An Overview of the UAS Research Program at the Carrington REC

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The first Unmanned Aerial Systems (UAS) flights at the Carrington REC (CREC) took place in 2014, and they aimed to explore potential uses of this technology for agricultural purposes. In that season, seven flights took place over the CREC research plots. Those flights yielded a very limited dataset for researchers to work with due to several reasons: a) limited number of trials covered, and in several occasions trials were only partially covered; b) limited flights over the same trials during the growing season; c) challenges with imagery data (reflectance) georeference corrections. The research team rapidly realized that more flights and repeated flights over the same area during the growing season would be needed to determine how this technology could be most useful for crop production. In 2015, three missions were flown at the CREC, but due to technical issues with the sensor (camera), the data collected during that season could not be used.

Materials and Methods

Using funds allocated to precision ag research during the last legislative session, in 2016 we were able to purchase a UAS (AgBot) and multispectral camera (MicaSense RedEdge 3). Flights were carried out on land owned and/or managed by the CREC, including trials located at the Oakes Irrigation Research Site. As part of the FAA regulations in place at that time, we were required to have an FAA-certified pilot to fly the system. To comply with this requirement, we temporarily hired a certified pilot to conduct the flights, while the author was going through flight training in Fargo. Flights took place from May 23 through September 9, and ranged in altitude from 50 ft to 300 ft above ground level (AGL).

At the end of each flight day, the images were retrieved from the camera and uploaded to MicaSense’s cloud service (Atlas), where they were stitched together. The georeferenced orthomosaic images were then downloaded to our computers. We used *ArcGIS 10.X* to calculate NDVI (Normalized Difference Vegetation Index) and NDRE (Normalized Difference RedEdge), and to extract average NDVI and NDRE values for individual plots on selected trials. That data was then cross referenced with data collected on the ground by CREC researchers.

A corn stand count study was carried out on a section (320 ft long by 55 rows wide) of a large corn silage field. The corn was planted on May 1, and we flew it on May 23, 2016, at 50, 100, and 200 ft AGL. The plot size was a combination of length (10, 20, 40, 80, and 160 ft) and number of rows (5, 10, 20, and 40). We counted all plants for all 55 rows up to 80 ft, and for at least 10 rows up to 320 ft.

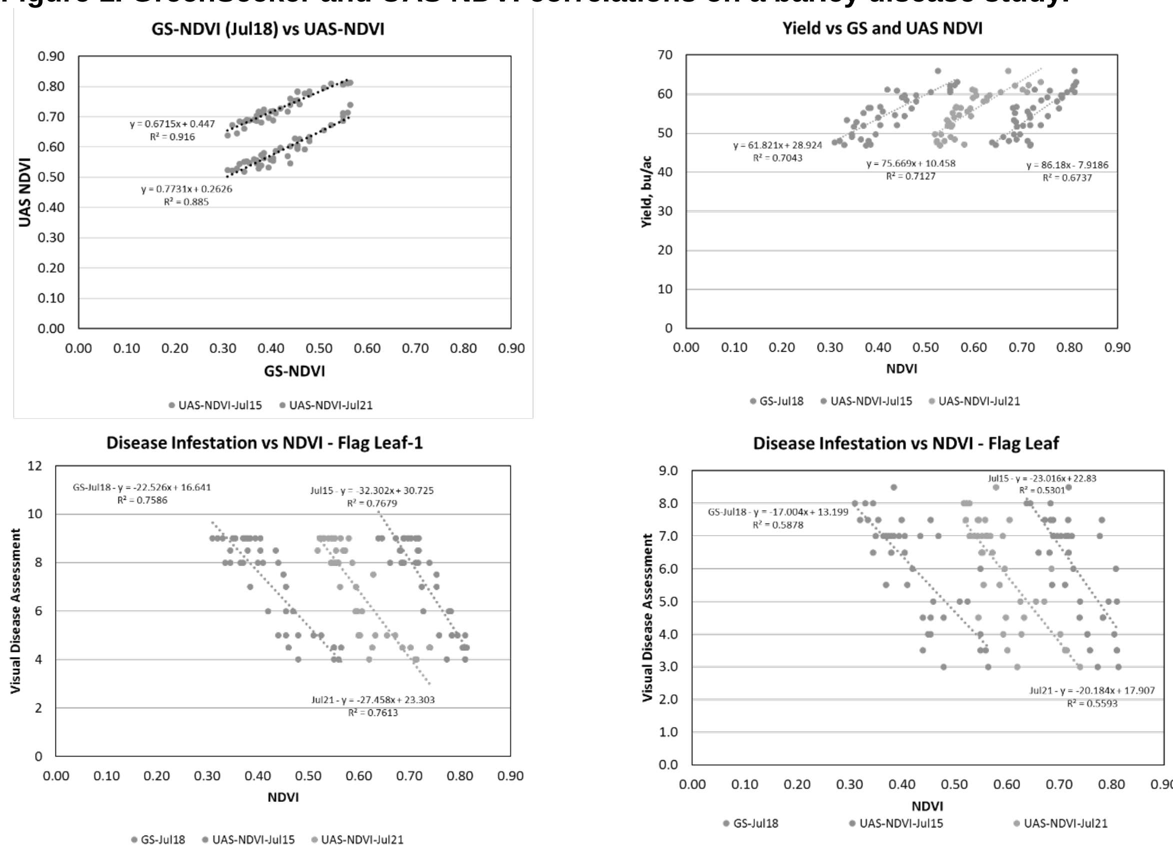
Results and conclusions

In 2016 we flew more than 80 flights over 16 days, covering the majority of the CREC’s land base. These flights captured around 14,000 images from more than 150 research trials at the CREC and at the Oakes Irrigation Research Site. In an effort to assess the changes that are inherent with crop development and to determine the best timing for image capture, we flew individual trials an average of 4.5 times (range 1 to 9 flights). Much of the data collected still needs to be analyzed and cross referenced with the ground data collected during the growing season. The crops and number of trials flown at the CREC were as follows: barley - 5; buckwheat - 1; canola - 14; carinata - 3; corn - 15; dry beans - 5; durum - 5; field peas - 6; flax - 6; safflower - 1; sunflower - 1; soybean - 37; and spring wheat - 29. Those trials can be further categorized as soil fertility (19), crop disease management (22), and weed control (10). Most of the remaining trials were variety trials, where crop development stages, crop maturation and canopy contrasts were the focus.

On the corn stand counts study, we were able to do a preliminary counting for the whole area (around 1 ac), which yielded 31,189 plants. Further processing is needed to eliminate the background noise (improve accuracy), and to count the plants on individual plots. We used RGB imagery and NDVI (black and white scheme color) to perform the counts, and NDVI showed to require less pre-processing to be used for stand counts. Regarding the flight height, the 50 ft AGL imagery was more appropriate for the counts, while the 100 ft AGL was still acceptable, and 200 ft was not suitable.

To ground proof UAS-NDVI, we collected NDVI from small grain plots using a handheld sensor (GreenSeeker [GS]). We found very good correlations between the two sensors for wheat on June 7 (R^2=0.76) and July 21 (R^2=0.86), and for barley (Figure 1).

Figure 1. GreenSeeker and UAS NDVI correlations on a barley disease study.



Based on those correlations, we plotted UAS-NDVI values versus other crop variables. For barley UAS-NDVI showed good correlations with yield on July 21 (R^2=0.71), and with visual disease (spot blotch+net blotch) assessment on the flag leaf-1 (leaf right below the flag leaf) on both July 15 (R^2=0.77) and July 21 (R^2=0.76), which were better than the correlations found for disease on the flag leaf (Figure 1). Very good correlations were found between UAS-NDVI and plant maturity for soybeans, and early August seemed to be the best time to sense for that (R^2=0.86, August 5). Similar results were found when plotting UAS-NDVI versus soybean yield for flights across the month of August (Aug.5 - R^2= 0.90, Aug.12 -R^2= 0.88, Aug.22 -R^2= 0.88).

The data analyzed so far do not allow us to draw very many in-depth conclusions because we still have a large amount of data to analyze. Based on the results found so far, we can conclude that: a) the UAS-NDVI values are in agreement with the NDVI collected by a GreenSeeker sensor for small grains; b) UAS-NDVI is a better yield predictor for soybean than for barley; c) UAS-NDVI can be used to fairly accurately predict soybean relative maturity; d) UAS-NDVI can be a usefull tool to assess the level of leaf disease in barley.