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Drones: An Advanced Technique in Precision Pest Management

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One of the major components in precision agriculture is crop health monitoring, which includes irrigation, fertilization, pesticide sprays, and timely harvest of the crop. Drones are semi-automatic devices that are continuously shifting toward fully automatic devices which have enormous potential for agricultural planning and pest management. The drone mediated technologies in pest management demonstrate great scope and promising alternative to conventional pest management approaches, should be positively promoted in Indian agricultural research and technology development, and encouraged widely for the effective utilization as a part of integrated pest management practices

Introduction

Precision farming in particular precision pest management is a favourite buzzword in today's agricultural discussions and promoted as an integral part of **integrated pest management** (IPM) which promises economic benefits for the farmers and environmental benefits for society. The **drone mediated technologies** which are reliable and cost effective being advocated in the **precision pest management** in many parts of the world and play a pivotal role in precision agriculture. The commercial use of drone in agricultural fields or forests has been limited to a few countries which need to be positively promoted in Indian agricultural research and technology development, and encouraged widely in pest management practices (Shamshiri *et al*., 2020).

What is DRONE?

A drone is **an unmanned aerial vehicle (UAV)** that is controlled remotely by a human operator or autonomously by an on board computer. Both **sensing and actuation technologies** for improved crop monitoring, advanced imaging solutions and precision treatment applications can be mounted on the drone. Hence, drone assisted precision insect pest management is a novel technological approach in the 21st century agriculture and operated as a multi-disciplinary research collaboration between agronomists, entomologists, software programmers, and engineers (Shamshiri *et al*., 2020).

Objectives of drones in pest management

- Deployment and performance of UAV for crop spraying
- Development and Evaluation of Drone Mounted sprayer for pesticide applications to crops.
- To determine the spraying systems by varying sprinkling speed with different Nozzle types.
- Challenges and outlook for the development of UAV pesticide application technology.
- To evaluate Droplet deposition at different altitudes of drones on various crops.

Different categories of UAV used in crop spraying

1. Fixed and Flying wing
2. Vertical take -off and landing
3. Single Rotor Helicopter
4. Multi-Rotor drone

Distinguish features of Rotary & Fixed wing drones

Rotary wing	Fixed wing
Vertical take-off landings	Hand / catapult launched
Ability to hover for long period	Limited Hovering ability
Limited flight time *i.e.*, Low endurance (20-30 Minutes)	Longer flight time; cover a large area (1 hour)
Requires more maintenance	Requires less maintenance
Relatively inexpensive	More expensive

Insect pest management by drones is of two fold

1) Reflectance-based crop monitoring can be used to identify pest hotspots by using drone mounted sensors. These are categorically referred as **Sensing drones**.

2) Precision application of agro chemicals & natural enemies by using drones. These are commonly referred as **Actuation drones.**

Acquired and processed canopy data obtained with sensing drones could potentially be transmitted as a digital map to guide a second type of drone, actuation drones, to deliver solutions to the identified pest hotspots, such as precision-release of natural enemies and precision-sprays of pesticides (Keller and Shields, 2014).

Spraying Mechanism

- For the spraying of pesticides on crops, the spraying arrangement has been used which helps in spraying the fertilizers or pesticides on the crops.
- For this a tank has been used for storing the pesticide and the sprayer has been technically connected to the tank which helps in spraying the pesticides.
- There is a nozzle being connected which when switched ON, starts the motor placed in the tank to pump the pesticide through the pipe with the power generated by the battery.
- To avoid the wastage of pesticide a uniform pressure has been applied to designate in the respective point of interest

Drones for monitoring insect pests in the field

Drone mediated remote sensing

- Drone-based remote sensing technologies offer several advantages that make them attractive for use in precision insect pest management.
- Sensing drones potentially allow for coverage of larger areas than ground-based, handheld devices.
- It is important to note that with remote sensing, not the pests themselves are detected, but patterns of canopy reflectance that are indicative of insect pest-induced plant stress. Hence, field observations to confirm the presence of specific insect pest remain necessary.

Drone mediated aerial photography

- Drone technology can provide farmers with a bird's-eye view of their farm field and allow them to make crucial management decisions in real time.
- While depending on spectral camera technology, drones can capture the images of farmland, and these images can be utilized for analysing the occurrence of insect pests.

- The images captured by drones are transmitted to the cloud data centre for analysing the degree of damage of pests based on spectrum analysis technology.

Drone mediated insect pest sampling

- A drone-attachable apparatus for trapping airborne insects either as position-fixed traps or freely movable traps can be sufficiently well developed and utilized for insect pests sampling.
- A double-charged dipolar electric field screen (DD-screen) attached with drone which forms an electric field between to create an attractive force to capture the insects that enter the electric field and is sufficiently strong that it prevents the captured insects from escaping the trap.
- A rotary-wing unmanned aerial drone with 2 remote-controlled insect nets that allows aerial sampling exclusively at designated altitudes developed in South Korea was successfully utilized for the sampling of insect pests in rice ecosystem.

Drones for controlling insect pests in the field

Crop monitoring: Drones come with a variety of features, including multi-spectral and picture cameras. Drones can assist in effective crop surveillance by checking the field with infrared cameras, and farmers can take proactive measures to enhance the status of plants in the field based on their real-time information (Devi *et al*., 2020)

Actuation Drones for Precise Application of Pesticides: While sensing drones may aid in the detection of pest hotspots, actuation drones may aid in the control of pests in these areas. Agri-drones can be used to spray chemicals since they have reservoirs that can be filled with pesticides for spraying on crops in very precise duration, as compared to traditional methods. As a result, drone technology has the potential to user in a new era of precision agriculture (Devi *et al*., 2020).

Better crop management: Many start-ups have also created drone planting systems that allow drones to shoot pods, their seeds, and spray crucial fertilizers into the soil. As a result, this technology improves the consistency and effectiveness of crop management while also lowering costs, hence boosting the agriculture sector's production and efficiency

Actuation drones for precise release of natural enemies: Drones could be a particularly valuable tool for augmentative biological management, which relies on the release of natural enemies on a massive scale for quick pest control. They could deliver natural enemies to exactly where they're required; thereby increasing biocontrol product efficacy while lowering distribution costs

Drones for matting disruption and sterile male technique: The introduction of sterile insects by drones is a potential new application in pest management.

The codling moth, *Cydia pomonella* L. (Lepidoptera: Tortricidae) is a major pest in apple orchards (*Malus domestica* Borkh.), and pilot programmes using drones to release sterile insects have been successful in reducing codling moth populations in New Zealand, Canada, and the United States (Lal and Bikram., 2019).

Advantages of drones in agriculture pest management

- Reduce the risk of pesticide to operator
- Useful in spot spraying or precision application over large areas
- Drones provide stressed and healthy images of crops
- Reduce the amount of formulation during spraying
- Drones are portable, foldable and accessible to inaccessible areas
- Drones change the flight velocity flexibly to reduce drift hazard

Disadvantages of drones in agriculture pest management

- High costs

- Requires skilled labour for operation
- Complexity in collection of data, its analysis and interpretation
- Can't be used during adverse climatic conditions
- Applicable only for large scale spray
- Drone Crashes
- Flight drones are covered by aviation law

Drone technology: to combat desert locust plague

- Complementary approach in Locust control.
- Drones can target small swarms
- Drones are specially fitted with Ultra Low volume sprayers along with spectral cameras.
- Enables mapping and precision spraying.
- Determine the extent of desert locust eradication from spraying operations.
- Two types of drones are available one with Fixed wing and the other with rotary wing used for survey and management of desert locust.
- However, a challenge is to find more accurately a small green patch of vegetation in the desert that may possibly contain locust infestations.

Economics of drone

- Cost of typical VTOL(Vertical Take-Off Landing) UAV(Unmanned Areial Vehicle) with 10-15 lit carrying capacity is about Rs. 12 lakhs (with minimum spares) in India.
- Total live VTOL in most favoured conditions lasts for 1000 landings (if any incidents do not occur).
- It means per landing construction of VTOL comes to 1200 Indian Rupees. In addition to it, other overheads will add like cost of pesticide, cost of labour, cost of transport, cost of operating overhead, cost of maintenance of UAV and profit of company.
- This roughly comprises to 2000 Indian Rupees per flight.
- In each flight UAVs are expected to cover only 1 acre (in *Kharif*).
- Therefore, the cost of operating VTOLs for crop spray becomes unaffordable.
- It is also observed that the cost of UAVs and operating overheads have not reduced that drastically over the years (Mahendran *et al*., 2021).

The Union Ministry Of Agriculture and Farmers Welfare has issued guidelines to make drone technology affordable to the stakeholders

- In 2022 Budget speech, Finance Minister Nirmala Sitharaman highlighted the government's resolve to promote what are being called kisan drones.
- On 23rd January 2022, to promote the use of drones for agricultural purposes and reduce the labour burden on the farmers, the government of India has recently offered, a 100% subsidy or 10 lakhs, whichever is less, up to March 2023 to the Farm Machinery Training and Testing Institutes, ICAR Institutes, Krishi Vigyan Kendras & State Agriculture Universities.
- Additionally, a contingency fund of Rs.6000/hectare will also be set up for hiring Drones from Custom Hiring Centres (CHC). The subsidy and the contingency funds will help the farmers access and adopt this extensive technology at an inexpensive price.
- The contigent expenditure to implementing agencies that purchase drones for drone demonstrations would be limited to Rs.3000 per hectare. The final assistance and grants would be available until March 31,2023.
- The farmers producers organizations(FPOs) would be eligible to receive grant upto 75% of the cost of agriculture drone for it's demonstrations on the farmers fields.
- In order to provide agriculture services through drone application, 40% of the basic cost of drone and it's attachments or Rs.4lakh, whichever less would be available as financial

assistance for drone purchase by existing Custom Hiring Centres which are setup by Cooperative Society of Farmers, FPOs and Rural entrepreneurs.

- The drone operations are being permitted by Ministry of Civil Aviation (MoCA) and Director General of Civil Aviation (DGCA) through the conditional exemption route. MoCA has published Drone Rules 2021.

Conclusion

Drones are increasingly being used in precision agriculture and integrated pest management. Drones equipped with remote sensing equipment (sensors) are used to monitor crop health, map out crop performance variations, and detect insect outbreaks. Early detection and response to inadequate abiotic conditions may prevent large pest outbreaks; hence they could be used as decision support tools. Different drones (actuators) could be used to deliver quick solutions to recognized pest hotspots if outbreaks occur. Automated pesticide applications and/or biological control organism release via communication between sensor and actuation drones, is the future. This strategy necessitates multidisciplinary research involving engineers, ecologists, and agronomists, and it has huge commercial potential.

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Spraying of chemicals through drone in different crop ecosystem in insect pests and disease management (Source- Internet images)