Crop Production Team

KSUCROPS

PRECISIONHAWK

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 for shedding light on rapid plant trait characterization (e.g., plant height, biomass, and yield prediction).

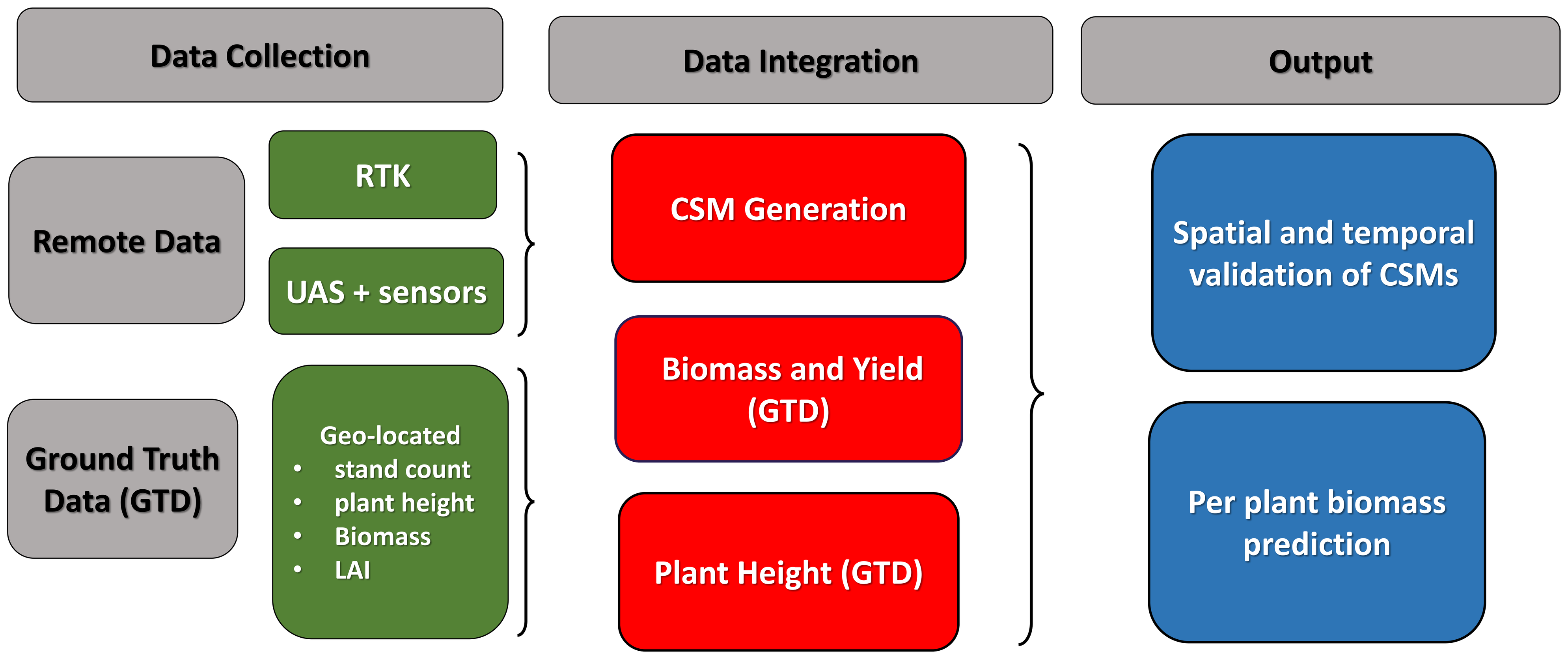
Objectives

•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
Software: Argis10.3.1®, Photoscan-Agisoft ®.

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.

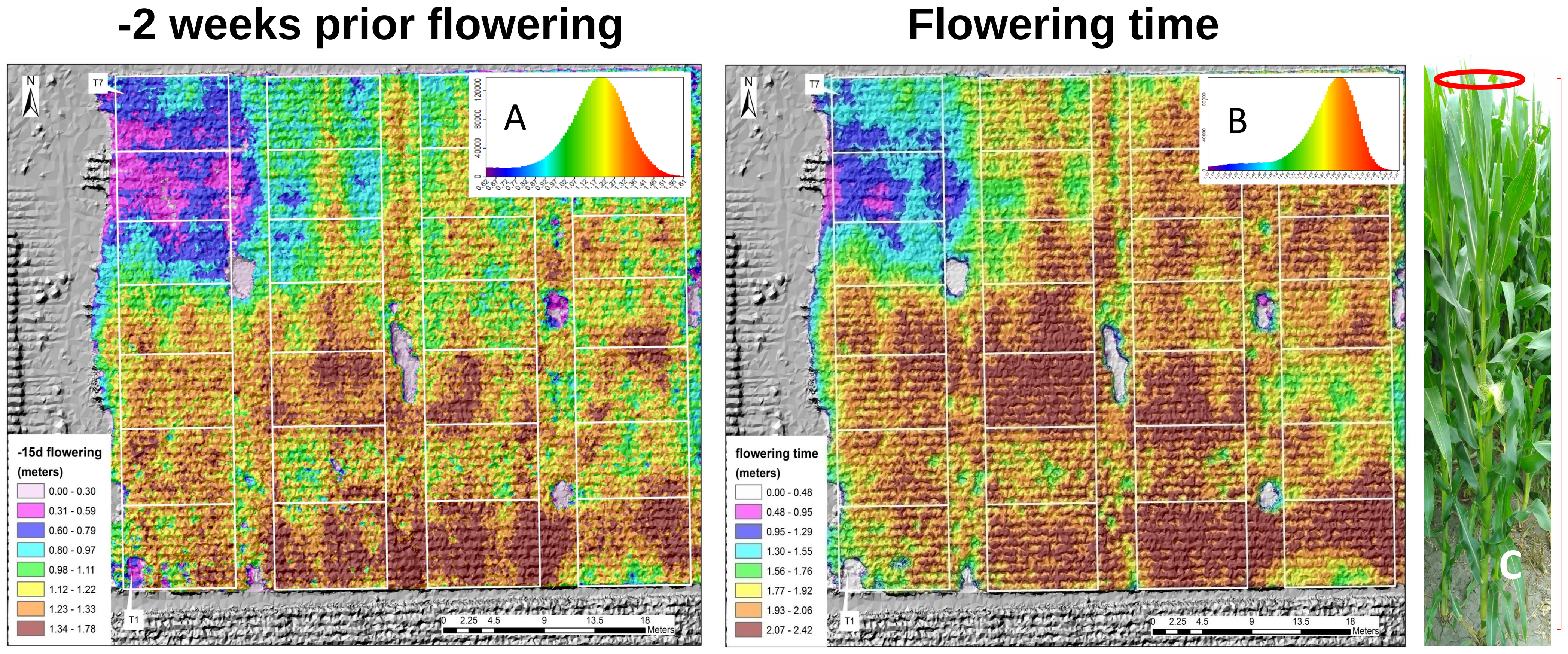


Figure 1. Crop surface models (CSMs) for predicting plant height on TOC at different timing during the corn growing season. Note: Green color refers to shorter corn plants; Brown color represent taller plants within the corn canopy. A and B: TOC height distribution within seeding rate experiment. C: Plant height measured by GTD and estimated by CSM.

Results (continued)

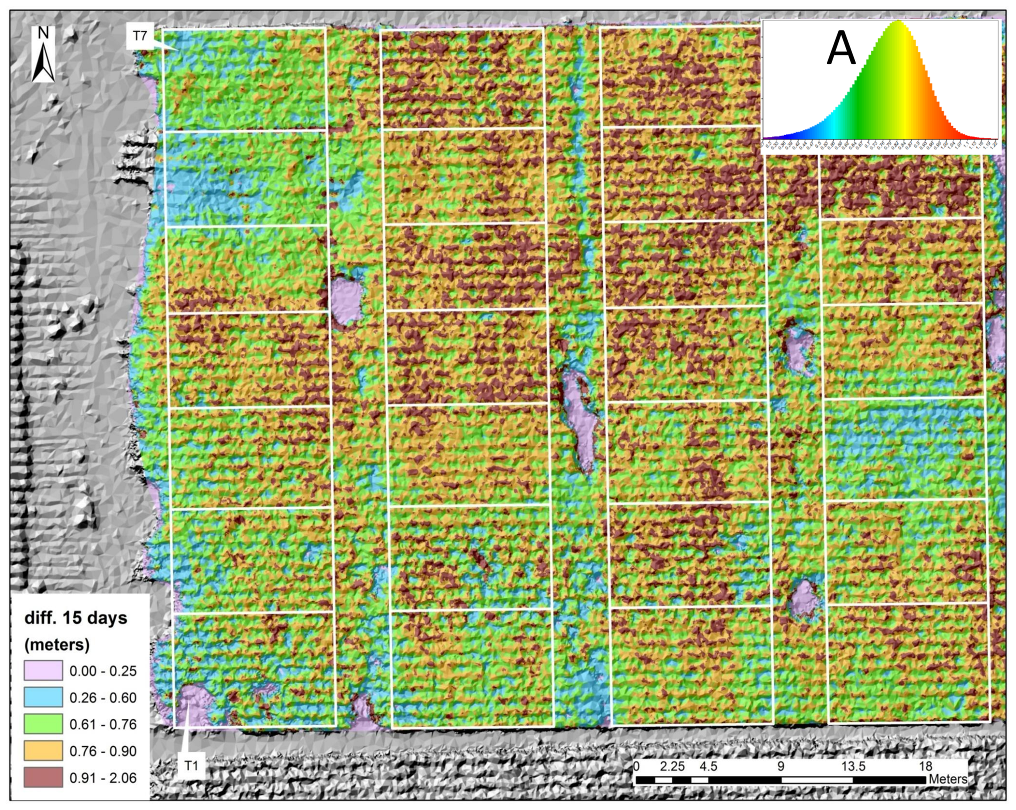
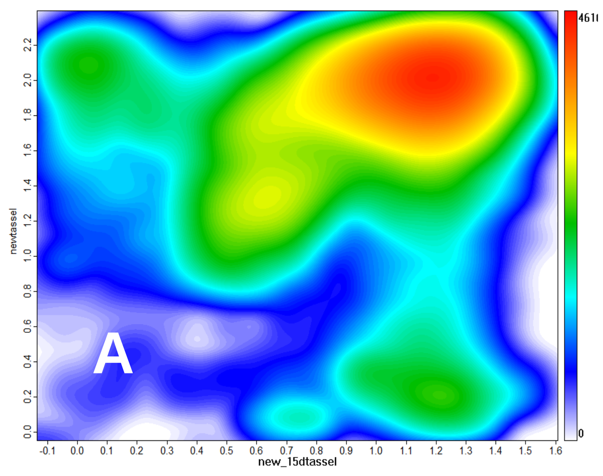
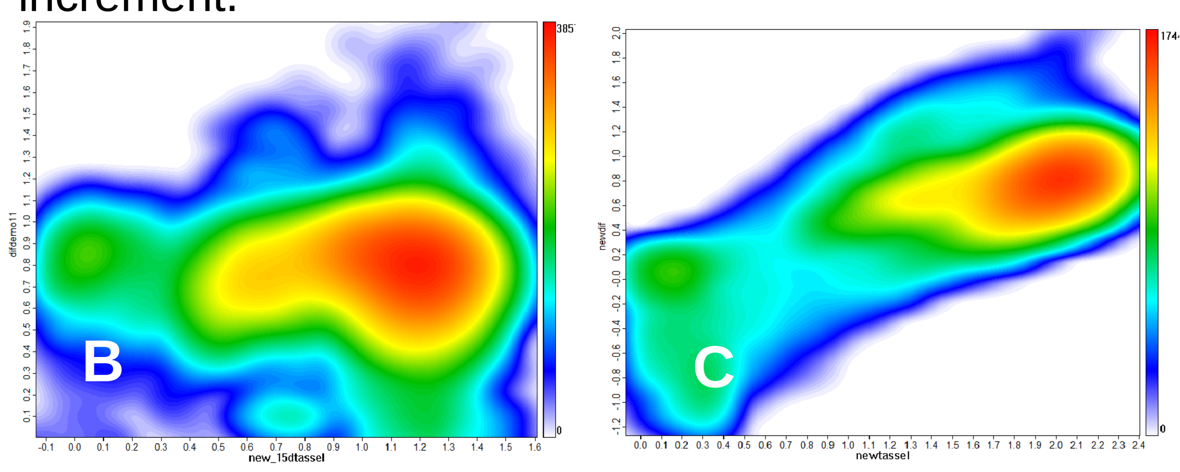


Figure 2. Temporal plant height trait change characterization. Population rate study, top-down view. A. TOC height distribution.

Figure 3. Scatter plot CSMs analysis, 15 days prior flowering - flowering, exemplifying spatial-temporal dynamic and plant height plasticity within the experiment. A. 2 weeks prior flowering vs. flowering time. B. 2 weeks prior flowering vs. 2 weeks increment.



C. Flowering time vs. 2 weeks increment.



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 with 2-weeks before flowering.

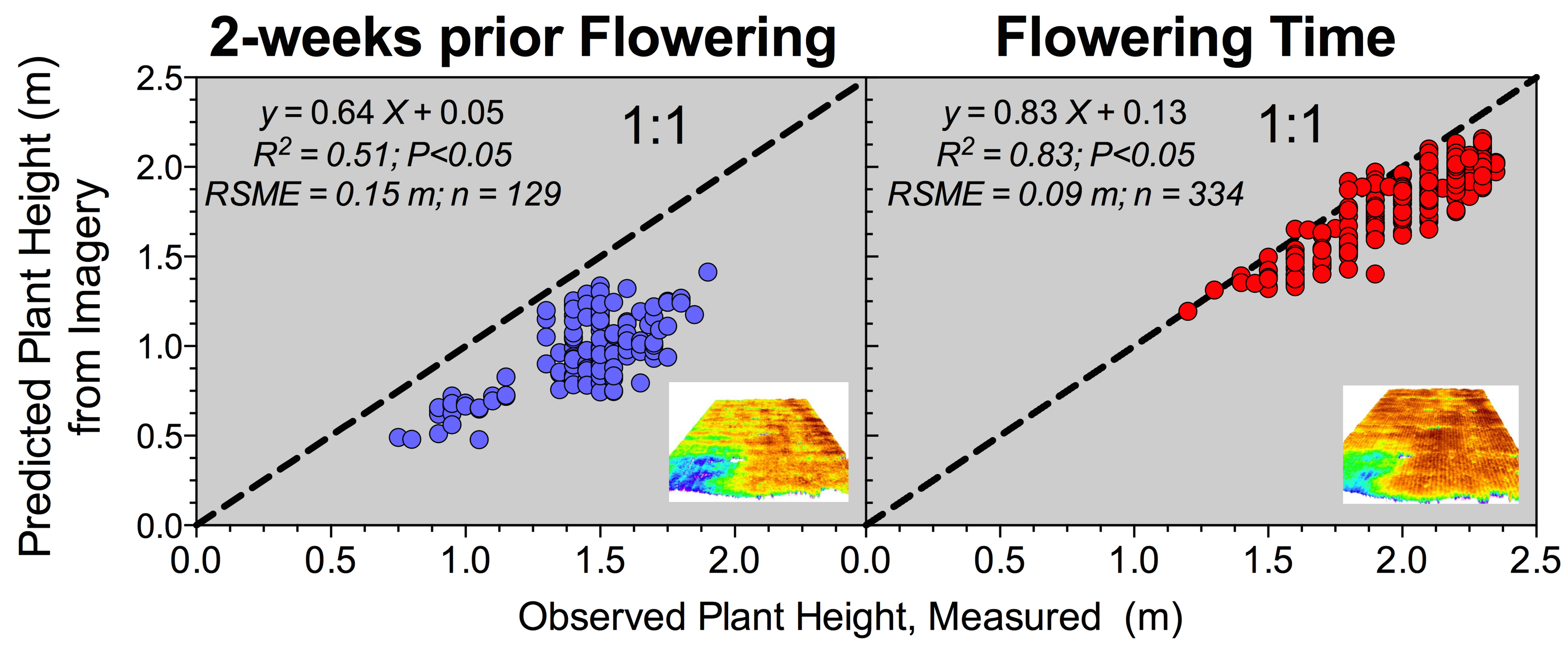


Figure 4. Plant height prediction via imagery collected by UAS – 2 weeks prior flowering and at flowering time relative to the plant height determined at the field (absolute height determined from the ground base to the top of the canopy). Note: prior flowering CSM generation was 5 days before GTD evaluation.

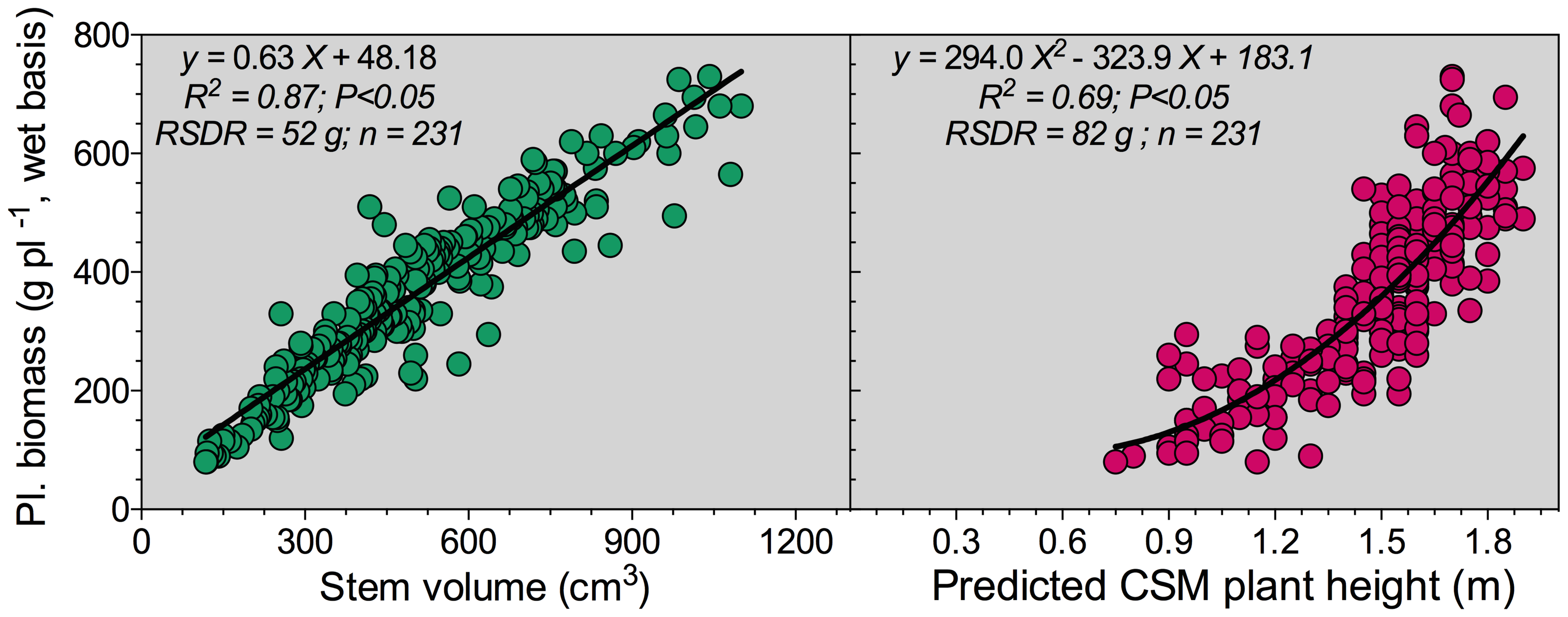


Figure 5. Per-plant biomass (wet basis) vs. stem volume and predicted CSM plant height at flowering.

Per-plant biomass (wet basis) was related to plant height trait predicted via CSM and stem volume estimated by the volumetric cylinder equation considering predicted CSM plant height.

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.