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ORIGINAL PAPER

Drones- application in agriculture pest management

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ABSTRACT

A reduction in global food grain production is majorly a result of the biotic stresses caused by diseases and pests which are well-known to cause devastating damage. It is therefore needs meticulous monitoring and genuine technology capsules to save the crops from devastation from these pests. 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

A reduction in global food grain production is majorly a result of the biotic stresses caused by diseases and pests which are well-known to cause devastating damage. Recently, the invasive alien pests like rugose spiralling whitefly in coconut (*Aleurodicus rugiperculatus* Martin) and fall army worm (*Spodoptera frugiperda* J. E. Smith) in corn threatening the crops cultivated in India by causing extensive damage during 2018 and 2019 (Lal and Bikram, 2019) and still it is in consideration. Therefore, meticulous monitoring and genuine technology capsules are to be adopted to save the crops from devastation from these pests. Several plant protection strategies are being followed in a consolidated way to ensure that crops are protected during the throughout the crop growing season. Community based approach are to be taken in order to make sure the effective management of pest and diseases that invade the growing crops. It is very difficult to manage the invasive pests, since more than 80 per cent of the farmlands in India belong to small and marginal land (<1 ha) category. The pests simply shift their

feeding to the neighbouring fields if one field is sprayed. The utilization of pesticides that are sprayed on the crops does not exceeds 20–30 per cent and the remaining 70–80 per cent goes as leaching, run-off, drift, and evaporation that cause aquatic and soil pollution as well as deteriorate the quality of the crop and food produce (Markle *et al*., 2016; Torrent *et al*., 2017).

The traditional techniques used for pesticides and fertilizer spraying require more time and are less effective, thus there is a need for technological advancement in this segment [FAO, 2018; Rolle *et al*., 2020]. Effective and timely spraying of plant protection measures is very important under such circumstances. For this, miniaturized unmanned aerial vehicles which are also known as drones which possess a wide array of benefits including high efficiency, reduced labour requirement, vast area coverage, saving of time and energy and quick response time, as well as environmental safety (Meng *et al*., 2018; Shamshiri *et al*., 2018). Drones are gaining traction even as a method for controlling insect pests in the agriculture sector.

Table. 1 Use of drone in various fields

Sl. No.	Industry	Drone application
1	Infrastructure	Investment monitoring, maintenance, asset inventory
2	Agriculture	Analysis of soil and drainage, crop health monitoring, yield prediction, pesticides and fertilizer spot spraying
3	Transport	Delivery of goods, medical logistics
4	Security	Monitoring lines and sights, pro-active response
5	Entertainment and Media	Advertising entertainment, aerial photography, shows and special effect
6	Insurance	Supporting claims, settlement process, fraud detection
7	Telecommunication	Tower maintenance, signal broadcasting
8	Mining	Planning, exploration, environmental impact assessment

AGRICULTURAL DRONE

Drones are semi-automatic devices that are continuously shifting toward fully automatic devices. These devices have an enormous potential for agricultural planning and related spatial information collection. In spite of some innate barriers, this technology can be utilized for productive data analysis (Grammatikis *et al*., 2020). Initially, the drone was originated as a military tool and was given different names such as Unmanned Aerial Vehicle (UAV), Miniature Pilotless Aircraft, or Flying Mini Robots. Nowadays it is being utilized in the business sector, infrastructure sector, farming, security, insurance claims, mining, entertainment, telecommunication, and transport sector, etc. Nowadays, the application of small unmanned aerial vehicles (UAVs) is growing at a very fast rate in agribusiness (Ramirez and Galvez, 2019; Devi *et al*., 2020; Giacomo *et al*., 2018).

TYPES OF DRONES

a. **Single Rotor Helicopter Drones** – They look exactly like tiny helicopters and can be gas or electric-powered that can be used to survey land, research storms and map erosion caused by global warming.

b. **Multi-Rotor Drones –** They are usually some of the smallest and lightest drones on the market. These drones can usually spend 20-30 minutes in the air carrying a lightweight payload, such as a camera.

c. **Fixed-Wing Drones** – They look like normal airplanes, where the wings provide the lift instead of rotors- making them very efficient. These drones usually use fuel instead of electricity. Fixed-wing UAVs are used by the military to carry out strikes, by scientists to carry large amounts of equipment and even by non-profits to deliver food and other goods to areas that are hard to reach.

d. **Fixed-Wing Hybrid VTOL Drones** – They are a blend of fixed-wing drones and rotor-based drones, featuring rotors that are attached to the wings. Due to its hybrid approach, this technology offers users the endurance of a fixed-wing design and the vertical flying capabilities of a rotor-focused design.

Single Rotor Helicopter Drone

Multi-Rotor Drones

Fixed-Wing Drones

Fixed-Wing Hybrid VTOL Drones

Working principle of Sprayer drone:

The basic components of any drone are Brushless Direct Current Motors (BLDC), Electronic Speed Control (ESC), flight controller, Camera, Transmitter and Receiver. The main parts of any spraying system are the pump and its controlling system. In accessories: Accelerometer, gyroscope, GPS are used for controlling the drone.

To design a drone for spraying application, the first step is to estimate the payload. Components of the drone are selected after the calculation of payload. Battery selection depends upon the current and voltage requirements of the drone modules. Finally, the frame of the drone is designed that depends upon the number of arms and payloads. First UAV (unmanned helicopter) for pesticides application was developed by Yamaha Motor Co. Ltd., Shizuoka Japan in 1983.

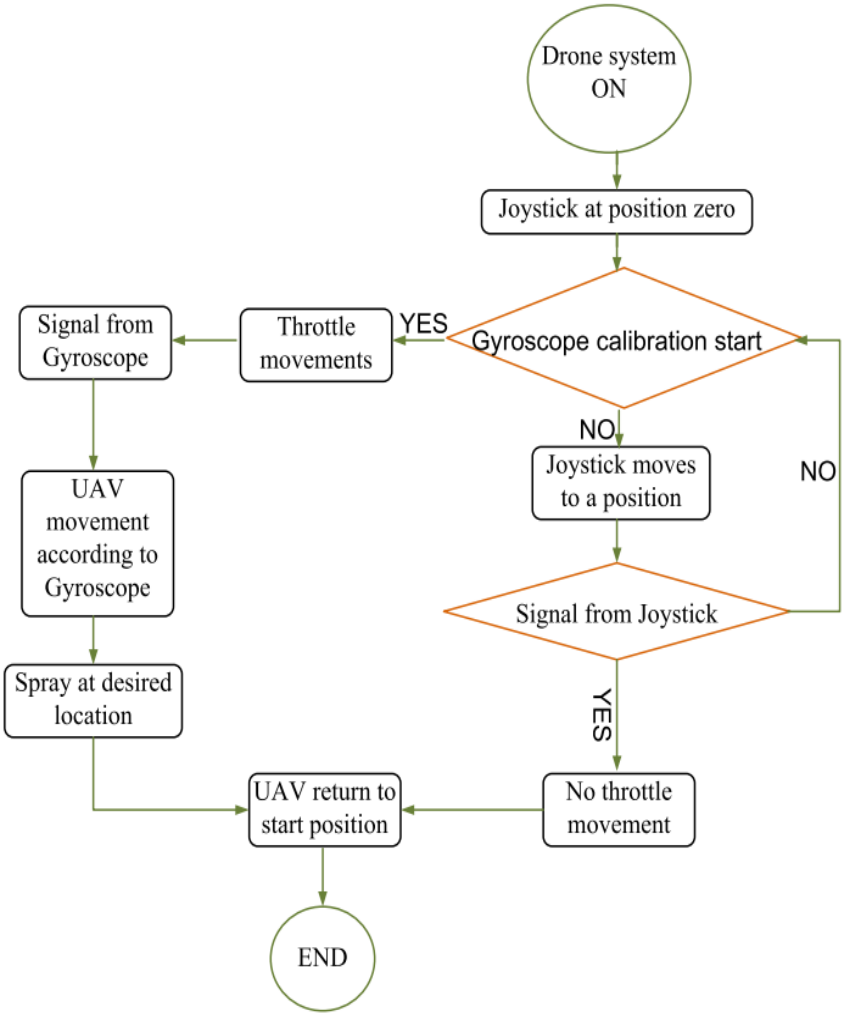

Fig. 1 Workflow diagram of Sprayer drone

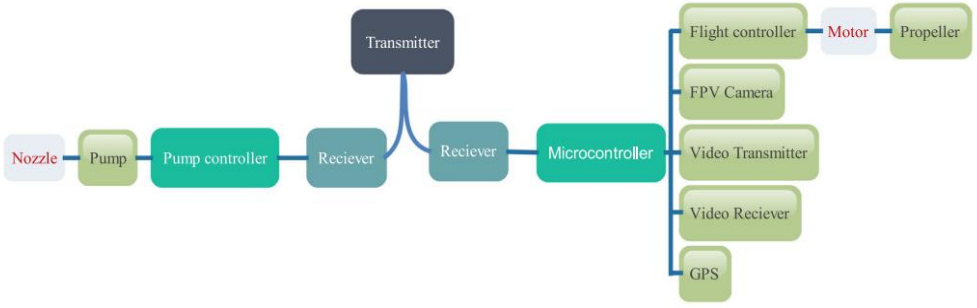

Fig. 2 Flow chart of Semi controlled UAVs for pesticide application.

APPLICATIONS IN INSECT PEST MANAGEMENT

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 likely allow the coverage of vast areas than handheld, ground-based devices. Particular biotic stresses, such as insect pest infestations, bring about physiological plant responses, lead to changes in the plants ability to perform photosynthesis and thus leads to changes in leaf reflectance spectral range. Drone can be equipped with an RGB (red green blue) sensor for aerial remote sensing, which is a multispectral sensor with between 3 and 12 broad spectral bands, or a hyper-spectral sensor with hundreds of narrow spectral bands (Keller and Shields, 2014). It is need 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-mediated aerial photography has enabled plant pest surveillance with clustering of wireless sensors and networks and precision agricultural design. Drone technology can give farmers with a great aerial view of their farm field and allow them to make crucial management decisions in problem solving time. 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 (Gao *et al*., 2020).

Drone mediated insect pest sampling

A drone-attachable apparatus is available 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 DD-screen (double-charged dipolar electric field screen) is attached with drone which forms an electric field between to create an attractive force to capture the insects that enter the electric field. The electric field is sufficiently strong that it prevents the captured insects from escaping the trap (Takikawa *et al*. 2020).

Drone mediated precision application of insecticides

An actuation drone could help control the pests at hotspots of the farm field through variable rate of application of insecticides. Novel types of drone fitted with crop dusters and/or spray equipments and available as commercial drones are currently being developed in different part of the world. Along with precision monitoring, precision application of pesticides could reduce the total number of sprays and thus contributing to reduced pesticide use and decreased resistance development in insects, as well as increased presence of natural enemies in the field.

Drone mediated precision releases of natural enemies

Now a day, drones are useful tool for augmentative biological control, which depends on the extensive release of natural enemies for immediate control of pests. They could distribute the natural enemies in the exact locations where they are needed, which may level up the efficacy of bio-control agents and reduce costs of distribution.

Drone mediated Sterile Insect Technique (SIT) and mating disruption

Another possible area for use of drones in pest management is the release of sterile insects. Experimental programs to release sterile insects with drones have been successful in controlling codling moth populations in Canada, New Zealand and the USA. Furthermore, experimental programs for control of cotton pink boll worm and Mexican fruit fly in citrus, with drone-released sterile insects proved effective for control of these pests in the USA

Advantages of drones in agriculture pest management:

- ♣ High payload capacity
- ♣ Higher flight time
- ♣ Higher speed
- ♣ Strong and durable
- ♣ Access to remote areas
- ♣ Petrol or gasoline powered UAV (unmanned aerial vehicle)
- ♣ Vertical take-off and the ability to land vertically
- ♣ Hover, and fly forward, backward
- ♣ Less time consuming
- ♣ Low labour requirement

Disadvantages:

- ♣ High costs
- ♣ Requires skilled labours 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

Future Prospects:

There is a ramp in drone application for precision agriculture after 2017. This is due to the reduction of weight, cost of UAVs, and increment in payload capability. Drones used in crop health monitoring and livestock detection are mainly multi-copter and fixed-wing types. The size and cost of these drones are continuously reducing day by day. Cameras are shifting from RGB to multispectral cameras and the operation has been shifted from semi-controlled to fully automated systems. But still the growth of drone

technology is in its early stage and maybe a scope for further development in both the technology and the agriculture applications. The major challenges are the cost of technology, limited battery life of drones, vision destruction, literacy about technology to enduser, and shortcomings of image processing and data analysis.

CONCLUSION

Drones are becoming progressively adopted as part of precision insect pest management. Drones with sensors (remote sensing equipments) are deployed to monitor crop health, map out variability in crop performance, and detect outbreaks of pests, insecticide application, and release of natural enemies. Despite progress in drone mediated technologies in precision agriculture in the past decade, the commercial use of drone in agricultural fields or forests has been limited to a few countries including the United States, China, Japan and South Korea. 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.

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