Unmanned Aerial Systems and Field Phenotyping Platforms for Assessing the Growth and Development of Cotton

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Abstract

Cotton (Gossypium hirsutum L.) growth rate as well as yield varies with different rates of management inputs. The ability to monitor and quantify these differences using remote sensing shows great potential for research as well as production. This technology can be used to help breeders select traits of interest by collecting data such as height and yield. Producers can use this technology to help facilitate making in-season management decisions by observing plant health using normalized difference vegetation index (NDVI). Using an unmanned aerial system (UAS) greatly reduces the time and labor required to collect field scale data in comparison to traditional methods. The objectives of this study were (1) to determine if growth and yield could be accurately monitored using imagery collected from a UAS, and (2) to use a field platform to map phenotypic data. Remote sensing data using a UAS were collected from a study testing the effects of irrigation on different commercial cotton cultivars grown at the Texas A&M Brazos Research Farm. The study has a split plot design with irrigation as the main plot (90% ET replacement, 45% ET replacement and dryland), and as the subplot treatments. Images were collected using two different fixed winged UAS platforms. Images collected contained four spectral bands, (Red, Green, Blue and Near Infrared). We also developed a field-based high-throughput phenotyping system.

Objective

The overarching goal of this project was the development of standardized phenotyping procedures to identify high yielding and drought tolerant cotton cultivars in South-Central Texas using field and UAS platforms.

Methods

- **Study area**: Texas A&M Brazos Farm, College Station, TX.
- **Soil type**: Belk clay (Fine, mixed, active, thermic Entic Hapluderts) 0-1% slope.
- **Experiment design**: Split plot.
  - **Main plot**: Irrigation (90% ET replacement, 45% ET replacement and dryland).
  - **Subplots**: Cultivars (PHY499, FM2807, DP15R551, DP1549, FM1900, ST6182, NG1511, ST4943).
- **Planting date**: 13-April-2016; **Harvest date**: 13-October-2016
- **Plot size**: 16 rows x 25m; **Row spacing**: 1m.
- **Phenotypic variables of interest**: Plant height, leaf area index, canopy temperature and canopy reflectance.
- **Reflectance data was used to calculate the normalized difference vegetation index (NDVI)**. 
- **Software used**: LoggerNet, ArcGIS, QGIS, ENVI.

Unmanned Aerial System and Sensors

- **Precision Hawk Lancaster**
- **Flight Plan**

Sensor Specifications

- **Pix4D Image Mosaicking**
  - **Nikon J3 Digital Camera**
    - Spectral sensitivity: R,G,B
    - Dynamic range: 8-bit
    - Imaging sensor pixel resolution: 4608 x 3072
    - Frame rate (s/frame): 1.6
    - Weight (g): 244
- **Images were collected with 75% overlap**
- **Used Pix4D software for pre-processing (image mosaicking) and ENVI for post-processing**

Phenotyping Platform: Sensors Attached to a High Clearance Plot Sprayer

- **Trimble FmX Display (GPS System)**
- **Campbell Scientific CR3000 Datalogger**
- **Decagon Spectral Reflectance Sensor (NDVI)**
- **Trimble Ag25 L1/L2 GLN Antenna**
- **ToughSonic 14 Ultrasonic Sensor (Plant Height)**
- **Apogee SL-131 Infrared Radiometer (Canopy temperature)**

Results and Conclusions

- **GPS Location of Data Points**
- **NDVI Map of the Field**
- **Canopy Temperature Data Collected Using IRT Sensors**
- **Plant Height Data Collected Using Sonic Sensor**

- **Yield vs Percent Lint Pixels**

- **The ground phenotyping platform was able to collect canopy temperature and plant height with reasonable accuracy. Further validations are necessary.**
- **Using high resolution RGB imagery acquired from a UAS, cotton yield was predicted by relating percentage of white pixels from each plot with corresponding lint yield.**
- **Future work will involve use of LiDAR and additional testing of the field phenotyping platform and UAS sensors for estimating cotton growth and yield.**

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