Multi-Temporal Biomass Estimation of Vegetable Crops Using Unmanned Aerial Vehicles

Supriya Dayananda, Thomas Möckel, Michael Wachendorf
Universität Kassel, Grassland Science and Renewable Plant Resources, Germany

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Introduction

3D point cloud analysis of imagery captured by unmanned aerial vehicles (UAV) are depicted to be a valuable tool for estimation of crop phenotypic traits (e.g. crop height) in several crops. Spatial information about these traits can be used to derive information about other important crop characteristics (e.g. biomass), which could not be derived directly from the point clouds.

Objective

To assess the applicability of UAV imagery by capturing the crop height information of three different vegetable crops (eggplant, tomato, and cabbage) during a complete crop growth period to infer the biomass.

Methodology

- The study was conducted in an experimental layout at the University of Agricultural Sciences in Bengaluru, India (Figure 1).
- The three crops height and the biomass were measured at five sampling dates from February to May 2017.
- Each plot was measured using an UAV, equipped with a photo camera. In total 14 crop height metrics were extracted from the point clouds (Figure 2). Machine learning methods were used to create prediction models for vegetable crop height.

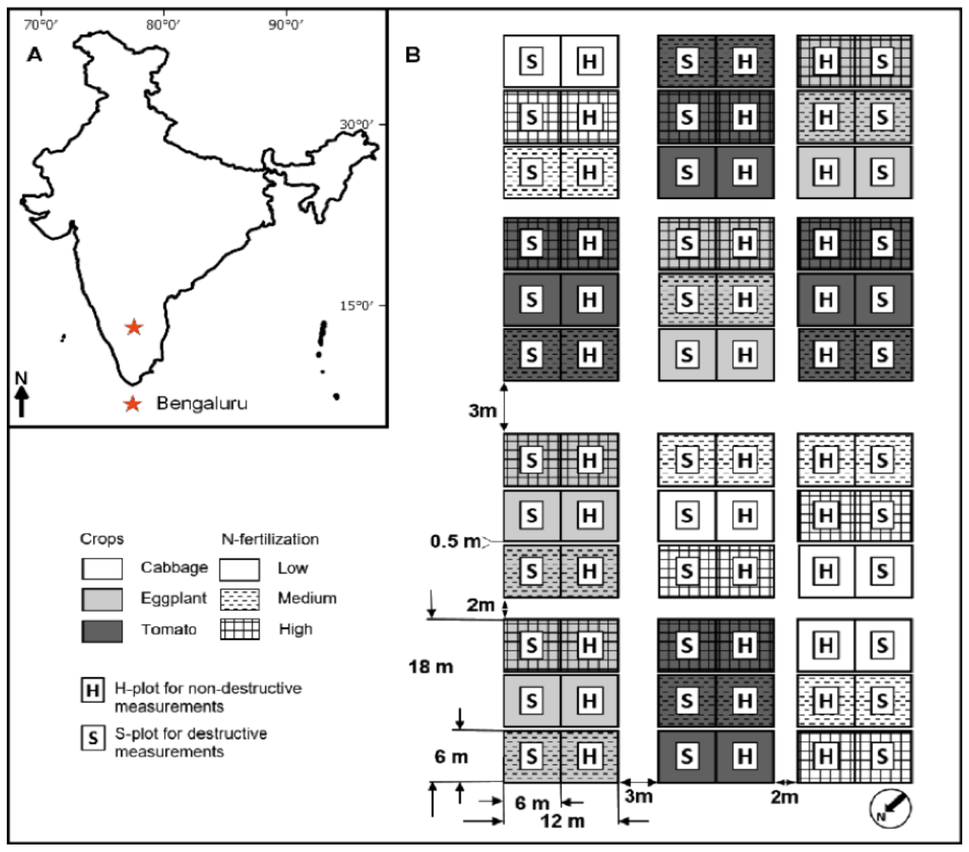

Figure 1. (**A**) India's political map shows the location of Bengaluru. (**B**) The experimental design of the study

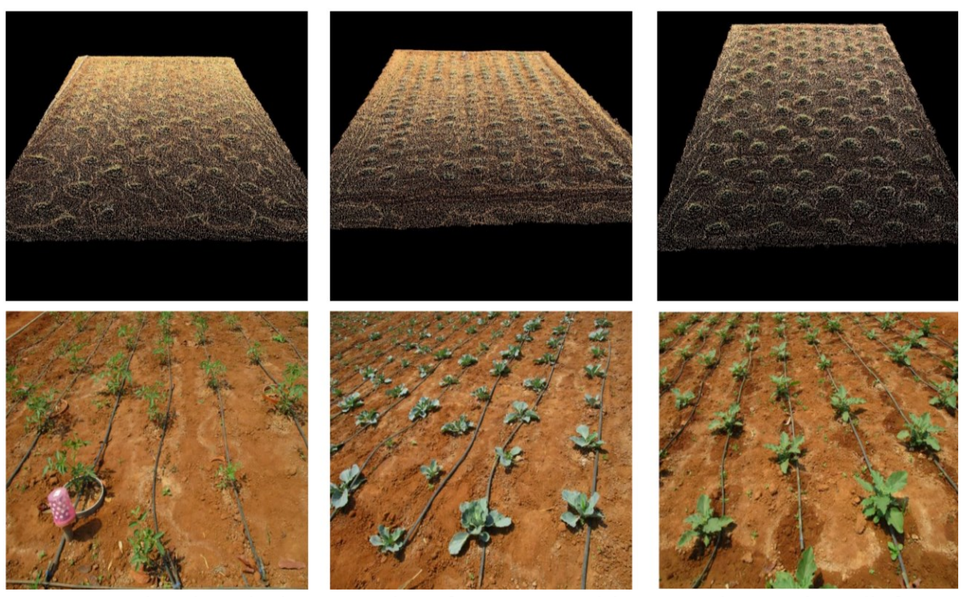

Figure 2. Point cloud and photographs of tomato, cabbage and egg plant (left to right) at second sampling date

Results

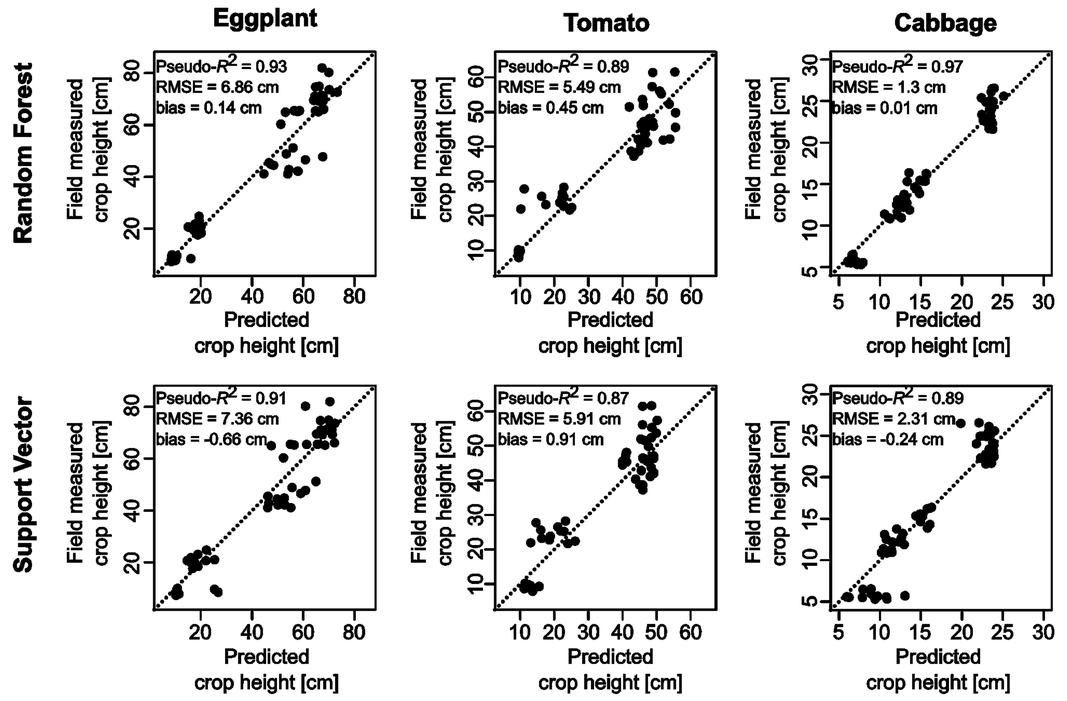

Figure 3. Field measured average crop height versus predicted average crop height for random forest regression (RFR, **top**) and support vector regression (SVR, **bottom**)

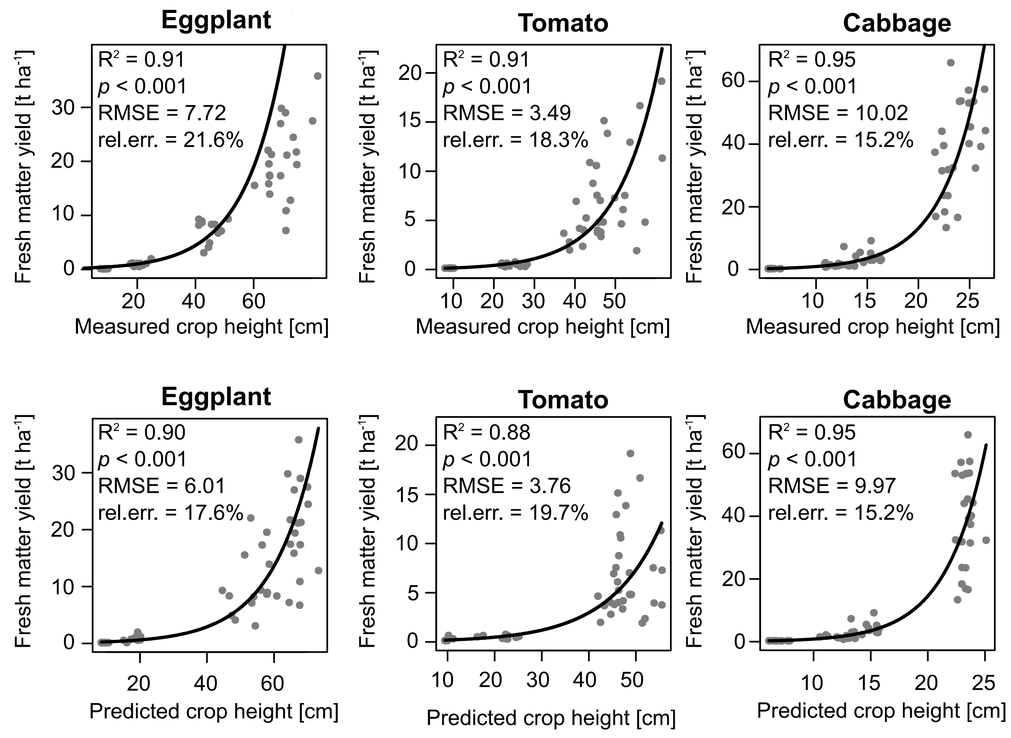

Figure 4. Biomass versus the (**top**) field measured crop height and (**below**) predicted crop height based on random forest regression.

Discussion

- In Figure 3, the best model acquired was for cabbage and for eggplant and tomato the results were similarly good.
- The slightly better performance of RFR over SVR might be explained by the lower sensitivity to data skewness and to model overfitting.
- The predicted vegetable crop height values of the present study show strong and highly significant relationships to the biomass for all three crops (Figure 4).
- Both modelling approaches showed clear deviations for the late growing stages (Figure 4). These deviations indicate that height is a less accurate estimator of biomass for crops in late growing stages.

Summary

The UAV borne RGB imagery processing and analysis approach exhibit stable model prediction quality for biomass during the entire growing period of the three crops. Further, evolving sensor fusion approaches might improve the model prediction performance.

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