Using UAV-mounted and Handheld Sensors to Assess HRSW and Durum Response to Nitrogen Rates

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Agriculture is considered by far the largest market for Unmanned Aircraft Systems (UAS) or Vehicles (UAV) in the U.S., which is at least 10 times larger than the second market. As mandated by Congress, the Federal Aviation Administration (FAA) announced in 2013 a list of six UAS test sites in U.S. The Northern Plains UAS Test Site (NPTS) was the first one to become operational (April 2014). Due to the importance of agriculture to the North Dakota economy, the variety of crops grown in the state, and the size of farms in the state, there are several groups working on developing applications associated with UAVs geared towards agriculture. The use of UAVs in agriculture is relatively new, but several researchers have shown the potential uses of this technology in agriculture, including researchers from the Carrington REC.

Materials and Methods

In early May of 2014, the NPTS started to fly a Draganflyer X4ES rotary wing small UAV over research plots at the Carrington REC. The main goal of those flights was to show that sensors mounted on a UAV can be used to assess different aspects related to crop production (weeds, stand count, nutritional status). The goal of this study was to verify how NDVI (Normalized Difference Vegetation Index) values calculated from images taken with a UAV compare to NDVI values collected with a handheld sensor (GreenSeeker) in two side by side trials (durum and hard red spring wheat [HRSW]) fertilized with 0, 50, 100, 150, and 200 lbs N/ac. The aerial imagery was acquired on August 6, 2014, using a Draganflyer X4ES UAV fitted with a Sony RX-100 camera, which collected imagery with four bands (Red, Green, Blue, and Near-Infrared [NIR]). GreenSeeker readings for each plot were taken on August 9, 2014. Those readings were then compared to the mean NDVI values for each plot, which were extracted from the UAV aerial imagery using ArcGis 10.2. In addition to comparing the NDVI values acquired with those two platforms to each other, the relationship of that data with the crops' response to N rates and yields was explored.

Results and Conclusion

There was good relationship between UAS and GreenSeeker NDVI values for the two crops when the data was plotted as one dataset, and that relationship was improved by considering crops individually (Figure 1). GreenSeeker is considered by many as the standard method to collect NDVI data. Results showed that there is a very strong correlation between the GreenSeeker-NDVI and the UAV-NDVI, meaning the UAV can be used to collect NDVI data from crops instead of using the GreenSeeker, without compromising the data accuracy.

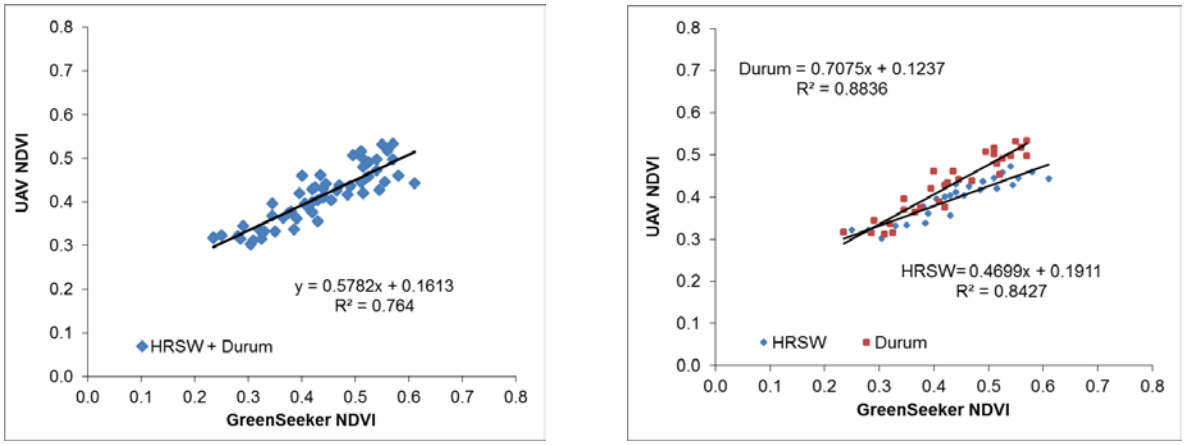

Figure 1. UAV and GreenSeeker NDVI value correlations for hard red spring wheat (HRSW) and durum.

The correlation between the NDVI values and N rates for durum showed a linear response for both sensors, while spring wheat showed a quadratic response for both sensors (Figure 2, left side). The reasons for those differences remain unclear, since several factors that can affect the results were not measured in the field. NDVI values were a better yield predictor for durum than for spring wheat (Figure 2, right side). At this point in time, we can only speculate about possible reasons for the results found. We believe that HRSW had more leaf area per unit of area than durum, and that could cause a saturation of NDVI values. Figure 2 (left) seems to illustrate that, where the NDVI values for HRSW do not change very much above the 100 lbs. N/ac. Durum, on the other hand, showed a positive linear response to the N rates, which could be due to an increase in the amount of leaves per unit area as the N rates increased. Differences in growth stage are very likely playing a role on the results found as well. The same factors are believed to be affecting the relationships between NDVI value and yields (Figure 2, right side) for both crops and data collection platforms.

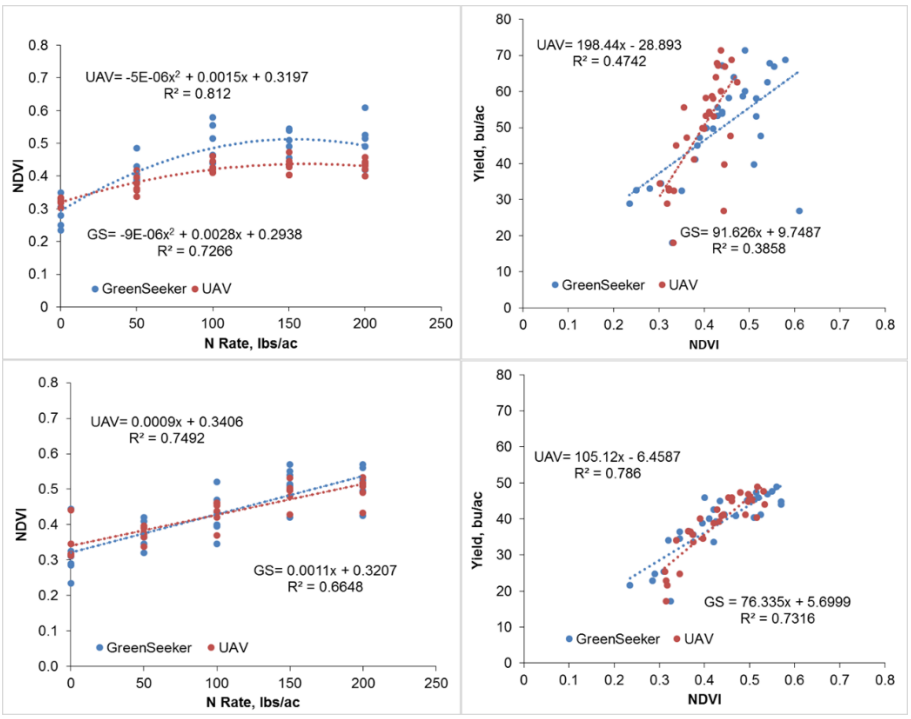

Figure 2. UAV and Greenseeker NDVI correlation with N application rates (left) and yield (right) for HRSW (top) and durum (bottom).

Overall, the sensor mounted on the UAV was able to capture differences in response of HRSW and durum to nitrogen rates, performing slightly better than the GreenSeeker for both crops. The NDVI values were a better yield predictor for durum than for spring wheat. The data shown here are preliminary, and more studies are necessary to confirm initial findings. Nevertheless, the data found in this study show a potential application of a sensor mounted on a UAV and the accuracy of the system compared to what is considered for many the standard procedure to assess NDVI in crops.