Using drone imagery to assess spatial variability in nutrient uptake efficiency of cover crops

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INTRODUCTION

- **Cover cropping** is one of the conservation practices that can limit nutrient loss and improve nutrient cycling within a field [1,2].
- Cover crops (Fig. 1) utilize residual nitrogen (N) and phosphorus (P) to accumulate biomass which is released back to the soil after their termination.
- The amount of nutrients released depends on the growth or biomass of cover crops which varies across a field due to within field variability.

Fig. 1 *Cover crop planted on a field with corn-soybean rotation*

- Knowledge about biomass variability is crucial to understand nutrient content within the field and develop effective management strategies before a cash crop growing season.

Objective

To investigate within-field variability in cover crop nutrients uptake by integrating drone images with field-based observations.

Study Area

- **15 cover crop fields in Northwest Ohio were used for field data collection (Fig. 2).**
  - 12 farmers from 10 counties participated.
  - Fields were planted in cereal rye after soybean harvest in the fall.
  - Drilling was used for planting cereal rye in 13 fields. An aerial approach was implemented in one and a broadcast in another field.
  - Field data were collected during the spring of 2021.

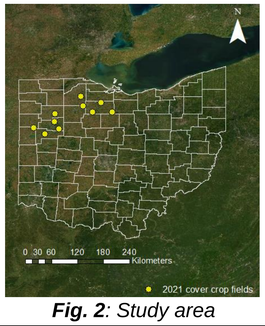

Fig. 2*: Study area*

MATERIALS AND METHODS

Data Collection

- Field data were collected for three times (Fig. 3).
  - *T1: March 2 to March 9*
  - *T2: March 29 to April 6*
  - *T3: April 26 to May 12*
- Six biomass samples per field were collected using six 0.5x0.5 m quadrats.
- Soil samples were collected alongside biomass from the same locations.
- Before sample collection, drone surveys were conducted with DJI Phantom4 with a multispectral sensor onboard.

Fig. 3*: Field data collection (a) drone survey, (b) soil and (c) biomass sampling*

Data analysis

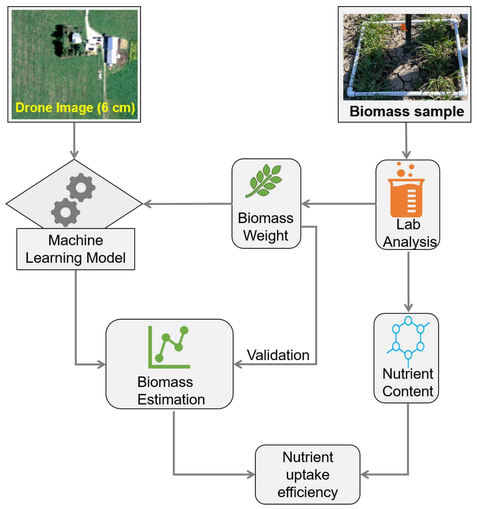

Fig. 4*: Processing and analysis of field-collected data*

- Biomass samples were analyzed for physiochemical properties: dry weight, N and P concentration.
- Drone images were stitched together using an image processing software, Pix4D.
- **Random Forest regression** model was trained to estimate cover crop biomass.
- 15 features (5 bands, 8 vegetation indices, Elevation and Digital Surface Model) were used as predictors in the model.
- Linear regression between biomass and corresponding nutrient concentration is used to assess the nutrient uptake efficiency.

RESULTS & DISCUSSION

Biomass Estimation

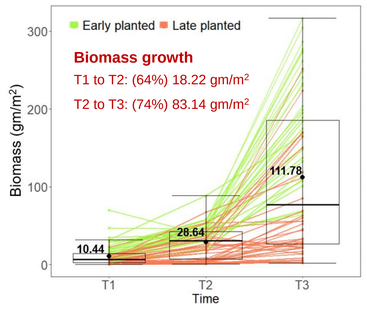

Fig. 5*: Cover crop biomass at three data collection periods*

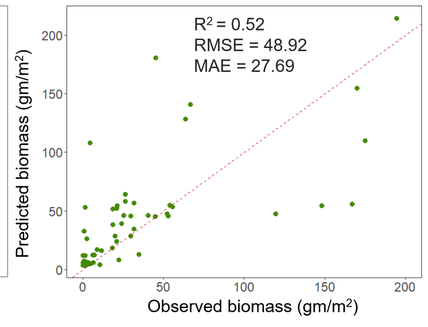

Fig. 6*: Relationship between model-predicted and observed cover crop biomass*

- Significant biomass growth occurred between March and May (Fig. 5).
- This could be due to warming of weather in spring.
- Early planted fields MB (Oct 9), AS (Oct 11), RS (Sept 30), BJ (Oct 5) were observed to have higher biomass.
- The model performed well for the lower biomass but not much for the higher biomass (Fig. 6).
- Inclusion of Red Edge-based vegetation indices as one of the covariates in the model improved the predictive accuracy from R^2 of 0.52 to 0.57.

Nutrient uptake

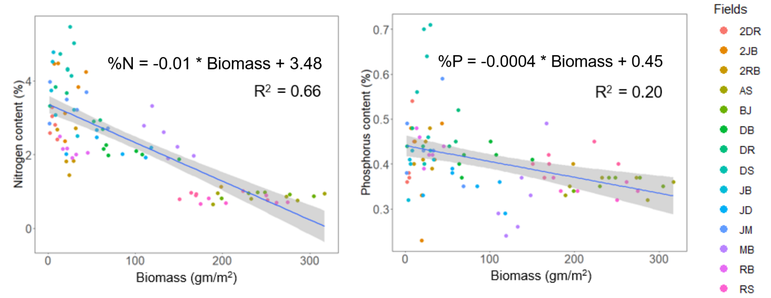

Fig. 7*: Relationship between dry biomass weight and corresponding N and P concentration in biomass samples collected at T3*

- Biomass had a stronger linear relationship with N concentration than P (Fig. 7).
- Rate of change in P concentration with an increase in biomass is lower than N.

Spatial mapping

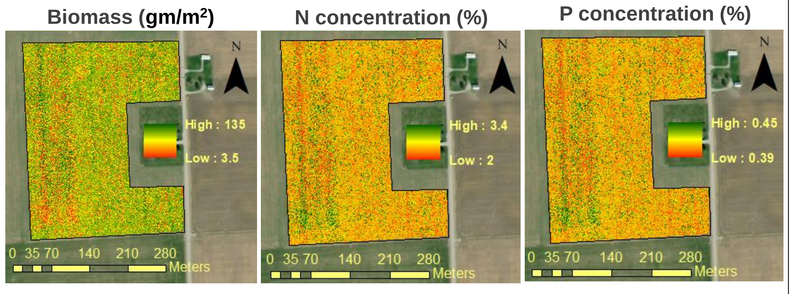

Fig. 8*: High (cm) resolution cover crop biomass, and N and P concentration in cover crop biomass estimated over one of the fields in the Western Lake Erie Basin*

- High-resolution spatially explicit maps (Fig. 8) help understand within-field variabilities in cover crop growth and nutrient recycling.
- It can be used with other spatial layers such as soil moisture, organic matter content, and soil nutrient to understand factors affecting cover crop growth and nutrient uptake efficiency.

CONCLUSION

- Models based on drone-collected images provide a cost-effective alternative to rapidly estimate cover crop biomass and their nutrient composition.
- High-resolution spatial maps of cover crop biomass and its constituent nutrients are useful for site-specific cover crop management.
- Understanding cover crop nutrient uptake efficiency can help in developing strategies to maximize water quality benefits.
- Future works would involve model improvement by integrating more ground-truth data collected during the 2022 season.

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