Spatial-Temporal Evaluation of Plant Phenotypic Traits via Imagery Collected by Unmanned Aerial Systems (UAS)

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Introduction
Detailed spatial and temporal data is critical to overcome challenges on current farming systems. Conventional methods for estimating plant growth are labor-intensive and are relatively at small-scale. Recent incursion of unmanned aerial systems (UAS) with ultrahigh spatial resolution sensors seems promising for overcoming these limitations and shedding light on rapid plant trait characterization (e.g., plant height, biomass, and yield prediction).

Objectives
• Generate Crop Surface Models (CSMs) for top of the canopy (TOC) by stereo vision workflow, evaluate correlation of ground-truth data (GTD, biophysical parameters) relative to CSM for plant height and biomass at both spatial and temporal scales.
• Spatial-temporal change detection of CSM model at critical crop stages for biomass prediction.

Materials and Methods
Four research corn studies were performed during 2015 growing season at K-State Ashland Bottoms Research Farm, Manhattan, KS:
1) Plant population study (7 seeding rates evaluated)
2) Random Gaps study (4 spatial arrangement on population gaps)
3) Hybrid study (4 contrasting hybrids – drought tolerant vs. conventional)
4) Fertilizer Nitrogen Rate study (6 fertilizer N rates evaluated)
Canon 110 NIR, Sony A5100 RGB, platform X8-M, RTK Topcon GR-5

Flow chart of all activities performed 2-weeks prior flowering and at flowering time

Results
Temporal and spatial changes in plant height can be predicted via imagery collected by UAS (Fig. 1). Plant height patterns could assist in the rapid phenotyping process for proper characterization of plant growth and, consequently, yield prediction.

-2 weeks prior flowering

Flowering time

Plant height prediction via imagery collected by UAS presented a stronger correlation with the ground truth data when corn plants were at flowering stage (Fig. 4) as compared to 2-weeks before flowering.

Conclusions
- Spatial-temporal correlation between CSM for plant height trait vs. ground-truthing suggested that the CSM integration could assist in the prediction of plant traits for rapid phenotyping.
- Still, there are clear evidences that other specific plant traits and/or phenological stages should be targeted for increasing biomass and yield predictions.
- Future steps: Scale-integration (multi-scales analysis), integration of UAS data into ultra-high spatial resolution analysis for crop growth modeling & integration with spectral remote data.