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Assessing Multi-season Table Beet Root Yield from Unmanned Aerial System

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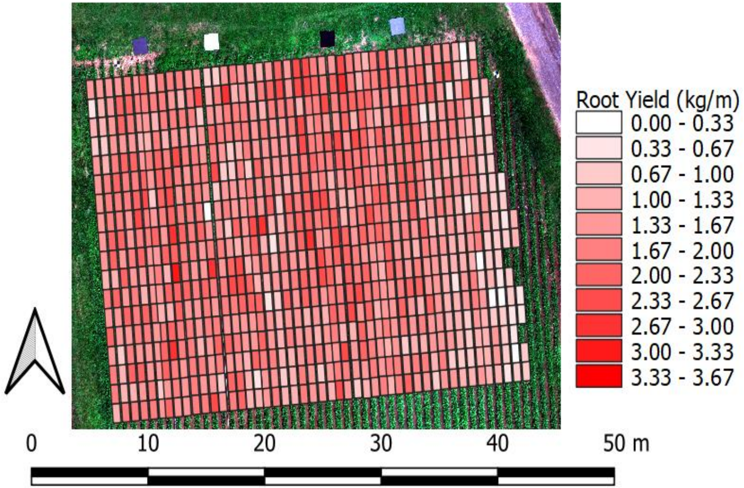
Background

- Sustainable agricultural practice calls for accurate harvest yield estimation to optimize logistics, reduce waste, and improve resource use.
- UAS provides high throughput, spatially-explicit information about a field, enabling precise and timely interventions for improved crop management.



- Challenges in existing UAS yield prediction:
  - Subterranean crop yield prediction is under-researched, e.g., beets, carrots, potato, etc.
  - Existing models are growth stage, harvest time, and season-dependent, thus limiting scalability and flexibility.

Objectives

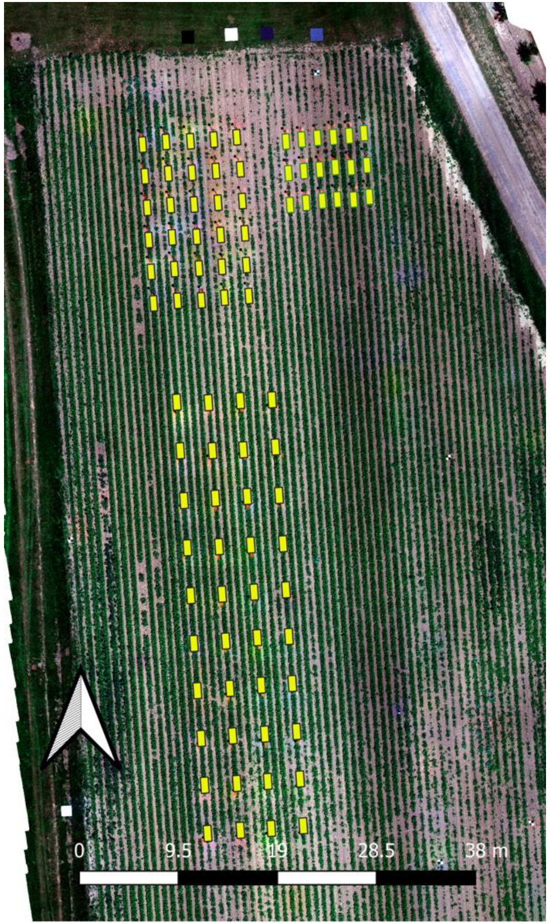
- Develop a methodology for a robust beet root yield model
- Assess the scalability of the model across:
    - Growing seasons
    - Data collection times within-season
    - Variable harvest timing

Data collection

- Conducted flights with DJI Matrice 600 over Cornell Agritech field in Geneva, NY, during 2021 and 2022 season.
- Images captured using Micasense Red Edge -M
- Dimensions for the plots are 5ft x 1 ft
- Table beetroot weight measured at harvest only.

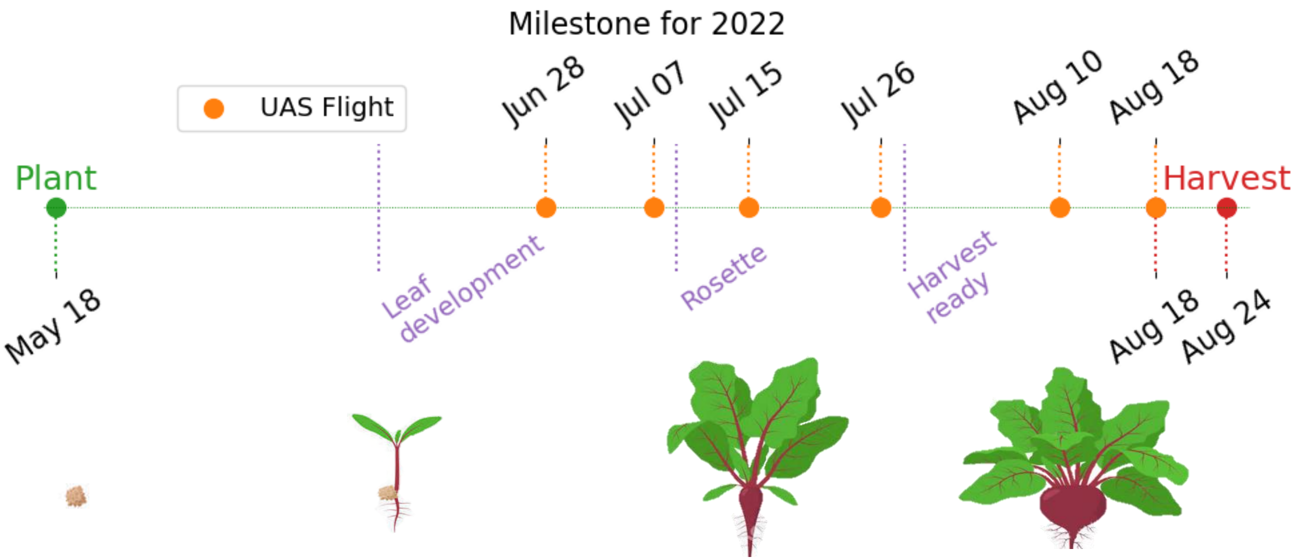
MicaSense Rededge-M (blue, green, red, red-edge, and near infrared bands)

Field view of the beet plots under study



Ortho-mosaic of the entire beet plot. The yellow rectangles are the plots under study.

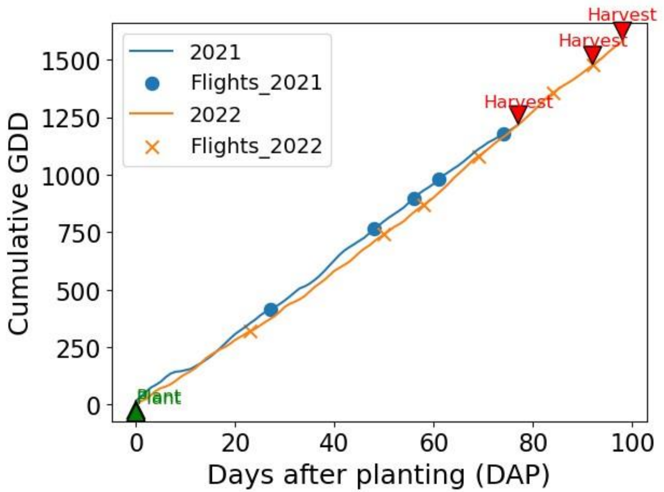
Timeline

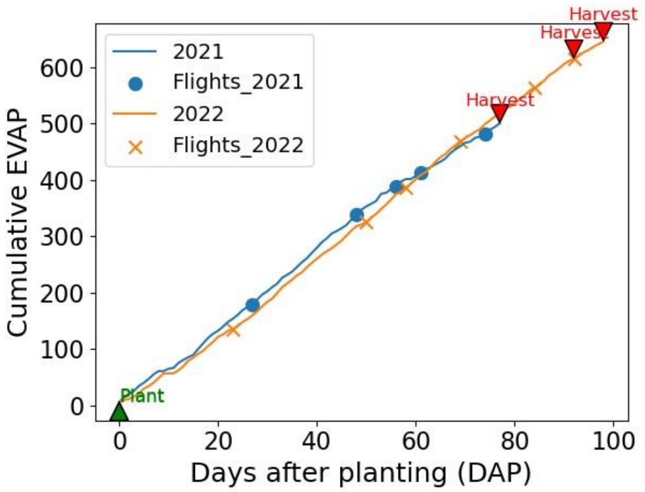


Beet cartoons from:https://depositphotos.com

Meteorology

- Growing degree days (GDD) is widely used strategy to track growth stages in crops.
  - $GDD = \frac{T_{max}+T_{min}}{2} - T_{base}$
- Evapotranspiration has been shown to be directly proportional to yield.
  - Accumulated pan evaporation data was used as model feature.





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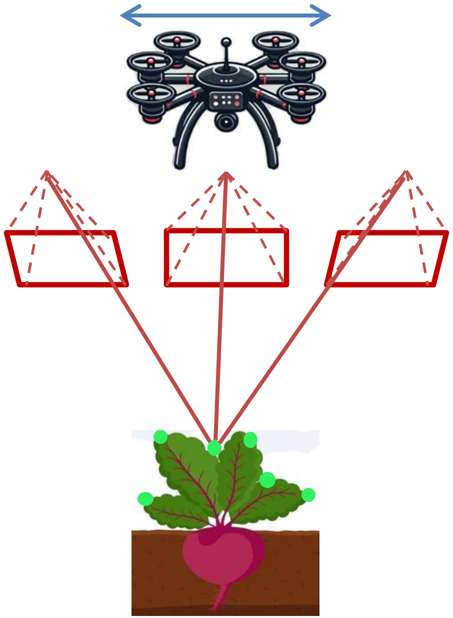
Structure

- Pix4D was used to generate point clouds through structure-from-motion.
- Generated digital surface model (DSM) and digital terrain model (DTM).
- Evaluated canopy height model (CHM)
    - CHM = DSM – DTM
- Canopy volume estimated by summing the heights of the extracted vegetation.

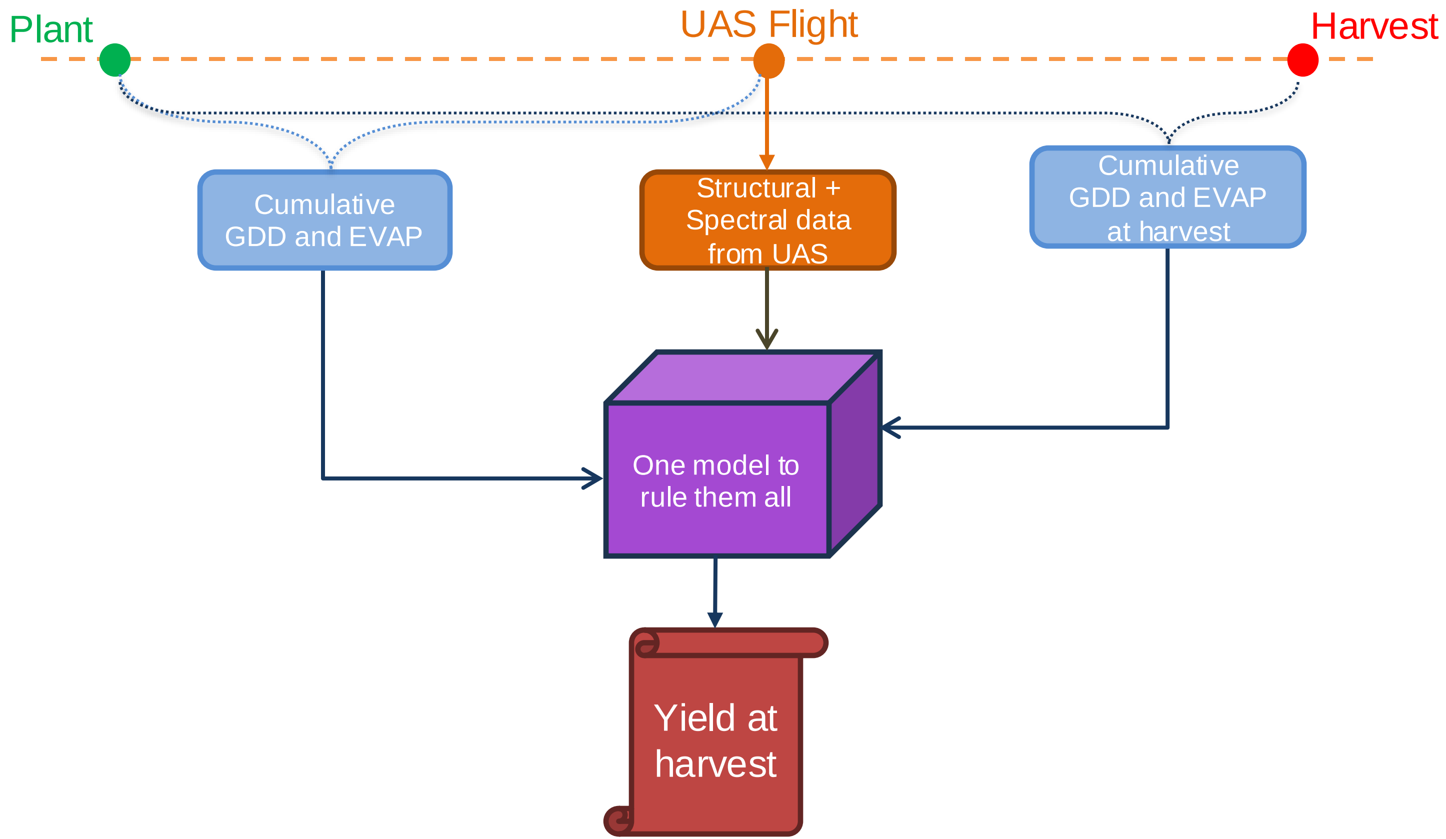


Spectral features

- Extracted mean canopy spectra.
- Obtained vegetation indices.
- Correlation, mutual information-based feature selection was applied to extract relevant uncorrelated features.
  - Features with a mutual information score above 75th percentile to harvest root yield and an inter-correlation below 0.8.

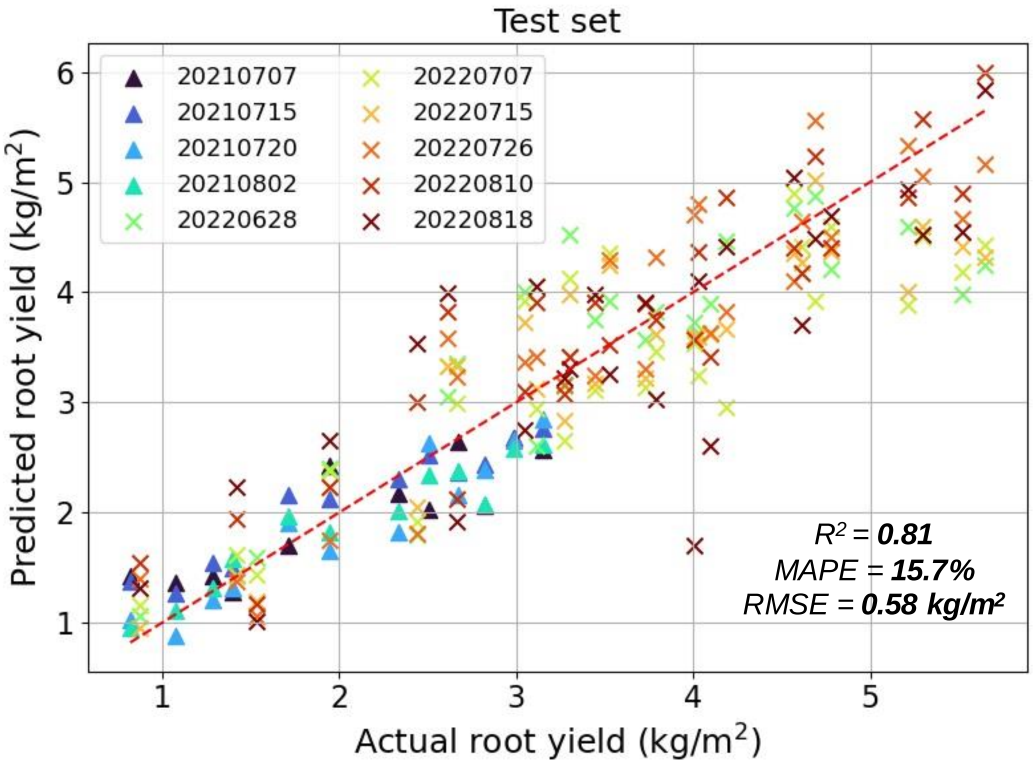
Name	Formula
Green normalized difference vegetation index (GNDVI)	$\frac{R_{800} - R_{570}}{R_{800} + R_{570}}$
Transformed chlorophyll absorption ratio index (TCARI)	$3 \times [(R_{700} - R_{670}) - 0.2 \times (R_{700} - R_{550})(R_{700}/R_{670})]$
Mean green reflectance	R_{550}

Yield modeling

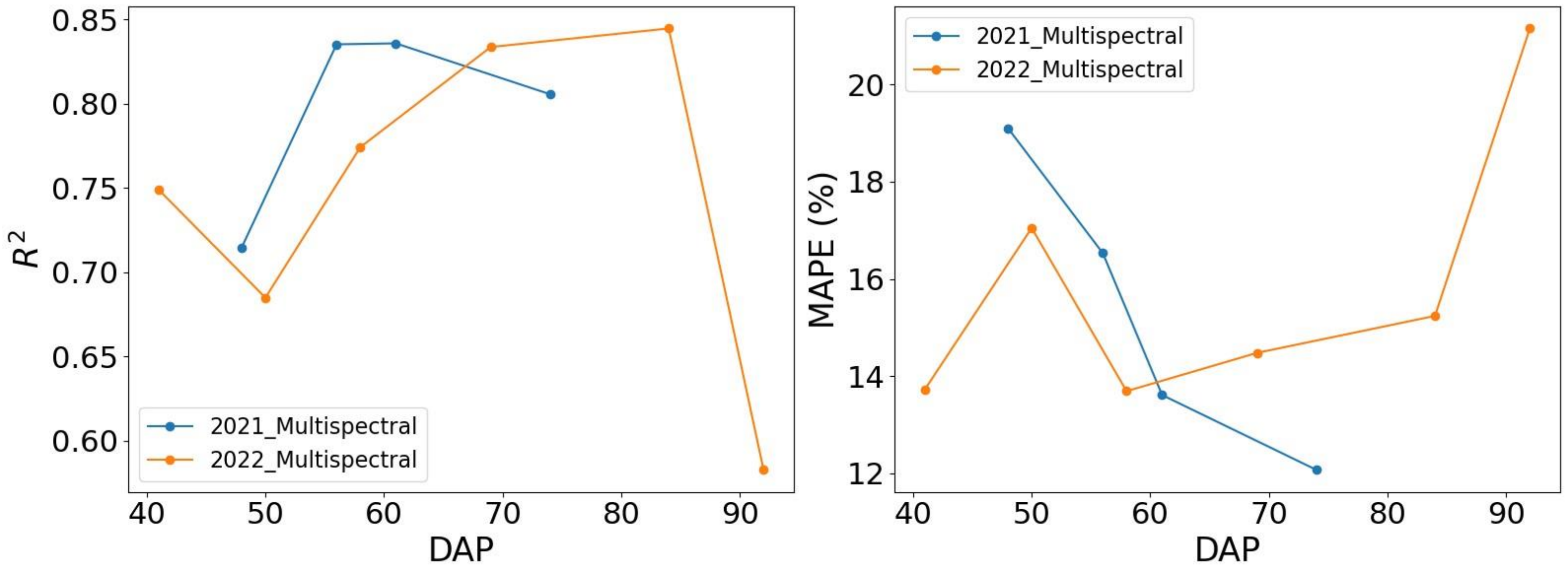


Model performance

Model trained on 70% of 2022 data and 30% of 2021 data



Performance breakdown by flight



- Peak model performance between 55~85 days (late rosette to harvest-ready stage)
- Relatively poor performance for the final 2022 flight was attributed to defoliation and weed growth

Conclusions

- Estimated harvest table beet root yield across two seasons using UAS multispectral data at overall $R^2 = 0.81$ and $MAPE = 15.7\%$.
- The end of the rosette stage and early harvest-ready stage proved to be ideal for optimal model performance.
- While our model has demonstrated reliability within the growth stages and harvest times reported, developing a truly robust and scalable model requires additional datasets spanning diverse growth stages and harvest timing.

Questions?

For further queries feel free to contact me at
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LinkedIn

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