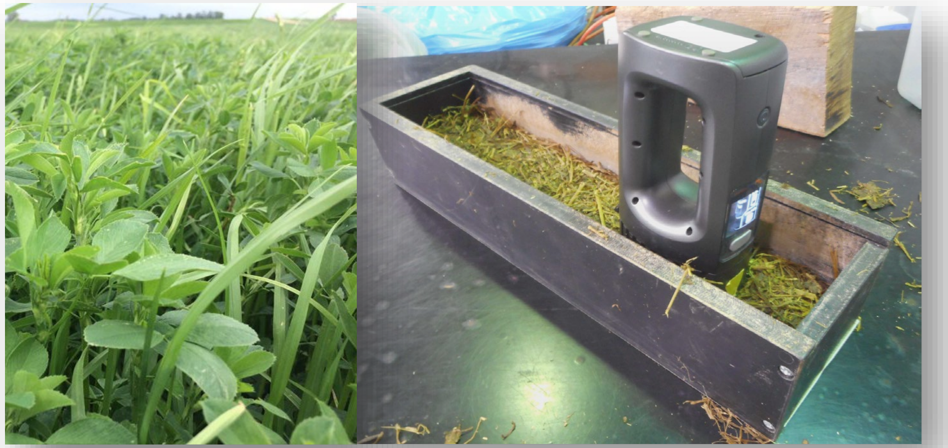
Use of hand-held NIR devices to predict the grass proportion in fresh grass-alfalfa mixtures: Improving sustainability in dairy systems



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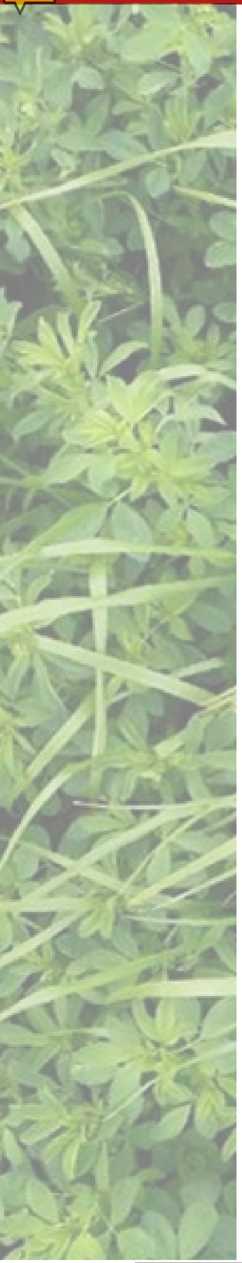
Introduction

- Over 85% of alfalfa sown in New York state is done in combination with a perennial grass → soils have suboptimal drainage quality.
- Cows can produce more milk with mixtures → because grass tends to have much higher NDFD than alfalfa
- Knowing the grass:alfalfa proportions provides insight into:
  - Estimating mixed stand forage quality (NDF)
  - Helps the farmer decide when to reseed
  - Information is used for nutrient management reporting.

Motivation

- Hand-held NIR technology allows for dairy feed analysis results in **real-time**.
- Sample analysis is **non-destructive** and is designed to be **used out in the field**.
- A robust, well calibrated model developed for the NeoSpectra hand-held device will provide farmers with the tools **to accurately estimate alfalfa and grass %**’s in their forage crops.



Objectives

1. Evaluate scanning technique and develop protocol for the using the hand-held NIR device for fresh grass:alfalfa mixtures.

2. Develop calibration equations (stationary and sliding) for the Neo Spectra Scanner to estimate grass % in grass:alfalfa **fresh** mixtures.

Methodology

Sample collection and Scanning:

- Collected pure, fresh alfalfa and grass samples over a range of maturities and locations
- Fresh samples were chopped
- Alfalfa and grass were combined in known proportions.
- Samples were scanned four times using both **stationary** and **sliding scans**
  - A portion of the samples was used for:
    1) calibration development
    2) the remaining used for model validation.

Methodology

Data analysis:

1. Averaged the 4 repeated scans for each sample with some outlier removal

2. For both stationary and sliding scans, a portion of the samples will be used:
   - Calibration equation development (75%)
   - The remaining used for external validation (25%)

3. Preprocessing: mean centering, Savitzky–Golay smoothing, first and second derivative.
   - Standard set of preprocessing methods to make better calibration equation

Methodology

Data analysis:

4. Fit partial least squares (PLS) model on the 75% calibration data:
   - Reflectance's from 257 wavelengths is too many → PLS selects Latent Variables (LVs) that worked well for predicting grass %
   - How many LVs to select?
   - Depends on how well they predict grass% on unseen data (80:20 dataset split again → 5-fold cross validation)

5. Applied the calibration equation to new data
   - Applied the equation to the 25% external validation dataset and look at residuals to see how well it works on new data.

6. We used Matlab PLS Toolbox software program from Eigenvector

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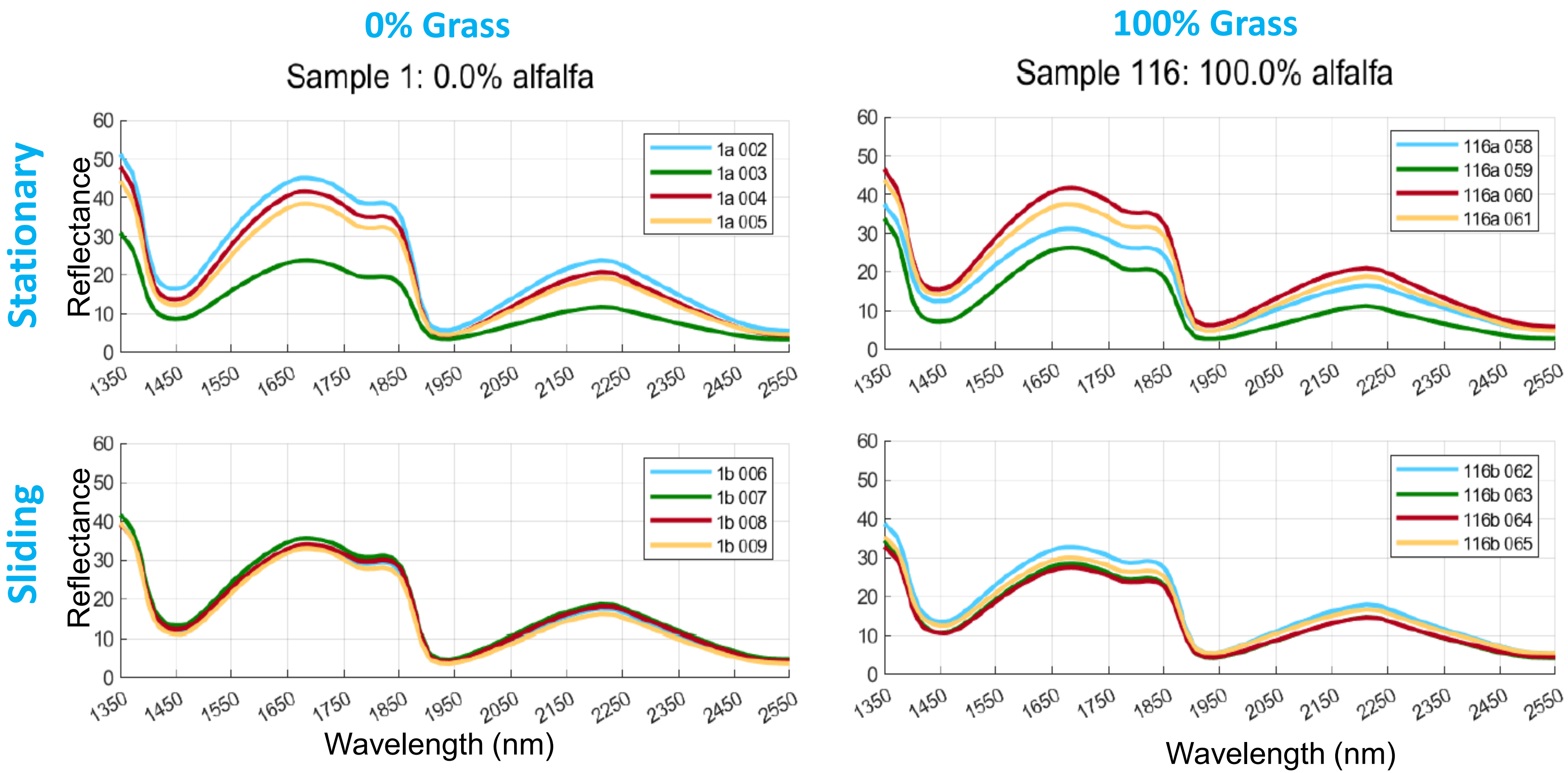
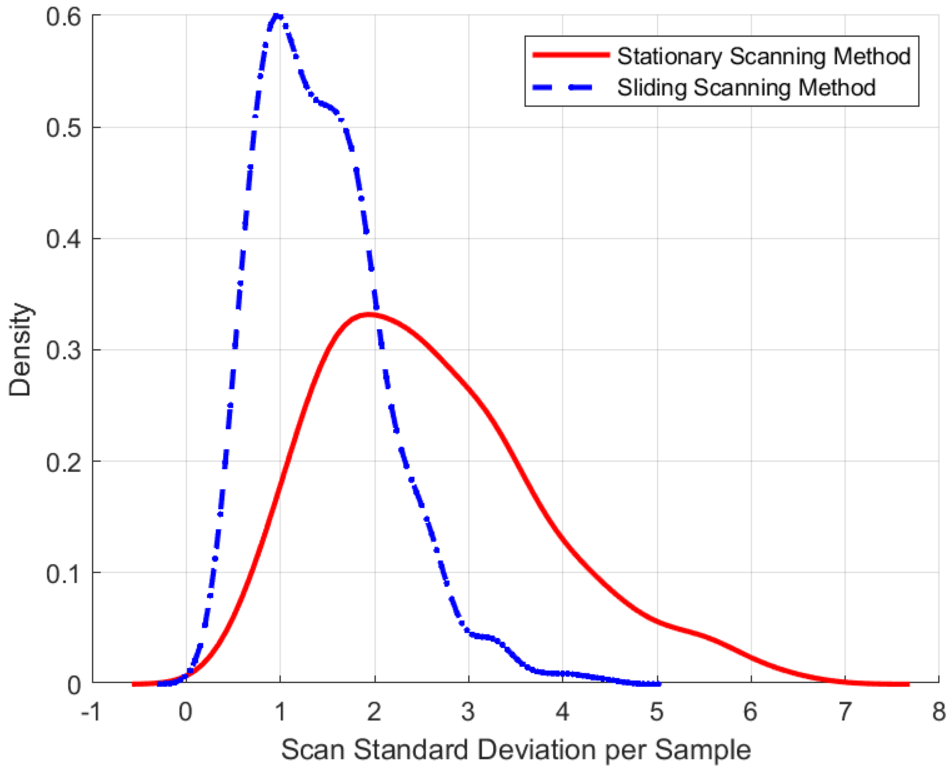
Results

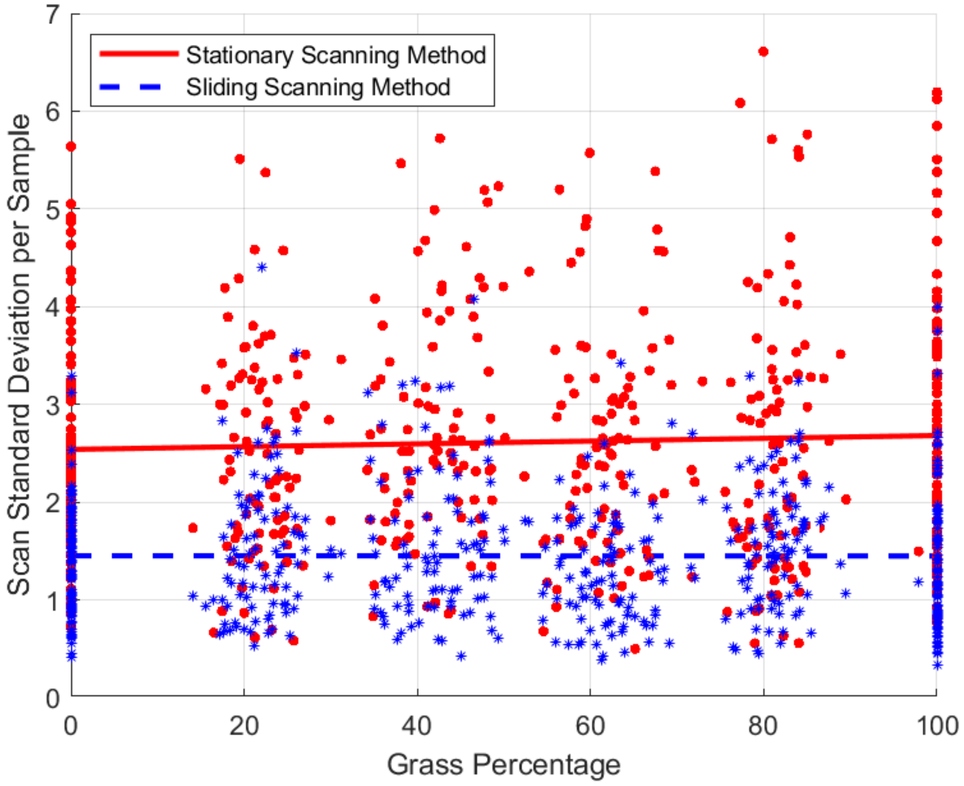
- Variability between stationary scans was greater than that of sliding scans



Results

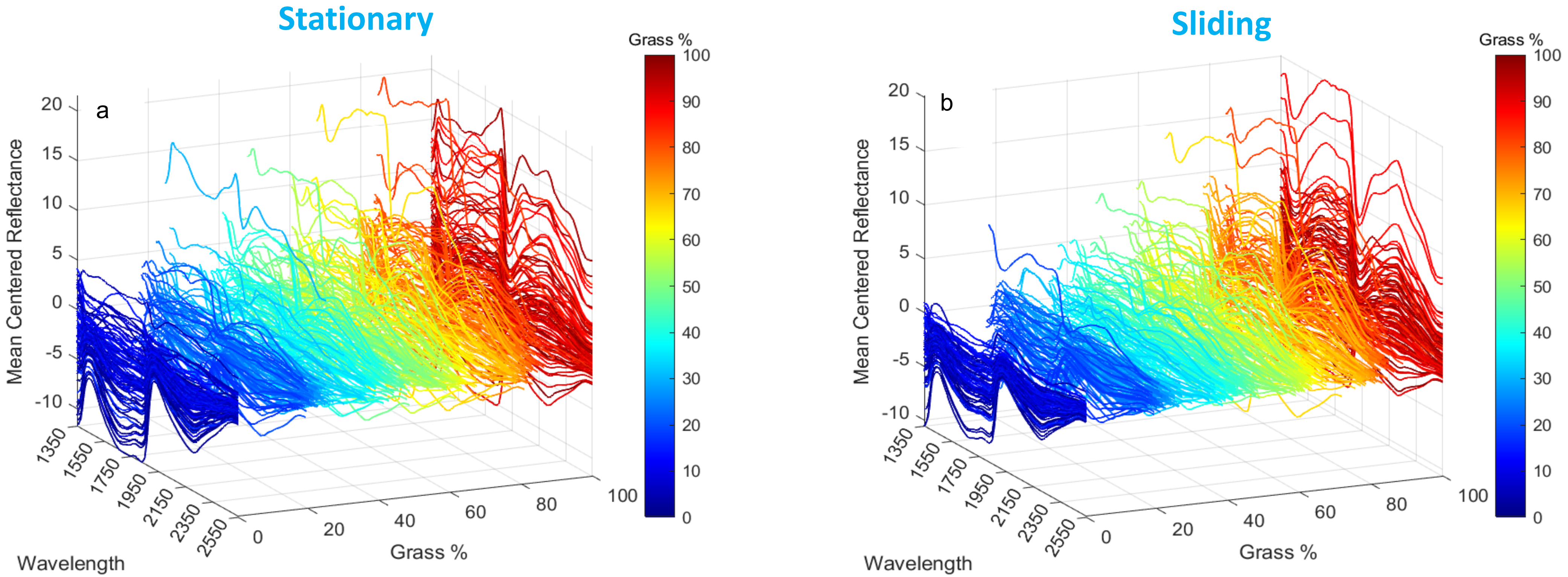
- The variability was greater for the stationary scanning technique compared to the sliding method.





Results

- High grass: above zero
- Low grass: below zero



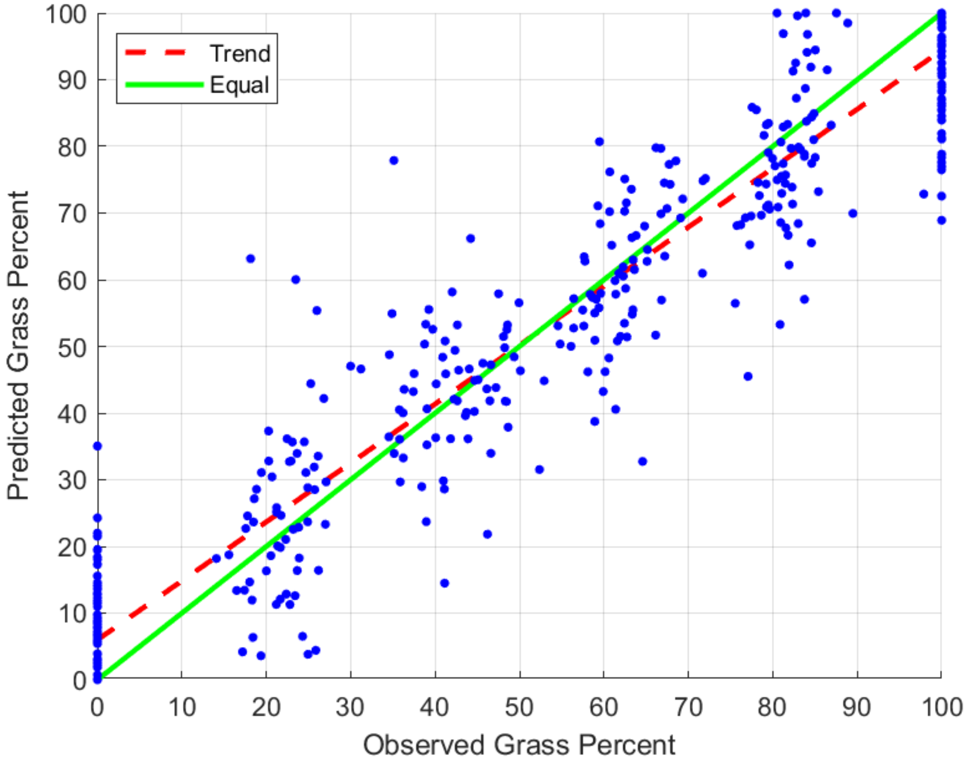
Results

	Calibration		Cross Validation		Prediction	
	R-squared	RMSE	R- squared	RMSE	R-squared	RMSE
Reflectance						
Stationary						
MC	71.8%	18.30	63.3%	21.03	65.3%	19.74
SG	71.8%	18.33	63.3%	21.03	65.3%	19.75
D1	77.0%	16.53	66.1%	20.30	70.2%	18.33
Sliding						
MC	84.9%	13.40	80.4%	15.30	77.9%	15.59
SG	84.8%	13.42	80.4%	15.31	77.9%	15.59
D1	85.3%	13.22	79.0%	15.88	77.5%	15.73
Absorbance						
Stationary						
MC	73.8%	17.66	65.3%	20.45	68.8%	18.62
SG	73.7%	17.70	65.2%	20.48	68.6%	18.67
D1	77.7%	16.29	66.2%	20.28	71.2%	17.82
Sliding						
MC	88.3%	11.76	84.0%	13.79	83.4%	13.58
SG	88.3%	11.80	84.0%	13.83	83.3%	13.62
D1	87.3%	12.29	80.3%	15.35	83.2%	13.58

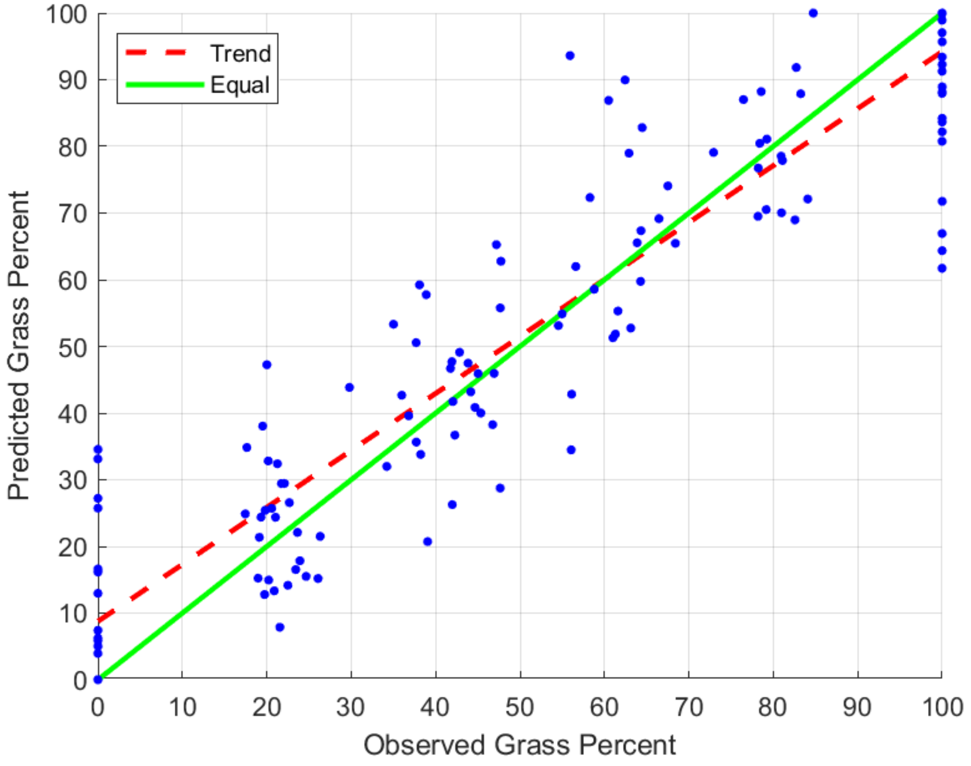
Results

- Results from PLS regression on calibration and external validation dataset
- Correlation between the observed and the predicted is:
  - 93% for calibration dataset and 91% for external validation dataset

Sliding on calibration dataset



Sliding on external validation dataset



Conclusions

- Sliding scanning technique yields better predictions – may be due to the scanning capturing more of the variability that exists in the sample.
- Absorbance gave a better result for grass predictions in this study
- Mean-centering is just as good as other preprocessing methods
- PLS on NIR spectra can give a prediction on unseen data with a correlation of over 85% but there's room for improvement
- Improvements from this preliminary work:
  - Further investigation on identifying outliers
  - Evaluate impact of grass and alfalfa varieties

What do these results mean for the farming community?

- Its feasible to use NIR on fresh forage samples, although further research is needed to improve accuracy.
- This research could improve the ability for grass-alfalfa producers to optimize field management and reduce variability in dairy rations, resulting in more environmentally and economically sustainable farming systems.


Thankyou

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