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Development of a Drone-Mounted Device for Aerial Application of Mating Disruption Agents in Agriculture

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ABSTRACT

In recent years, drones have been increasingly adopted to reduce workforce and improve the efficiency of pest control in agriculture. However, most drones are optimized for spraying low-viscosity liquid pesticides and thus have limitations in stably applying high-viscosity liquid or solid formulations. In particular, the mating disruption agent (MDA) used in this study, which contains pheromones, must be attached to the crown to maximize pheromone diffusion. It is necessary to develop a technology that can stably spray and attach MDA and adhesives.

In this study, we developed a drone-mounted mission device for the aerial application of high-viscosity adhesives and solid MDAs. The device consists of four modules: supply, mixing, conveying, and discharge. The supply module loads the MDA, while the mixing module employs a screw mechanism to uniformly combine the adhesive and the MDA. The blended material is then transported via a conveyor in the conveying module to the discharge module, where it is evenly distributed using a rotating brush.

The system was fabricated with lightweight materials, keeping the total weight—including the MDA—below 10 kg to ensure compatibility with the payload capacity of commercial agricultural drones. A modular design enables installation on multiple UAV platforms (e.g., DJI, EFT, AXG), and each module is equipped with a motor whose speed can be adjusted in real time to ensure stable operation under varying conditions. Field validation demonstrated an application rate exceeding 1.2 kg/ha and an operational efficiency above 80%. Furthermore, by orienting the discharge direction opposite to the flight path, losses caused by propeller downdraft were reduced, thereby improving deposition uniformity and adhesion.

This mission device is expected to enhance the automation and precision of drone pest control operations through repeated field validation. Ultimately, it can be capable of stably applying diverse formulations, thereby improving field applicability and contributing to the advancement of smart agriculture.

Keywords: Drone, Aerial Pest Control, Mating Disruption Agent, Forest Pests, Pheromone

INTRODUCTION

Unmanned aerial vehicles (UAVs) are widely used in agriculture to reduce workforce and improve the efficiency of pest control, with particularly increasing application in the field of pest

management, which directly influences crop productivity and economics. Accordingly, in addition to conventional pesticide spraying methods, MDAs—an advanced preventive control method that interferes with pest mating activities to reduce population levels and suppress subsequent generations—have been introduced. However, most commercial UAVs for pest control have been developed for low-viscosity liquid pesticide spraying, resulting in limitations in application due to the formulation characteristics (ref). Furthermore, MDAs have been primarily developed for fruit orchards and are typically applied manually, which poses challenges for large-scale or field applications such as forestry. Therefore, in order to expand the applicability of UAV-based pest control technologies, the development of dedicated mission devices capable of aerially dispersing various formulations is required. This study developed a commercial drone-mounted mission device capable of reliably mixing, transporting, and spraying high-viscosity adhesives and solid mating disruptors.

MATERIALS AND METHODS

FABRICATION

The developed mission device consists of four modules: supply, mixing, transfer, and discharge, and was designed based on the commercial agricultural drone (DJI Agras T10). The supply module is designed to be directly attached to the commercial drone's spray canister, stably delivering a solid mating disruption agent containing pheromone to the mixing module. The mixing module uses a screw mechanism to uniformly mix the mating disruption agent with the adhesive. The transport module conveys the mixture at a constant speed via a conveyor belt, and the dispensing module disperses the mixture into the air via a rotating brush. Considering the drone platform's load capacity of 10 kg, lightweight aluminum and PLA materials were used to reduce the weight of the entire mission device, resulting in a total weight of less than 10 kg, including the MDAs. Compatibility with various drone platforms was ensured, and the motor speed of each module was designed to be controllable in real time.

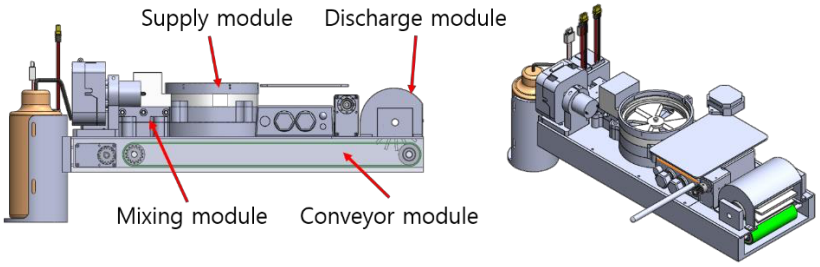

Fig.1 3D modeling of drone-mounted mission device.

FIELD DEMONSTRATION

The field demonstration was conducted at a 1ha chestnut farm in Chungju, Korea. The drone's flight conditions were set at an altitude of 7 m, a speed of 7 m/s or less, and a working path length of 3 km. The performance of the mission device was evaluated using the spraying amount per unit area (kg/ha) and the spraying success rate (%). The spraying success rate was calculated by counting the number of MDAs that fell to the ground after spraying and subtracting them from the total sprayed amount, the diameters of the MDAs used for control were 3 mm and 5 mm.

RESULTS & DISCUSSION

The developed mission device stably performed the entire process of supply-mixing-transport-discharge. Under test flight conditions, it achieved a spraying capacity of more than 1.2 kg/ha and a spraying success rate exceeding 80%, demonstrating that the device possesses sufficient spraying capability for practical field operation. The discharge module was designed to spray in the opposite direction of the flight path to minimize interference with the propeller downdraft, resulting in improved spray uniformity and surface adhesion. The screw mechanism of the mixing module enabled homogeneous mixing of the adhesive and mating disruptor, preventing clogging inside the device, and stable viscosity was maintained throughout actual operation. The use of lightweight materials and a modular design enhanced the ease of maintenance of the mission device, and compatibility was verified with various drone platforms (e.g., DJI, EFT, AXG). Unlike conventional UAVs developed exclusively for liquid pesticide spraying, this device demonstrated technological differentiation by stably handling multiple formulations, thus proving its potential to expand the applicability of UAV-based pest control technologies.

CONCLUSIONS

In this study, we developed a drone-mounted mission device and verified the performances of capable of stable aerial spraying of high-viscosity adhesives and solid MDAs. The device is enabled stable spraying, demonstrating its field applicability in terms of spraying rate and efficiency with its modular structure consisting of a supply, mixing, conveying, and discharge section. This device refined the limitations of existing drone platforms and expanded the potential for the use of 3 mm and 5 mm diameter mating disruptors and high-viscosity formulations. Further research on mating disruptors and adhesives for pesticide application is needed. The results of this study are significant in that they lay the foundation for evolving agricultural drones beyond simple liquid pesticide spraying tools into general-purpose mission platforms capable of handling next-generation agricultural materials.

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