UNMANNED AERIAL SYSTEMS IN AGRICULTURE: PART 3 (MID-SIZED UAS)

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Abstract

In recent years, the agribusiness industry has been trying to keep pace with rapid developments, one of which is in the sector of small unmanned aerial systems (UASs). These systems have gained the attention of growers and researchers alike. Undeniably, the reach of this technology in agricultural decision making is only limited by the imagination. We must look beyond small UAS to realize the full potential of UAS technologies in precision agriculture. This publication describes the domain of mid-sized UAS with pertinent discussions on their suitable use, including case-study scenarios of such in agricultural production management.

Introduction

An unmanned aerial system (UAS) with a gross weight of less than 55 lb (25 kg) is classified as a small UAS by the Federal Aviation Administration (FAA 2015; Khot et al. 2016). Currently, the FAA does not provide a classification for a UAS beyond small UAS. However, the US Department of Defense (DOD 2011) has categorized UAS into five groups according to the gross weight and operating altitude and speed, with Group 1 (0–20 lb; less than 1,200 ft above ground level [AGL]) and Group 2 (21–55 lb; less than 3,500 ft AGL) falling under the FAA definition of small UAS. Group 3 includes systems with a maximum gross takeoff weight of less than 1,320 lb and an operating altitude of less than 18,000 ft above mean sea level.

For the following discussion, we are considering Group 3 as a "mid-sized UAS" (Figure 1). Some examples of commercially available small- and mid-sized UAS, developed for non-imaging type applications, are listed in Table 1 with additional details at Homeland Surveillance & Electronics LLC (2015), Hayhurst et al. (2016), Yamaha (2016), and Hill (2018).

Figure 1. Small- (top) and mid-sized (bottom) UAS being tested for orchard spraying application. (Photos by Lav Khot, WSU.)

As of today, irrespective of small- or mid-sized UAS, FAA regulation dictates that they need to be operated within line-of-sight and during daytime, including twilight hours, only. For small UAS, commercial operations need to be performed under [FAA Part 107 operating rules and guidelines](#)

For any other higher gross weight UAS, commercial operations need to be performed through UAS specific certification of waiver/authorization (COA) with section 333 exemption from the FAA. Detailed procedures for obtaining such [COA](#) can be found on their website.

Table 1. Examples of commercial small- and mid-sized unmanned aerial systems (UASs) for non-imaging applications.

Model/Type*	Usable Payload (lb)	Rotor Type/ Dia. (ft)	Power Source	Approx. Flight Time (min)	Autonomy (Remote control /Auto pilot)	Application Areas	Manufacturer
Agras MG-1 (Small)	19.4	Multi/1.8	Li-Po battery	10	Y/Y	Liquid spraying	DJI Science and Technology Corp.
AG-8A (Small)	22	Multi/ 1.5–2.5	Li-Po battery	10–20	Y/Y	Liquid spraying	Homeland Surveillance & Electronics LLC.
AG-RHCD-80-15 (Mid-sized)	33.1	Single/3.2	Gas	10	Y/Y	Liquid spraying, granular	Homeland Surveillance & Electronics LLC.
RMAX (Mid-sized)	35.3	Single/10.3	Gas	> 60	Y/N	Liquid spraying, granular	Yamaha Motor Corp.
JF01-20 (Mid-sized)	44.1	Multi/~1.0	Li-Po battery	8–12	Y/N	Liquid spraying	Wei Jia UAV Technology Corp.
Fazer (Mid-sized)	52.9	Single/10.2	Gas	> 60	Y/N	Liquid spraying, granular	Yamaha Motor Corp.
DP-14 Hawk (Mid-sized)	430	Dual/13.0	Gas	144	Y/Y	Liquid spraying/ Search & Rescue	DPI UAV Systems.

*This list is not inclusive.

Field Operation

Ideally, one pilot and one observer form a team to safely operate a mid-sized UAS. Mid-sized UAS have a relatively large form factor (size) and gross weight compared with small UAS; thus, they require highly skilled operators, often with a commercial pilot license for field flights. Mid-sized UASs are operated with remote control systems, thereby creating less risk to pilots than manned helicopters in low altitude field operations. As the industry advances, the flight technology, including autonomous operational capabilities, are being added to the upcoming platforms. The idea is to use the same platform for multiple applications, similar to that of a tractor, which can not only scout the field for anomalies but can also perform other operations in crop production management.

A WSU team held field demonstrations and meetings with stakeholders (progressive growers and academia) in July 2015 and follow-up meetings in 2017 and 2018 to get their input on the desired attributes for successful commercialization and adaptation of mid-sized UAS technology in crop production management. Stakeholders expressed need for the following integral attributes of such mid-sized UASs: heavy payload lift capabilities (1); versatility of attachments (2); reliable accuracy of global positioning system for way-point guided autonomous flights (3); extended flight time (in hours) (4); flexibility of night operations (5); on-farm (off-road) vertical takeoff and landing capabilities in restricted space (6); robust fail-safe configurations (7).

Agricultural Applications

Most UASs are being optimized and used for imaging-type agricultural applications. Commercialized optical sensing technologies integrated with UASs are being used for mapping fields and for rapid and reliable pest and disease symptoms detection in a variety of cropping systems. Going beyond crop scouters, mid-sized UASs can be utilized for non-imaging-type applications. For example, mid-sized UAS have been used in Japan since the 1980s for crop seeding and spraying of liquid and granular agrochemicals (Yamaha 2016). Such UAS have versatile applications in variable or rough terrains where farmers have poor access to fields during crop production season.

Traditionally in US agriculture, manned, full-size helicopters and fixed wing planes were used for imaging as well as agrochemicals spraying and dusting applications in row and field crops. Such operations in irregularly-shaped fields scattered over the semi-rural landscapes with power lines, communication towers, and residential or commercial development areas is a known risk to human life. In an encouraging move for the UAS industry, the FAA has approved (in 2015) mid-sized UAS (Yamaha RMAX; see Table 1 for specifications) for commercial agricultural operations. A University of California-Davis team has successfully tested UAS for chemical applications in rolling vineyards, specifically, testing whether they might be more efficient and safe compared to ground sprayers and manned helicopters (Bailey 2013).

Besides spraying, mid-sized UAS have the potential to be used for crop loss management, especially in horticulture. In sweet cherry orchards, seasonal summer rain can induce fruit splitting or cracking. Fruit cracking may also lead to premature decay making them commercially unmarketable. In the Pacific Northwest, growers currently utilize traditional helicopters that fly over cherry crops after a rainfall to remove rainwater from cherry fruit surfaces and canopies. However, this process proves to be costly and dangerous.

As an alternative, a research team at WSU has tested a Yamaha RMAX with a rotor diameter of 10.3 ft (3.1 m) for effective rainwater removal (Zhou et al., 2016; Figure 2). A mid-sized UAS hovering above the tree canopies was able to generate sufficient wind and air downwash to remove rainwater from canopy surfaces. The results have been promising,

Figure 2. A mid-sized UAS (Yamaha RMAX) flying over cherry tree canopies. (Photo by Lav Khot, WSU.)

especially in modern cherry architectures. At maximum gross payload, a mid-sized UAS was able to effectively remove 88 to 96% of rainwater when operated at 6 mph (2.7 m/s) and 20 ft (6.1 m) above ground level. This could be a complementary and economically viable option available to small acreage growers in the region.

Ideally, growers can use such technology for a range of agricultural operations. Similar to the concept of cherry drying by utilizing wind and air downwash to remove rainwater from tree canopies, a mid-sized UAS could potentially be used for frost control in vineyards, cherry orchards, and apple orchards. By flying at an appropriate height above crops during an inversion, the air from the UAS can mix the warm air at high altitude with the cold air in the lower vineyard or orchard floor to mitigate the damage to fruit buds or flowers due to unexpected low temperatures.

Another potential application includes aerial dispensing of apple sunburn protectants to reduce the fruit loss due to warm summer temperature. UASs may also be suitable to implement site-specific crop management tools, particularly where ground sensors or scouts are used to identify problematic areas within a larger acreage block and then conduct site-specific spot spraying of chemicals. Such applications can reduce the production costs (chemicals, fuel) while promoting ecosystem stewardship.

Summary

To address the global food security challenge, we need to take advantage of all available resources. Rapid developments in emerging technologies, such as small- and mid-sized UASs, are expected to dominate the field of precision agriculture to a great extent. Researchers and Extension specialists in particular have a key role to play in the safe and meaningful "ground-to-aerial" farm management transition so that the US farming community successfully adopts the technology.

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