



Drone Technology in Floriculture : Applications from Crop Monitoring to Precision Management

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INTRODUCTION

Floriculture is one of the most sensitive and quality-dependent agriculture sectors. Market value of flowers is not dependent only on yield but also on the colour, stem length, uniformity, freshness, freedom from diseases and defects and the exact timing of harvesting. Late identification of water stress, nutrient deficiency, insects or disease may have a detrimental effect on the quality of produce of an entire crop. Traditional field scouting is useful, but it is time-consuming and may not reveal issues occurring in inaccessible or seemingly unaffected locations. Drone technology gives floriculture growers a quicker and more comprehensive look at their crop. Using aerial platforms equipped with sophisticated sensors, artificial intelligence and precision machinery, drones can transform crop surveillance into timely management decisions.



From Aerial Photography to Intelligent Crop Management

Agricultural drones or UAV (unmanned aerial vehicle) are small drones controlled remotely or autonomously that have the ability of carrying cameras, sensors as well as spraying systems. Multirotor drones are ideal for floriculture as these drones have the ability to slowly fly, hover over specific plant and the overstay at small production area.

Fixed-wing drones are used to cover larger areas, but need larger space for flying. Drones, depending on the payload, can take regular color photos, multispectral images, thermal data or 3D data. These days, software stitches together hundreds of overlapping images to create maps of crop variability. The real power of the technology, said Martin, is not in capturing pretty aerial images, but in translating those images into recommendations for irrigation, nutrition, crop protection and harvest.

Rapid Assessment of Crop Establishment

Consistent stand establishment is important in commercial flower production because the variability in population results in differences in flowering time, stem quality, and harvest length. Drone images taken a few days after planting can be used to detect missing plants, poor germination, transplant death, water-soaked patches and uneven row formation. AI models can separate plants from soil and predict the number of surviving plants in a field. This enables growers to determine the percentage of establishment and to identify areas that need to be filled or otherwise managed. In the case of bulbous ornamentals, like gladiolus and tuberose, aerial scouting can detect irregular emergence due to planting depth, inferior quality planting material or soil-related factors. Early intervention stops small establishment failures from developing into permanent gaps in the production system.

Monitoring Growth and Canopy Development

Repeated drone flights provide a continuous record of crop development and help estimate canopy cover, plant height, biomass, growth rate and bed uniformity. The 3D models through photogrammetry provides the opportunity to measure crop structure without routine field visits. Maps derived from aerial photos can reveal areas advancing above or below the field average growth rate, bringing attention to potential variability in soil fertility,

irrigation, seeding, shading, or crop health. This selective method has important role also in cut flowers, loose flowers, ornamental shrubs and nursery plants, where optimal vegetative development is a primary determinant of flowering, marketable quality and production uniformity.

Identifying Water Stress and Improving Irrigation

Uneven watering can reduce size of bloom, stem strength, quality of flowering, and life of the flower in the vase, while overwatering may promote root diseases, nutrient leaching, and weak growth. Thermal cameras mounted on drones detect variations in canopy temperature related to the plant water status since moisture-stressed plants tend to lose less heat through transpiration and exhibit higher temperatures. Thermal maps can thus identify such areas before severe wilting can be observed. When integrated with soil-moisture data and weather information, the maps can be used to help schedule irrigation, identify blocked emitters, broken pipes or under-watered areas, and allow growers to conserve water without sacrificing the quality of high-value flowers.

Precision Nutrient Management

Nutrient imbalance can influence foliage colour, stem length, flowering intensity, bloom uniformity and postharvest quality. Multispectral drone cameras can capture reflected light outside of the visible spectrum, and vegetation indices calculated from the images can indicate differences in chlorophyll activity, canopy vigour and plant stress. Areas with low vigour can be due to nutrient deficiency, root damage, poor drainage or other limiting factors and thus need to be checked with field inspection and plant or soil analysis. After the cause is identified, fertilizers and amendments can be targeted to affected areas, minimizing input use, reducing production costs, preventing losses of nutrients and improving flower production homogeneity.

Early Detection of Diseases and Insect Pests

Diseases and insect pests can quickly destroy the marketability of flowers as even tiny lesions, spots or deformities may render blooms unsaleable. Drone-based RGB, multispectral, thermal and hyperspectral sensors can identify changes in leaf colour, canopy temperature and light reflectance that are indicative of pest or disease stress. Artificial intelligence systems analyse the patterns and produce early-warning maps indicating where a possible infestation may be starting. Workers can then go to the affected areas, identify the organism causing the disease and start treatment before the disease becomes widespread. Drone observations, however, need to be complemented with field or laboratory diagnosis, as diseases, nutrient deficiencies and water stress can cause similar spectral symptoms.

Flower Counting and Yield Forecasting

High-resolution images from drones along with computer vision can detect visible flowers by their colour, shape and location, thus reducing the workload of counting by hand. Repeated flights can follow the progression of flowering and predict the rates of buds, open flowers and harvested flowers. Growers use this data to predict yield and plan

labor, packaging, transportation and marketing around festivals, weddings and other high demand periods. The technology is sensibly adaptable for use with flowers like marigold and chrysanthemum, where the flower is prominently displayed at an angle above the canopy but overlapping flowers, leaf obstructions and background similarities can impact accuracy and therefore crop specific artificial-intelligence models are required.

Precision Spraying and Targeted Treatment

Spraying drones can quickly apply pesticides, foliar nutrients and biological products to open-field flower crops, especially in areas with wet soil, dense vegetation or bumpy land that restrict workers and tractors. They can use pre-planned routes and location-specific maps to apply treatment only to hotspots of pest, disease or nutrient deficiency rather than the entire field. This targeted application may reduce chemical usage, water usage, labour needs and worker exposure. However, the right application of pesticides also depends on careful selection of droplet size, nozzles, flight height and operating speed. Each system needs to be carefully calibrated as rotor airflow may enhance canopy penetration but may also increase drift or cause damage to delicate flowers.



Applications in Nurseries and Protected Cultivation

Drones and aerial imaging systems can assist with nursery management by counting containers, finding empty spaces, assessing canopy size, detecting irregular growth and mapping the locations of separate plant lots. Consistent imaging can also expose irrigation malfunctions, disease outbreaks and plants reaching market size, leading to better inventory management and shipping schedules. The use of drones in greenhouses is still difficult as signals can be weak and the structures, wires, screens and workers can be barriers to the movement of drones. Small drones with obstacle detection, protective guards and visual navigation might one day patrol large greenhouses, although recently fixed cameras and ground-based robots are more practical and reliable for many indoor floriculture applications.

Supporting Pollination and Biological Management

Experimental UAVs that can detect and fly to a single flower are opening up the possibility of assisted pollination in greenhouses, where natural pollinators are scarce. Potential future uses include the release of beneficial insects, the application of biological control agents, and the mapping of floral resources for commercial pollinators. These operations are less refined than aerial imaging and spraying, but they provide examples of how drones could evolve into active crop management tools. They should be used with flowers with great care as the rotor downdraft or the contact may damage petals, remove pollen or relocate other organisms that could be beneficial. Future systems will need to generate a gentle flow of air, perform reliable flower detection, and have the ability for very precise positioning, especially for high-value crops grown in protected environments.

A Data-Driven Precision Management System

The best advantage of drone technology comes when aerial observations are combined with soil analysis, irrigation files and records, weather data, and field inspections. A scheduled flight generates first maps of crop population, canopy vigour, temperature and suspected stress. They review anomalous areas, verify the cause and develop a site-specific response, such as fixing an irrigation line, adjusting a fertilizer rate, treating a disease hotspot or prioritizing a block for harvesting. A follow-up flight can assess if the intervention has had a positive effect. This repeated cycle of observation, diagnosis, action and verification transforms the drone from a simple imaging platform into an effective precision-management and decision-support system.

Economic and Environmental Advantages

The use of drones in agriculture can reduce the time taken for crop inspection, increase labour efficiency and generate digital records asset for comparing crop performances in different seasons. Site-specific management can reduce consumption of water, fertilizer, and crop-protection chemicals and the associated contamination of the environment. They also prevent soil compaction and the physical harm that comes with large agricultural equipment. Profitability, however, is a function of crop value, size of the farm, how often the system is used and how good the decisions taken based on the data are. Small growers may derive greater returns by hiring drone service providers or sharing equipment through cooperatives. Economic value should be assessed through reduced losses, improved flower quality, lower input consumption and better marketing decisions rather than technological novelty.

Practical Limitations and Challenges

Insufficient battery life, inclement weather, high sensor costs and the requirement for specialised software and trained operators all limit the uptake of drones. Fields can harbour multiple species with different flower colourations, growth habit and canopy architecture, adding further complexity to floriculture. Crop reflectance may also change by flowering and confuse models that were developed for green vegetation. Misinterpretation may lead to unnecessary treatment as nutrient deficiency, disease and moisture stress can all generate similar patterns in images. Growers must also navigate a patchwork of regulations governing drone registration, pilot certification, flight zones and pesticide application, as well as issues related to privacy, data ownership, spray drift and the safety of workers, flowers and pollinators.

Future Prospects

In the coming years, floriculture drones will become smaller, safer and more autonomous. Artificial intelligence onboard the drone may process images as the drone flies, identifying missing plants, stressed plant areas, disease patches, or flowers ready for harvesting right away. Autonomous charging stations may enable scheduled monitoring, while integration with robotic sprayers, variable-rate irrigation, greenhouse controls, and digital farm records

could create a continuously-operating decision-support system. Models for roses, chrysanthemums, marigolds, gerbera and gladiolus will become more accurate as more labelled images are produced. Adding hyperspectral and depth sensors will enhance early stress detection, flower counting and canopy measurements, but human expertise will still be required for diagnosis and final management decisions.

CONCLUSION

Drones technology enables precision management to begin in floriculture. It can help growers evaluate crop establishment, track growth, observe water and nutrient stress, locate disease hot spots, predict flower production, and apply inputs in a targeted manner. Its greatest legacy is perhaps the ability to detect what otherwise goes unseen within a field on a regular basis. But successful introduction of the technology relies on accurate sensors, analysis specific to crop types, field verification, trained operators, and sound financial planning. Drones should thus be seen not as substitutes for growers and crop specialists, but as instruments that enhance their observations and decisions. When integrated responsibly with other precision technologies, they can help floriculture become more productive, resource-efficient and responsive to demanding markets.