NMSP's Collaborative Study with Industry Explores Drones for Nitrogen Management

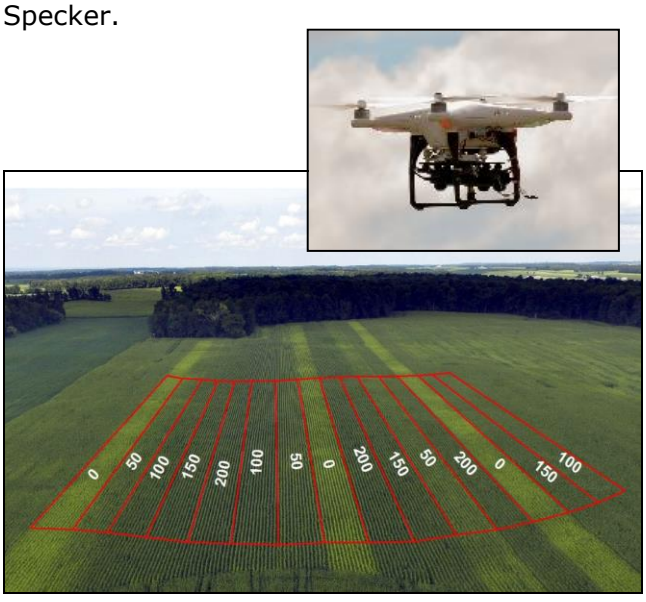
By Lisa Fields

As the technology of aerial drones evolves, the interest in their use for precision agricultural operations has grown. This interest inspired collaborative research initiated in 2017, "Decision Agriculture: Managing Nitrogen and Yield in Corn and Forage Sorghum Utilizing Drone NDVI images." The project is led by Professor Quirine Ketterings, director of Nutrient Management Spear Program (NMSP), Cornell University Department of Animal Science, in collaboration with Dr. Elson Sheils of the Entomology Department at Cornell University, and participating farmers and farm advisors.

Funded by a New York Farm Viability Institute (NYFVI) grant, the project has three objectives. The major objective is to learn how to translate Normalized Difference Vegetation Index (NDVI) images taken by drones into accurate yield prediction maps. Along with this objective is to determine the amount of N needed to achieve optimal yields in corn and forage sorghum while reducing the environmental and economic risk of over-fertilization. Another project objective is to determine the most optimal time of the day and crop growth stage to collect NDVI images for best predictions of end-of-season yield and crop responsiveness to N. The NDVI values reflect the greenness and the leaf area of the crop canopy together, so it serves as a vigor index. The final objective is to find out what the impact of timing of N application is on NDVI values and yield predictions.

Ketterings commented, "The drone study expands on a NYFVI funded project that started in 2014 entitled, "Greenseeker Technology for Greater Corn Yield and Enhanced Nitrogen Fertilizer Use for Corn." Our focus for that project was to examine the best crop growth stage to use the GreenSeeker handheld tool, which uses an active sensor to obtain NDVI images for yield predictions and N recommendations. The tool's NDVI readings can be paired with on-the-go variable rate fertilizer application technology. The GreenSeeker was used at 11 farm locations, and showed very good predictions of crop yield and N response from scans at V6-V7 in corn." In 2016, Donald Specker, Du Pont Pioneer Field Agronomist joined the project and farm sites with replicated N rate trials were added, providing much needed additional data. That year, along with the NDVI images collected with the GreenSeeker, drone flights were done at various heights, plant growth stages and times of day. In contrast to the GreenSeeker's active sensors, drone cameras are passive sensors, which means their images can be affected by clouds and other factors that impact sunlight.

Images collected with the drone required a post-process in which they are stitched and corrected (geo-referencing and radiometric corrections). This generates an orthomosaic that can be used to predict yield and N status of the crops. Thus, fine-tuning that translation process also became part of the project in 2016. In 2017, the NYFVI drone grant enabled the team to repeat the trials at the Musgrave Research Farm and expand flights to include a nitrogen rate study at Sheil's Farm in King Ferry, NY, in collaboration with Donald Specker.



Picture 1: Nitrogen rate study at King Ferry, NY, conducted in partnership with Donald Specker of DuPont Pioneer, and Sheil's Farm generated lots of useful information.

"Although we've developed many N management tools over the years, variables such as weather conditions and soil type put guesswork into deciding how much N will meet crop needs without losses to the environment," Specker said. "The potential for drone technology to help take the guesswork out of in-season N applications without the labor needed for the handheld sensing tools is exciting."

Angel Maresma, NMSP Post-Doctoral Research Associate, described the drone study's progress. "We saw that of the three flight heights, 100, 200 and 300 feet, the 300 feet height was optimum to provide enough images with good resolution while maximizing field coverage per flight."

He elaborated "At the V11 stage, on July 11th, flights early in the day and at the end of the day gave us 60% accuracy in predicting corn yield, while predictions generated from midday flights were not very accurate. The very dry growing season of 2016 resulted in water stress of the corn plants causing leaf curling during the day. Those curled leaves covered less soil surface and that greater soil area caused a reduced NDVI value. This affected the translation of the drone's photos into meaningful NDVI images. These results illustrated for us the impact of flight times on NDVI estimations and the need for a standardized protocol."

At Sheils farm in King Ferry, NY, the study focus was to determine the optimum N rate in grain corn with no manure history and examine how well the sensing tools performed in predicting that optimum N rate. Maresma explained, "In 2017 we had really wet conditions through July with the corn recovering during August and September when fields started to dry. The early season scans with the sensing tools did not correlate well with the actual yields. Nitrogen became deficient at V10-12 only (not earlier), and sensors picked up the deficiency at that stage. At V12 NDVI imagery from the drone estimated the final yield at 70% accuracy."

"That in-season check-in and adjustment is a really important piece that drone images can add to N management," Specker commented. "It tells us what the crop is saying; is it in line with what we thought? Because the use of drone flights is fairly quick and not labor intensive, it enables N management flexibility," He added, "If a crop needs more N, the economic impact of that application can be huge. I'm really encouraged by the 2017 results, and excited to acquire more data and see what we learn in the 2018 season."

Ketterings spoke about 2018 drone project activities. "We have had two extreme years in a row: record drought in 2016 and record moisture in 2017. Moving forward into this growing season we know how important it is to collect imagery at the right time but we don't quite know what the best timing is. The trials help us as we examine our data with the goal of developing sound recommendations for using sensors to predict yield and adjust N applications accordingly. Working within the decision-making framework of precision agriculture, there are a lot of details to examine and get right. It is great to be able to work with farmers and Donald Specker on replicated trials that continue for several years. Although weather extremes are challenging, they do give us data in a wide range of conditions. We have had the two extreme years and are really hoping for a more regular weather pattern this year!"

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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.