Virginia Cooperative Extension
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How Drones (UAVs) Are Helpful in Today's Agricultural Practices

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Introduction

Virginia's agricultural producers work diligently through all seasons—engaging in essential field activities: planting, cultivating, and harvesting. Their unwavering commitment to "Mission Nation Feeding" drives them to optimize their farming approaches and ensure food security and sustainability. Virginia's diverse geography is a unique canvas that supports a wide range of agricultural practices. With this diversity comes the challenge of tailoring management practices across different Virginia's agricultural regions. For instance, plant issues such as nutrient deficiencies and disease symptoms observed on the Eastern Shore may manifest differently at other locations such as Blacksburg or Winchester. This can be further complicated across various crops, including soybeans, peanuts, wheat, and corn.

Key Uses of Drones

To address these challenges effectively—whether on large, medium, or small-sized farms—growers are increasingly turning to Unmanned Aerial Vehicle (UAV) technology. The UAVs, also called drones, are emerging as a significant asset in the agricultural sector, supporting a range of applications that can enhance productivity and streamline farm management. Below are several key uses of drones in Virginia agriculture:

Crop monitoring

Staying informed about the status and health of their crops is crucial for producers. Drones offer an effective solution for real-time monitoring of crop conditions, allowing growers to quickly assess whether the crop is thriving or experiencing stress. Drones are versatile and beneficial tools for producers, enabling proactive responses to potential issues and minimizing losses.

Additionally, drones play a vital role in evaluating crop development across various growth stages, identifying variability within fields, and generating continuous data streams that can be analyzed over time. This time-series information empowers farmers to develop tailored management strategies for specific areas within their fields, enhancing overall productivity and sustainability.

Figure 1: DJI Mavic 3 enterprise flight over a trial farm in Port Royal, Virginia

Diseases, pests, and weeds detection

Growers' concerns associated with potential crop damage from pests, diseases, and weeds can feel

overwhelming. But imagine if we could pinpoint with precision. Drones can help growers to promptly and effectively identify these “enemies of the crops”, facilitating a timely, targeted response. And the best part? This approach can be implemented at a relatively low cost, considering an often much greater cost of yield loss.

Today’s advanced drones are equipped with artificial intelligence (AI), allowing them to analyze field imagery and detect patterns and anomalies with remarkable accuracy. For instance, these UAVs can identify aphid infestations in wheat fields with over 90% accuracy. By creating detailed weed maps, growers can implement precision spraying, reducing herbicide use by up to 50%. This approach is not only agronomically effective but also environmentally friendly, leading to healthier crops and soils and supporting sustainable agriculture.

Yield prediction and forecasting

Achieving higher crop yields is always the primary goal, but unpredictable weather can often pose significant challenges. While growers may not be able to control the weather, they can certainly be timely and effective in their responses. Incorporating drone technology into their farming practices can help growers to support their crops experiencing environmental stress.

Drones are playing an increasingly important role in predicting crop yields. By leveraging their ability to analyze crop canopy structure, spectral reflectance, and growth trends throughout the season, drones, in conjunction with artificial intelligence (AI) models, can offer accurate yield estimates. For example, an AI tool using satellite and drone data has been shown to predict wheat yields with over 90% accuracy.

These advanced predictive capabilities are crucial for planning harvest operations, managing market supply chains, and assessing fertilizer and other input application impacts. By utilizing drones effectively, growers can take proactive steps to enhance yields, ultimately leading to more successful and sustainable farming outcomes.

Soil and water resource management

Healthy, productive soils are the cornerstone of crop production, housing vital fertility resources beneath the surface. Knowing the soil productivity potential is essential. Growers require real-time, accurate information about the nutrient status of their fields. Although macronutrients like nitrogen (N) are typically most limiting in crop production, it’s important to have complete data on all 14 mineral nutrients essential for plant growth provided by the soils. Drones can help detect nutrient variability within fields and crop response to fertilization (Figure 1). Drone-derived data can facilitate efficient nutrient management by creating field management zones according to varied yield potential and supporting precision fertilization. This approach helps to minimize fertilizer over-application and promote enhanced soil health.

Adequate soil moisture is key to plant development and effective nutrient uptake. Accurate nutrient and moisture information can be obtained using drones. Drones facilitate high-resolution soil moisture monitoring and are useful for detecting water stress in crops. Drone data combined with smart sensors installed in the soil or inserted directly into plants can support dynamic irrigation scheduling, minimize drought and heat stress, and optimize water use.

Conclusion, Challenges, and Future Directions

Drones are gaining popularity as valuable tools within the contemporary agricultural landscape. Their capacity for high-resolution monitoring, especially when combined with smart sensors and AI, empowers farmers to implement sound management strategies for crops, resources, and risks. As technology continues to advance and becomes increasingly accessible, drones are poised to assume a central role in the evolution toward sustainable, data-driven agriculture.

As with all technologies, certain challenges exist with using drones. These include relatively high initial investment costs, the necessity for skilled operators, intricacies surrounding data processing, and the regulatory limitations governing drone flights. Additionally, the effectiveness of AI models is contingent upon the availability of high-quality data, which can often be scarce in developing

regions. Addressing these challenges will be vital to fully harnessing the transformative power of drone technology in agriculture.

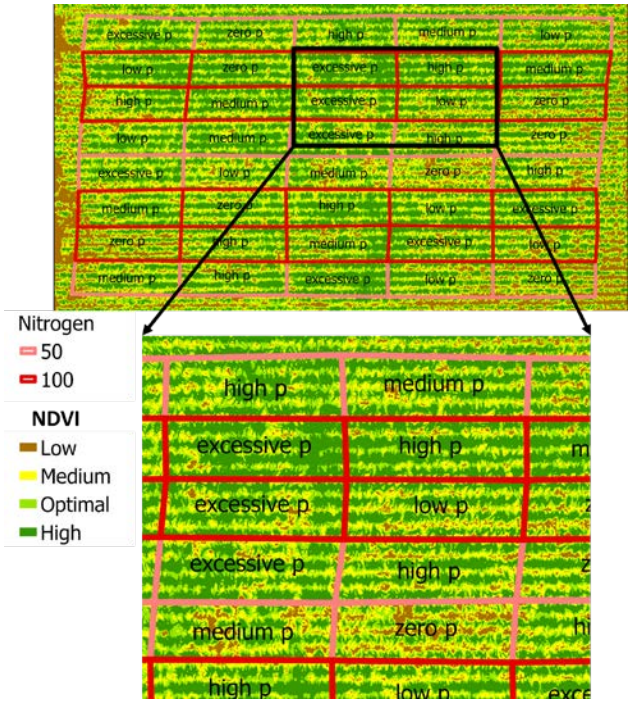

Figure 2. Mapping of crop response to nitrogen and phosphorus fertilizers applied at various rates using drone data.

Grain Crop Program led by Dr. Olga S. Walsh at Virginia Tech

Grain crop groups are exploring various applications of UAVs in precision agriculture and nutrient management. The latest findings show that winter wheat, as measured by UAV-derived NDVI, is more reliable than handheld chlorophyll meters (SPAD) for detecting nutrient responses and predicting yield. In corn, the late vegetative stage, after canopy closure, gave the most accurate prediction models for chlorophyll readings and yield (by Aarati Khulal). At the same time, research by other graduate students shows that aboveground biomass can be effectively estimated using drone imagery at the late tillering, booting, heading, and harvesting stages in winter wheat (by Sheetal Kumari).

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