Estimation of plant nutrient status based on hyperspectral data and machine learning

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SCOPE OF RESEARCH

- Potassium is one of the most essential components of plant organic matter, which play an important role in many metabolic processes. It's deficiency causes poorly roots system development, slow growth, low resistance to stress and diseases, delayed maturity, and lower yields
- The efficient application, as well as rapid and time monitoring of K status in crops is crucial for ensuring crop yield and for minimizing the negative environmental impact of fertilization
- Hyperspectral imaging has shown to be a promising non-destructive tool for determination of nutrient content in plant leaves
- **The objectives of this research is to develop the model based on hyperspectral data for estimating K status in plants**

Plant material

- **Celery** (*Apium graveolens L.*, cv. Neon)
- **Sugar beet** (*Beta vulgaris L.*, cv. Tapir)
- 216 samples treated with four different doses of potassium fertilizer (33%, 67%, 100% and 133% of reccomended dose)
- Plants growth condition:
  - temperature: 20-22^{o}C,
  - photoperiod (day/night) 12/12h
  - time of experiments: 180 days

Hyperspectral data

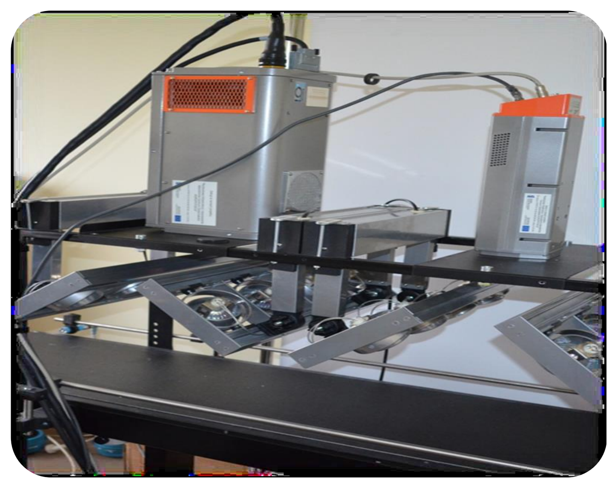
The experiminet setup consist of Visible and Near Infrared camera (VNIR) with an ImSpector V10E imaging spectrograph and a Short Wavelength Infrared Camera (SWIR) with a N25E 2/3" imaging spectrometer manufactured by SPECIM, Finland

Spectral range: 400-1000 nm (VNIR camera)
1000- 2500 nm (SWIR camera)

Spectral channels 468

Spectral resolution 3 nm (VNIR) 7 nm (SWIR)

Data pre-processing:
- radiometric correction of images,
- transformation Savitzky-Golay 2nd derivative.



Hyperspectral data were correlated with reference data obtained by spectrofotometric analysis of K content in plant

Results

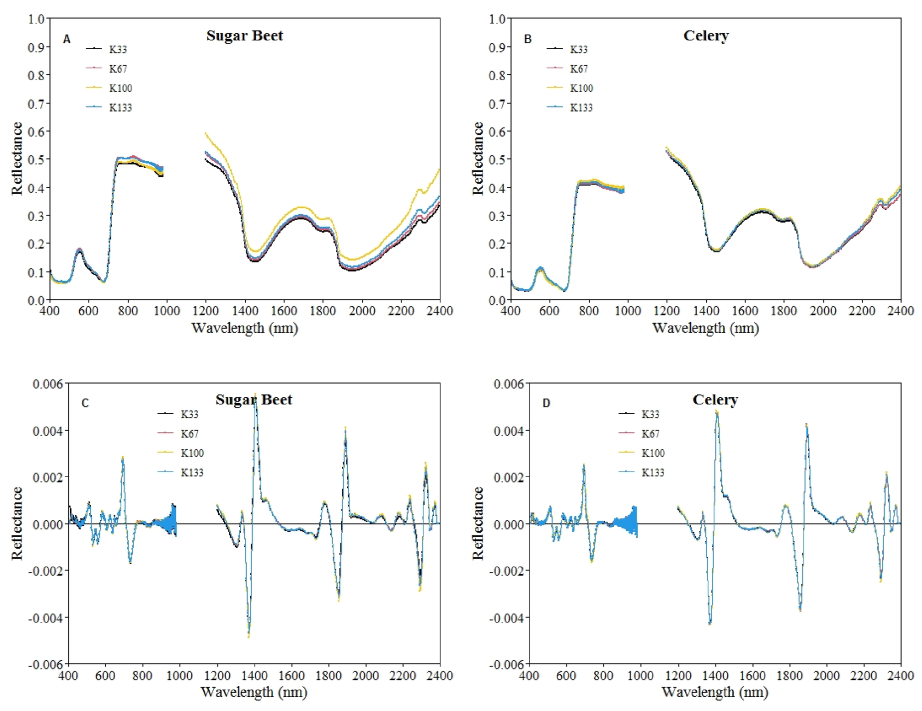


Fig.1. Raw and 2nd derivative spectra of sugar beet (A,C) and celery leaves (B,D)

- **Spectra were transformed using the Savitzky-Golay second derivative method**.
- **Twelve optimal wavelengths were selected by Correlation Future Selection (CFS), for prediction of K content**

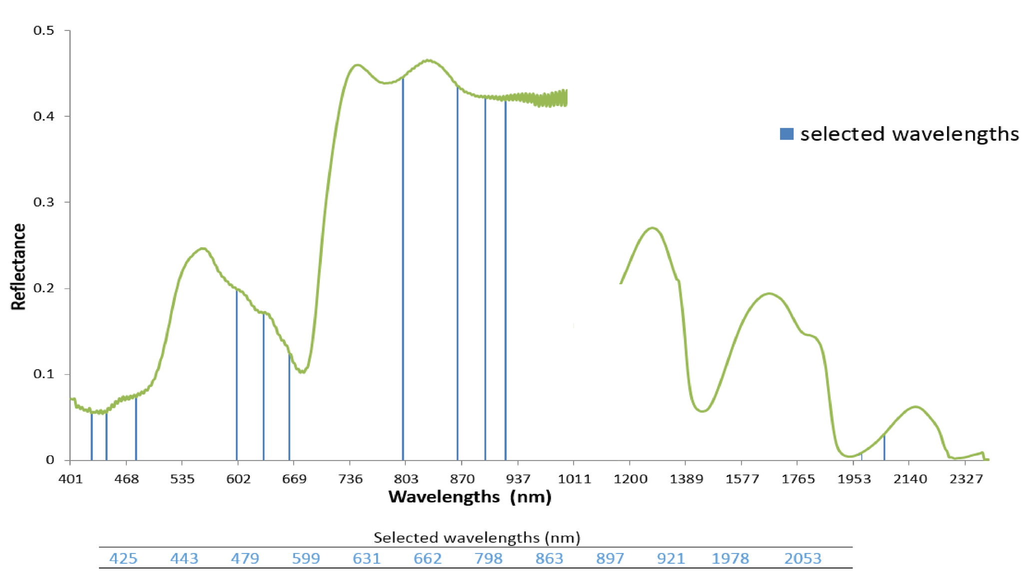


Fig. 2. Representative spectrum obtained for celery plants treated with recommended potassium dose. Solid lines represents 12 wavelengths selected using CFS algorithm for prediction of K content

- ***To evaluate the model performance, leaf samples in each datasets were randomly divided into training and test datasets in the ratio 75:25***

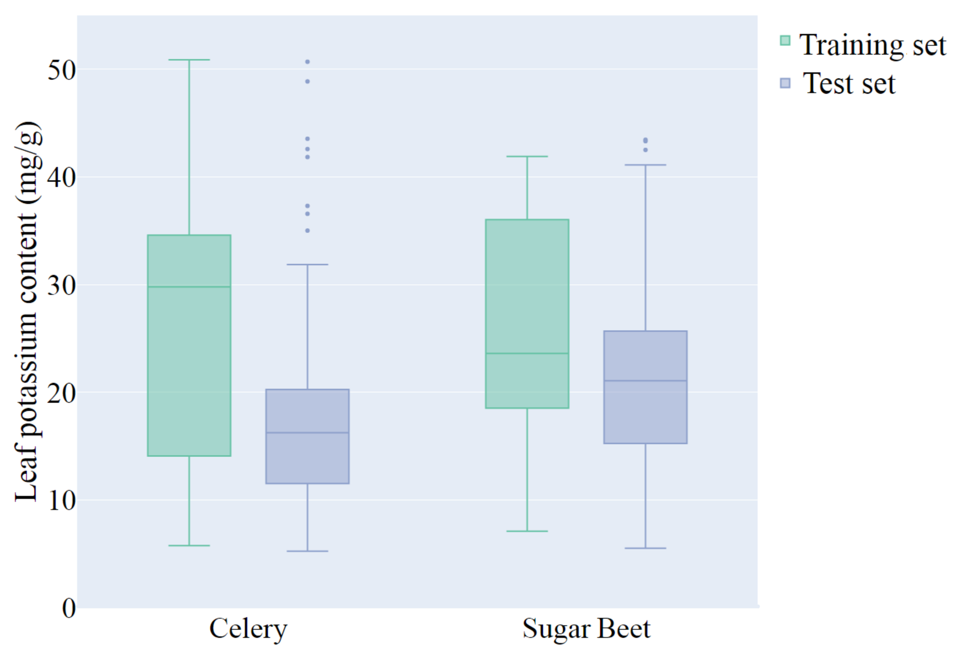


Fig. 3. Boxplot of measured value of K content in sugar beet and celery leaves in training and test sets

- **Random Forest algorithm with R^2 = 0.80, RMSE= 5.88 and with R^2 = 0.81, RMSE= 6.61 for sugar beet and celery plants, respectively**

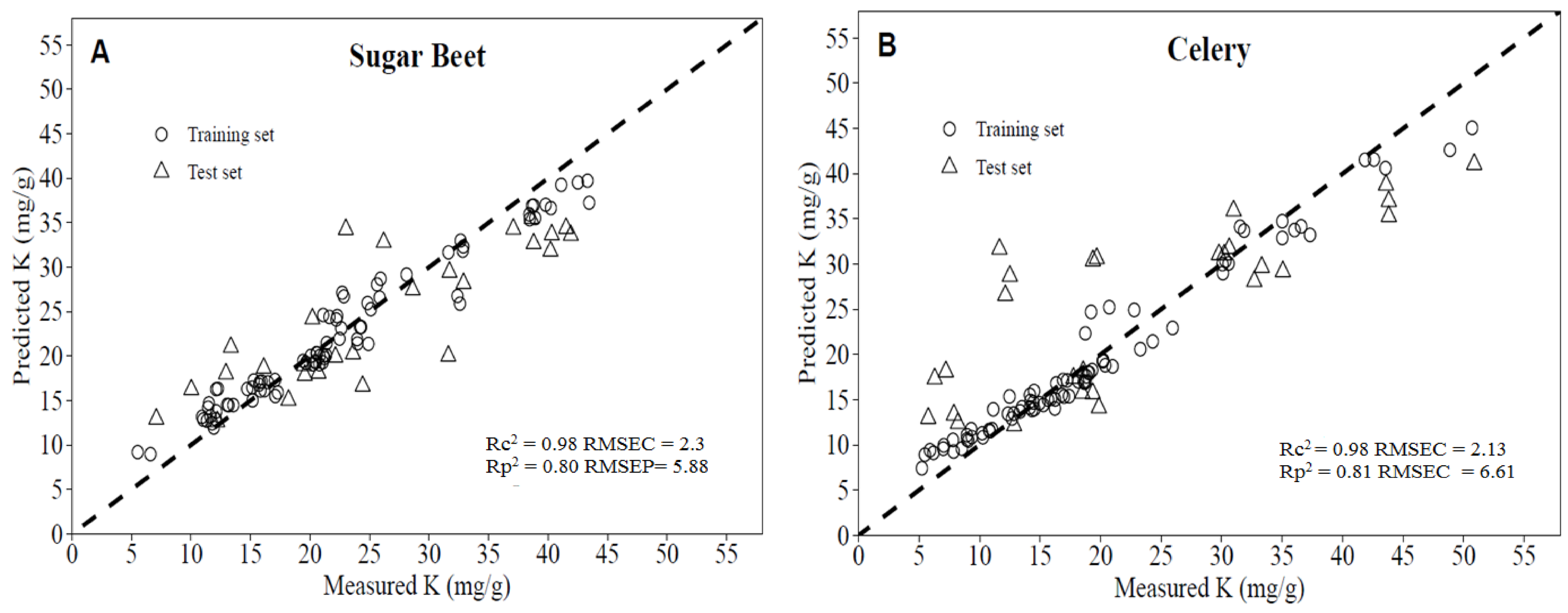


Fig. 4. Correlation between the measured and the predicted values for K contents in sugar beet (a) and celery (b) plants obtained by CFS-RF model

Summary

- **The proposed approach uses leaf spectral data in the VNIR and SWIR region to predict potassium content in sugar beet and celery leaves. It was indicate that leaf spectral reflectance, especially in visible and NIR regions, was very usefull to build the K content prediction model.**
- **Results obtained in this study demonstrate that hyperspectral imaging could be utilized for developing a decision-making tool for farmers to allow a real-time foliar nutrient assessment leading to control fertilizer inputs in farm.**

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