Industry and NMSP Collaboration to Advance UAV Research for Yield Predictions and Nitrogen Management of Corn

By Lisa Fields

The use of unmanned aerial vehicles (UAVs), commonly referred to as drones, for in-season crop management decisions is becoming more practical for both farmers and crop advisors. A collaborative project between the Cornell Nutrient Management Spear Program (NMSP) and AeroVironment, Inc. applied drone imagery and data analytics to on-farm research in field corn. The project is part of an initiative to develop protocols to obtain accurate yield predictions from drone imagery. Ultimately, the goal is to apply yield predictions to in-season nitrogen (N) recommendations that achieve optimal economic return.

The NMSP team started this work in 2016 with drone pilot Dr. Elson Shields of Cornell University, evaluating active sensors drones for yield predictions and N management. Angel Maresma, NMSP post-doctoral researcher, explained, "In 2018, we started collaborating with AeroVironment, Inc. They provided a Quantix VTOL hybrid drone and access to the AeroVironment Decision Support System (AV DSS) data analytics platform. We used these in our field research in corn silage and grain. It was a great partnership, as it helped us add a lot of useful information from our on-farm trials to our database while evaluating the technology for ease of use."

Brad Carraway of AeroVironment, Inc., commented, "This was our first University collaboration utilizing Quantix and AV DSS for an in-season corn yield research project. We're very happy for the opportunity to support the NMSP team and get their unbiased feedback."

"Working with the team at AeroVironment moved our crop sensor and drone research forward beyond what we could have done otherwise," noted Professor Quirine Ketterings, leader of NMSP. "The timing was perfect, too, as our work in 2016 and 2017 with Dr. Shields, had shown the need to include more fields and growing seasons in the project to determine the factors that influence the accuracy of our corn yield predictions."

Angel Maresma sets up Quantix for its fully automated flight over a neighboring corn field, measuring true color and near-infrared multispectral light reflected from the leaf canopy and soil.

The data that are captured by the integrated sensors on the Quantix drone include RGB (red, green, blue), and near-infrared multispectral light reflected from the leaf canopy and soil. The reflectance values of each band are then used to calculate vegetation indices such as NDVI (Normalized Difference Vegetation Index), which in turn can be used to estimate crop biomass at the time of data collection. Reliable UAV protocols have to be developed to obtain consistent and meaningful NDVI imagery from the sensors in the face of weather challenges and changes in crop growth during the season.

"We received a grant from the New York Farm Viability Institute to evaluate use of drone collected imagery, specifically, when to fly in terms of crop growth stage and time of day, and how to translate imagery collected into yield predictions that are consistent with the maps obtained with yield monitor data," Ketterings explained.

"Weather conditions affect the ability of images from the UAV cameras to accurately

predict yield. Shadows from sun angle, cloud cover, and leaf curl during stress from dry conditions can all skew the NDVI values of the canopy," Maresma explained. "Data from prior years showed that the best timeframe within the growing season to predict yield using NDVI is from V6 up to stage V12, but equations to translate NDVI data into yield predictions were timing sensitive. Flights earlier in the growing season (V6) are preferred because the farmer still has the opportunity to make management changes, but the later flights were also good options for obtaining accurate yield predictions. As for optimum time of day, the results show that the best data are obtained when the flight is as close to solar noon as possible. This gives the most consistent light conditions to avoid the effect of shadows." With the capability to scout up to 400 acres per 45 minute flight, the Quantix system enabled the NMSP team to fly more and larger fields in 2018. "I did about 45 flights on 34 different corn fields across NY with the Quantix system, later in the season, between V12 and VT", Maresma remarked.

"The primary objective in 2018 was to learn how to fly the Quantix drone, gain experience with the AV DSS data analytics platform, and provide direct feedback. In addition, as we obtained yield monitor data from each experimental field, we wanted to evaluate the imagery and its ability to predict final yields", Ketterings added.

"Quantix has one-touch flight planning, and automated takeoff, flight, and landing for ease of operation. The system is designed to work across a variety of environmental conditions and agricultural applications," noted Carraway. "Angel's feedback on performance, efficiency and ease of use of Quantix and the images obtained were extremely useful to our team. His input was helpful in developing the product updates and refinements planned for 2019."

"I was nervous the first time I flew the Quantix because you set the menu on the drone's operating tablet and then it takes off and flies the pre-determined route all on its own," Maresma noted. "Before 2018, I flew quad-copter drones that required a hands-on controller to guide the drone if I needed to over-ride the automated flight. The Quantix unit is fully automated. It was amazing to watch the Quantix take off, conduct its mission, and return exactly as programmed through the flight planning menu. I quickly learned to trust the system." He added, "Quantix flight planning set-up is done with the operating tablet that's included with the unit. You identify the field, label it, and then it automatically loads that map into the drone. Before launching, a set-up menu affirms the flight area, assesses battery capacity and current wind conditions to determine if the flight can be completed, and then you hit 'Go.'"

Post-flight, before leaving the field, a Quick-Look feature on the operating tablet confirms whether images were captured during flight. Additional imagery data analytics and crop vegetation indices (such as NDVI) are calculated from the drone's photos by connecting to AeroVironment's on-line AVDSS.

Currently, Maresma is analyzing the 2018 results to see how well these data can predict end-of-season corn silage and grain yield in New York. "I have a lot of images to review and data to compile," he said. "It's exciting to have made the progress we did this season."

The NMSP team will continue with Quantix flights in 2019, adding more fields to their database. Ketterings concluded, "It's great to have an opportunity to work with a company like AeroVironment and their entire team. They are truly committed to the agricultural applications of their drone system in the Northeast and eager to receive and work with our feedback. We look forward to continuing our collaboration."

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The **Nutrient Management Spear Program** (NMSP) is an applied research, teaching and extension program for field crop fertilizer and manure management on dairy and livestock farms. It is a collaboration among faculty, staff and students in the Department of Animal Science, Cornell Cooperative Extension, and PRO-DAIRY. Our vision is to assess current knowledge, identify research and educational needs, facilitate new research, technology and knowledge transfer, and aid in the on-farm implementation of strategies for field crop nutrient management including timely application of organic and inorganic nutrient sources to improve farm profitability while protecting the environment. An integrated network approach is used to address research, extension and teaching priorities in nutrient management in New York State. For more information on NMSP projects and extension/teaching activities, visit the program website (http://nmsp.cals.cornell.edu) or contact Quirine Ketterings at qmk2@cornell.edu or (607) 255-3061.