Using 3D Point Clouds to Estimate Biomass of Cover Crops

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INTRODUCTION

- Cover crops can be effective for weed control if they produce at least 5,000 kg ha^{-1} / 4,500 lb ac^{-1} of biomass.[2]
- Detecting areas in the field where cover crops are underperforming can help predict and target late-season weed escapes.[1,2]
- Most methods for measuring cover crop biomass across are laborious or expensive.[3]
- This study tested a new method for estimating biomass using 3D models called “point clouds” generated from GoPro videos.
- The end goal is to create a tractor-mounted system that maps biomass across the field, to show where the crop is underperforming, and where late-season weeds are most likely to have emerged.

METHODS

- Time frame: Oct 2021-Feb 2023
- Sites: 12 rye and wheat fields across NC, IA, and MD
- Videos were recorded walking over the cover crop with a GoPro camera in a straight line (25 ft / 10 m) (Figure 1).
  - 5 random locations per field every 3-4 weeks
  - Camera was facing forward and tilted down 45°
- Canopy measurements were made in 3 quadrats per video
  - Crop height, leaf area index, and photosynthetically active radiation (PAR) light penetration at the soil surface (Figure 1)
- Cover crop was harvested in 0.25 m^2 quadrats and oven-dried to obtain dry biomass (Figure 1)
- Videos were processed using a SfM algorithm in Python to create 3D point clouds of the crop canopy (Fig. 2-5)
- Point clouds and crop height were used to model biomass

Fig. 1: Video and data collection in winter wheat (Clayton, NC)

RESULTS

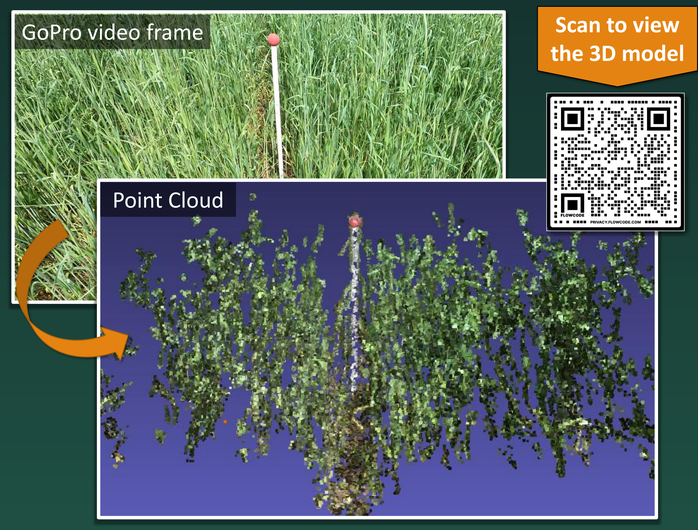

Fig. 2: GoPro video frame and 3D point cloud of cereal rye.

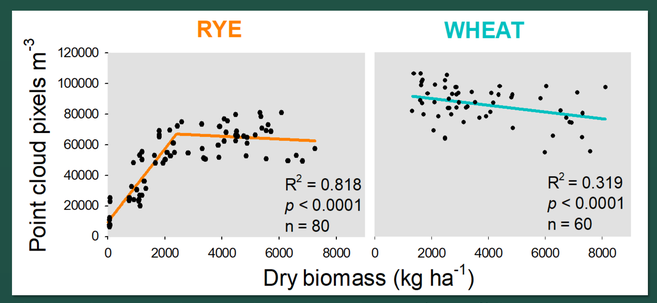

Fig. 3: Point cloud pixel density and dry biomass (kg ha^{-1}) for rye and wheat. Note the saturation in pixel density when biomass surpasses 2,500 kg ha^{-1}).

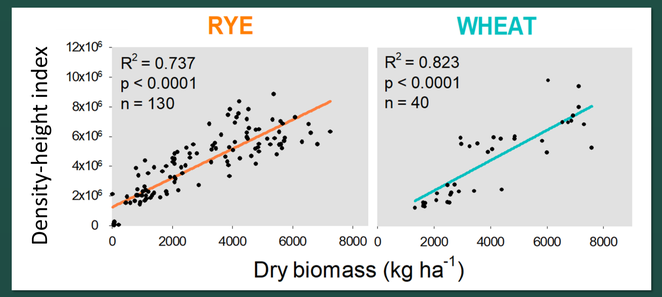

Fig. 4: Density-height index (pixel density x height) and dry biomass (kg ha^{-1}) for rye and wheat. Note the improved accuracy gained by including height.

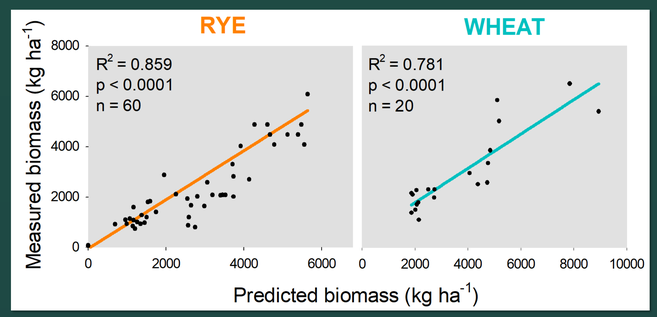

Fig. 5: Predicted vs. measured biomass (kg ha^{-1}) in rye and wheat, based on point cloud pixel density by crop height.

DISCUSSION

- 3D point clouds were successfully generated from GoPro videos using the SfM algorithm (Figure 2).
- Leaf area index increased as biomass and height increased.
- PAR light penetration below the canopy decreased as biomass increased.
- In denser canopies, lack of light penetration made the SfM signal unable to detect the lower vegetation layers.
- Therefore, pixel density of the point clouds became saturated after biomass reached ~2,500 kg ha^{-1} (Figure 3).
- However, multiplying crop height with pixel density improved the predictive ability of both models (Figure 4, 5).
- After testing both models with independent data, pixel density multiplied by crop height could predict biomass in both crops with greater accuracy than crop height alone (Figure 5).

CONCLUSIONS & FUTURE WORK

- This proof-of-concept study shows that 3D point clouds can be used to estimate biomass in rye and wheat at single points in the field.
- This technique can potentially be developed into a tractor-mounted system that scans the field at crop termination and maps the entire field using 3D point clouds.
- Mapping areas where cover crops are underperforming would help growers target spray late-season weeds.
- 3D imaging has potential for estimating cover crop biomass with minimal cost and time in the field.

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References: 1) Florence AM et al. (2019). Cover crop mixture diversity, biomass productivity, weed suppression, and stability. PLoS One 14(3), e0206195. 2) MacLaren C et al. (2019). Cover crop biomass production is more important than diversity for weed suppression. Crop Sci 59(2)733–748. **3)** Gil-Docampo, ML et al. (2020). Above-ground biomass estimation of arable crops using UAV-based SfM photogrammetry. Geocarto. Int. 35(7), 687–699.