Quantification of Soybean Canopy Development and Weed Competition Using LiDAR-Based UAV Imaging

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Introduction

Over the last decade, soybeans have become one of the most important crops in Canada, ranking among the top three most widely planted. Soybeans are a warm-season crop with slow early growth, making them vulnerable to environmental stressors and weed pressure that can reduce yields by up to 50%.

Adjusting row spacing and seeding rate can reduce weed competition, but responses are variable and hard to quantify across heterogeneous fields. This opens an opportunity to use UAV-based remote sensing, particularly LiDAR, which directly measures canopy height and structure, to quantify soybean productivity and weed competition under differing agronomic practices.

Materials and Methods

The first season of a multi-year factorial field experiment was conducted at Carman, Manitoba, to test whether multispectral and LiDAR-derived indices can quantify soybean weed competition. Treatments combined three seeding rates (80,000, 160,000, 240,000 seeds ac⁻¹) and three row spacings (7.5, 15, 22.5 in) under weedy and weed-free conditions.

Ground data included biomass, height, and final yield, collected with weekly UAV multispectral and LiDAR flights. Imagery was processed using Agisoft Metashape, CloudCompare, and ArcGIS.

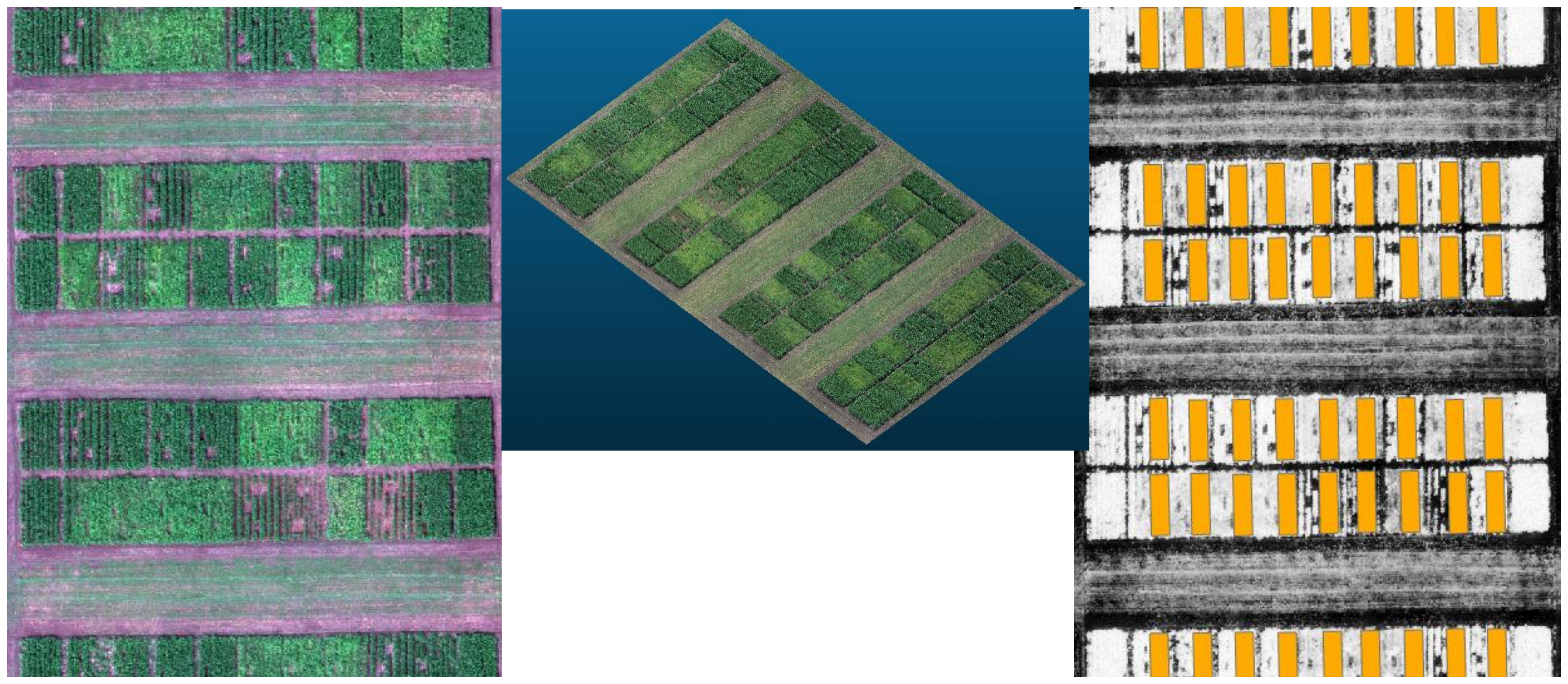

Fig 1. Remote Sensing data extraction: Aerial view of the field after multispectral image stitching (left). Image of the field after processing LiDAR point cloud (middle). NDVI layer with polygon plot boundary layer overlayed for stat extraction (right).

Fig 2. Side view of weedy and weed free plots from LiDAR point cloud.

Results

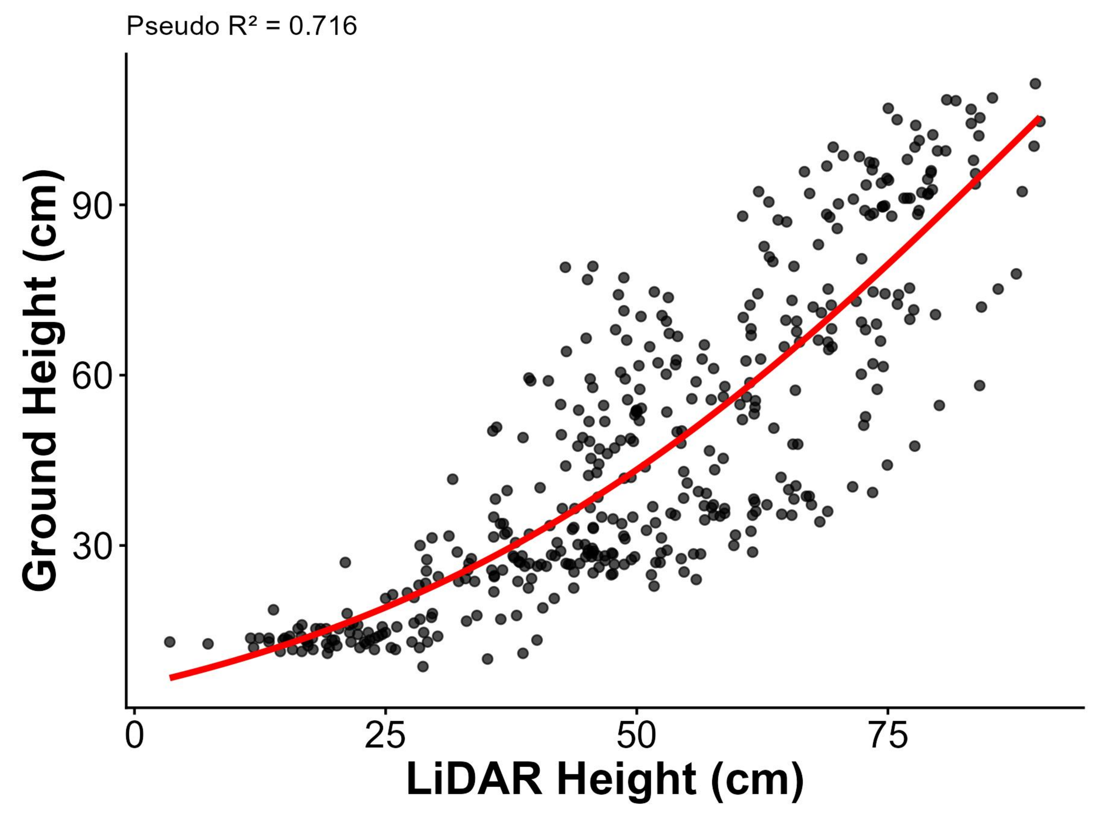

Fig 3. Non-linear regression between ground measured crop height and LiDAR height along the growing season.

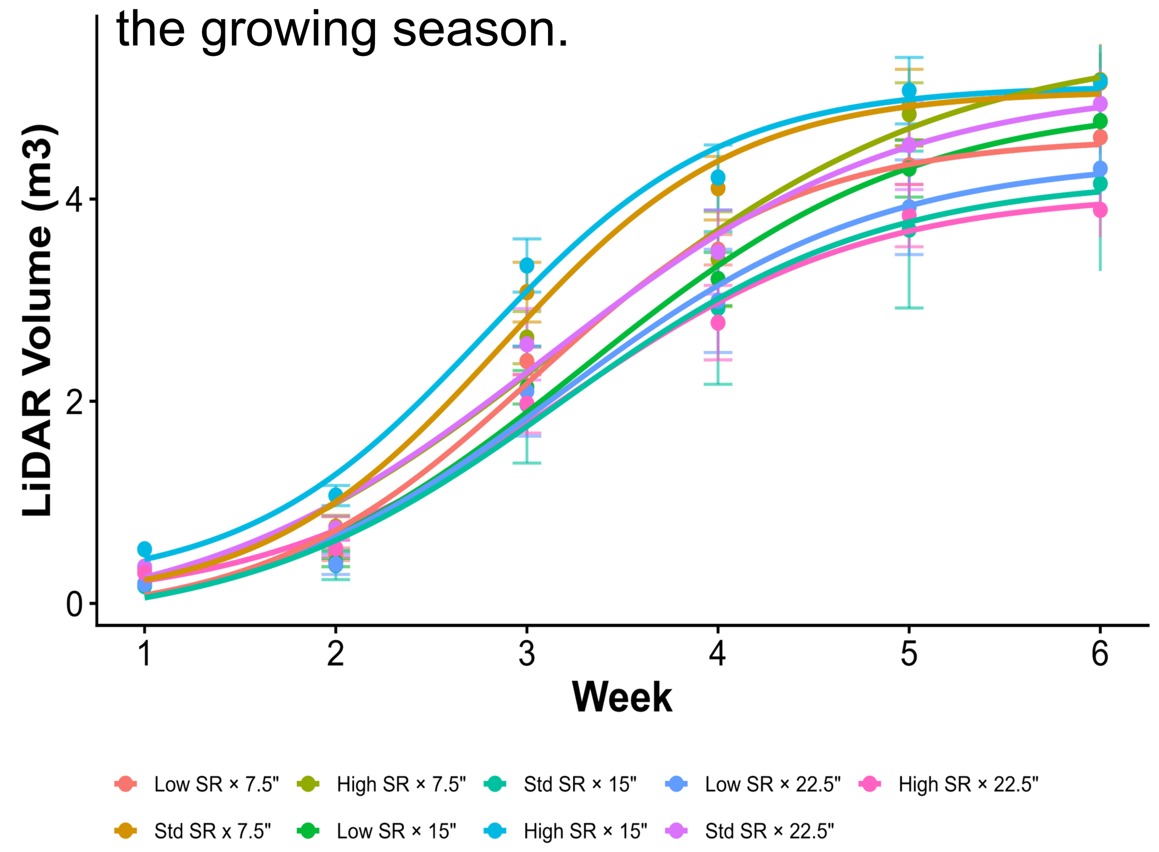

Fig 4. LiDAR volume development over a 6-week period across different treatments.

Key Findings

- Ground height and LiDAR height share a strong non-linear relationship (four-parameter log-logistic, $p < 0.05$ for key curve parameters) (Fig. 3).
- LiDAR volume clearly separated row spacing × seeding rate treatments over time (Fig. 4).
- Weedy conditions reduced early-season crop biomass across most treatments, with 7.5-inch rows partially mitigating losses (Fig. 5).

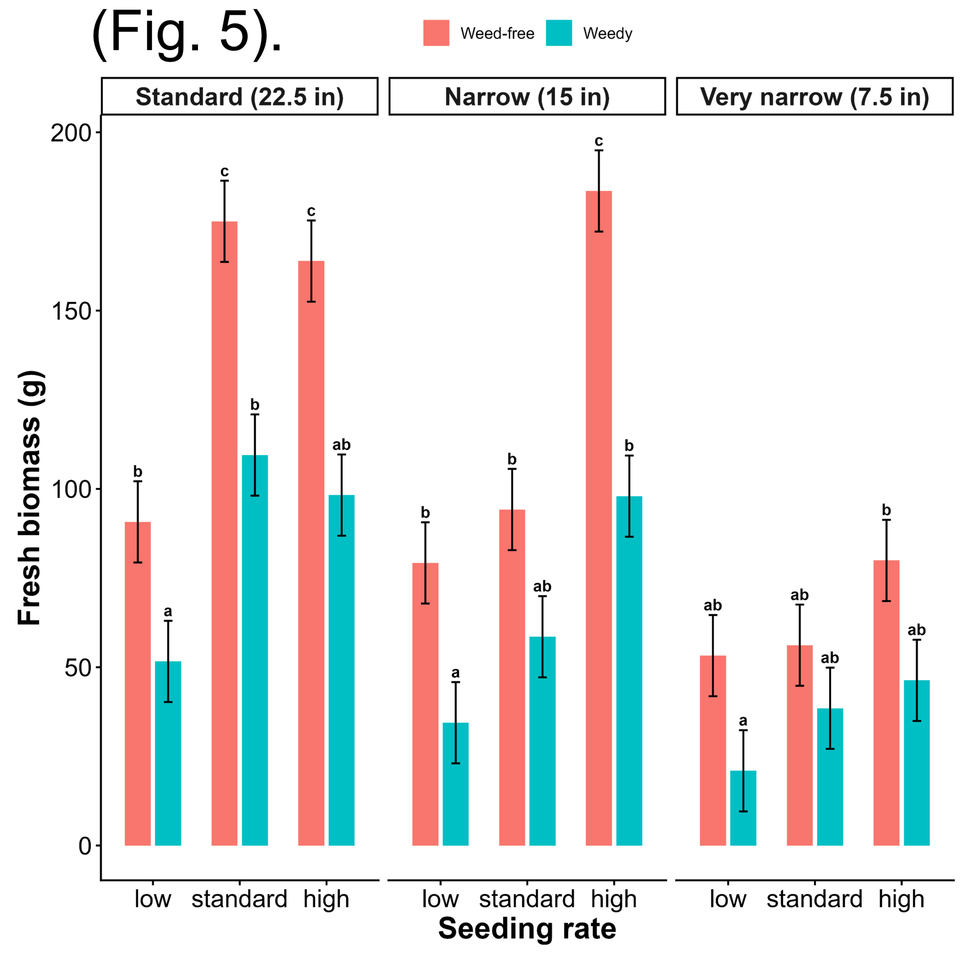

Fig 5. Early season (V3) crop biomass reductions by treatments under weedy and weed free conditions.

On-Going and Future Work

LiDAR has shown more potential in the remote sensing workflow than multispectral so far. Next steps will be attempting to utilize segmentation to visualize stronger relationships between multispectral and ground data.

Modelling yield loss under weedy and weed free conditions is also going to be one of the next steps in this project.

Acknowledgments

Thank you to my supervisor Dr. Dilshan Benaragama, and PI Kristen MacMillan. Technicians: Brodie Erb, Claudia Quilesfogel-Esparza, and Jon Rosset, my committee members: Dr. Yvonne Lawley and Dr. Kevin Falk, all members of the Digital Weeds and Agronomy Lab. Finally, thank you to the project funders:

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