help farmers become more resilient to global issues. Global food security is at risk from changing climates, unpredictable monsoons, degraded soil, and an increase in pest outbreaks. By identifying stress indicators in crops before they are noticeable to the human eye, drones can act as an early warning system, allowing for quick and focused reactions. By quickly evaluating damage, directing replanting initiatives, and assisting with insurance claims, they can also be extremely important in disaster recovery. Drone use will spread beyond elite or experimental farms to become a common tool for millions of small and marginal farmers as governments and institutions start to make greater investments in Agri-tech infrastructure and policy assistance. Drones are essentially the result of a strategic fusion of innovation and necessity, guaranteeing that agriculture is not only efficient but also intelligent, sustainable, and prepared to meet future demands (Singh *et al*., 2021).

Challenges and Opportunities of Precision Agriculture Facilitated by Drones in the Future:

Drone-assisted precision agriculture has the potential to revolutionize agriculture, but it is hampered by a number of serious issues. Many small and marginal farmers cannot afford the high upfront expenses of drone equipment, sensors, and data analysis software, particularly in developing nations. Another obstacle to efficient utilization is a lack of technical expertise and trained personnel to fly drones and decipher complicated data. Drone deployment is made more difficult by regulatory concerns such limited airspace, licensing requirements, and ambiguous data ownership policies. Real-time data processing and integration with other smart farming instruments are further restricted by infrastructure constraints, such as limited digital infrastructure in rural areas and poor internet connectivity. Additionally, drones' usefulness in large-scale or difficult terrain may be diminished due to their sensitivity to weather conditions, limited battery life, and cargo capacity (Smith *et al*., 2020).

However, precision agriculture made possible by drones presents a plethora of opportunities that have the potential to completely transform contemporary farming methods. Farmers can monitor crop health, identify pests and illnesses early, and apply fertilizers or pesticides with pinpoint accuracy thanks to drones' high-resolution aerial imagery and real-time data, which also drastically lowers input costs and their impact on the environment. By swiftly covering vast areas, getting to difficult-to-reach places, and lowering labor dependency, they improve efficiency. The potential for broad adoption grows as technology develops and becomes more accessible, particularly with government backing, public-private collaborations, and customized hiring models. Drone capabilities can be further increased by integration with AI, machine learning, and IoT, enabling data-driven decision-making and predictive farming. In the end, drones have the potential to significantly contribute to sustainable agriculture, increase food security, and enable farmers to meet the demands of a growing world population and climate change (Singh *et al*., 2021).

CONCLUSION

In summary, using drone technology into crop health management is a revolutionary step toward achieving "Vikshit Bharat", a vision of agriculture that is not just resilient, sustainable, and technologically advanced, but also productive. Drones eliminate long-standing issues in disease and pest management while reducing input costs and environmental impact by enabling the precise, effective, and timely administration of fungicides and insecticides. In addition to improving produce quality, this strategy protects farmer health and promotes the long-term health of the soil and ecosystem. A new era of intelligent, climate-resilient, and internationally competitive agriculture will be ushered in as India adopts this innovation, bolstered by progressive policies, training programs, and equitable access models. Drone-enabled precision agriculture will become a fundamental component of contemporary farming.

REFERENCES

Gupta, S., Sharma, R., Patel, A. and Mehta, K. (2022). "Role of Drones in Crop Health Management: A Case Study in Indian Agriculture." *Agricultural Drones and Robots*, 79-96.

Mishra, A., Kumar, S., Verma, R. and Singh, P. (2020). "Emerging Trends in Precision Agriculture: A Review." *Journal of Agricultural Engineering and Biotechnology*, 8(3):119-132.

Patel, A., Mehta, K., Sharma, R. and Gupta, S. (2019). "A Review on Applications of Drone in Agriculture." *International Journal of Engineering and Advanced Technology*, 8(5):1045-1049.

Singh, R., Kumar, S. and Mehta, K. (2021). "Drone Technology for Sustainable Agriculture: Opportunities and Challenges." *Sustainable Agriculture Reviews*, 47:47-65.

Smith, J. R., Johnson, M. L. and Williams, T. S. (2020). "Drones in Agriculture: A Comprehensive Review of Applications and Challenges." *Journal of Unmanned Vehicle Systems*, 8(3):214-238.