The Application of Unmanned Aerial Vehicle and Machine Learning Techniques for Red Clover-Grass Mixture Yield Estimation

Kai-Yun Li[1], Ants Vain[1], Karli Sepp[2], Niall Burnside[3], Kalev Sepp[1]

(1) Estonian university of life sciences institute of agricultural and environmental sciences, Tartu, Estonia
(2) Agricultural research centre (ARC), Estonian Ministry of Rural Affairs, Estonia
(3) University of Brighton, School of Environment and Technology, Brighton, England

Introduction

Red clover (*Trifolium pratense L.*) is the main cropping perennial forage legume species in Estonia. With the ability to transfer fixed nitrogen to nearby pastures and help to lower greenhouse gas emissions by reducing the use of chemical fertilizers which improves the sustainability of the agricultural ecosystem compared to monocrops. This highlights the importance of unmanned aerial vehicle systems (UAS) in estimation and quantification of clover-grass mixtures especially from the laboratory to the field-based performance trials studies.

Aims

In this study, we compared two pre-harvest (11 days and 38 days) dry matter (DM) prediction capabilities under clover-grass cultivation trials. The multispectral-based six vegetation indexes were extracted and implicated for training and evaluation of random forest (RF), support vector machine (SVM), and artificial neural network (ANN) models. We hope to establish a rapid, non-destructive, low-cost UAS framework for field-based red-clover DM modelling.

Methodology

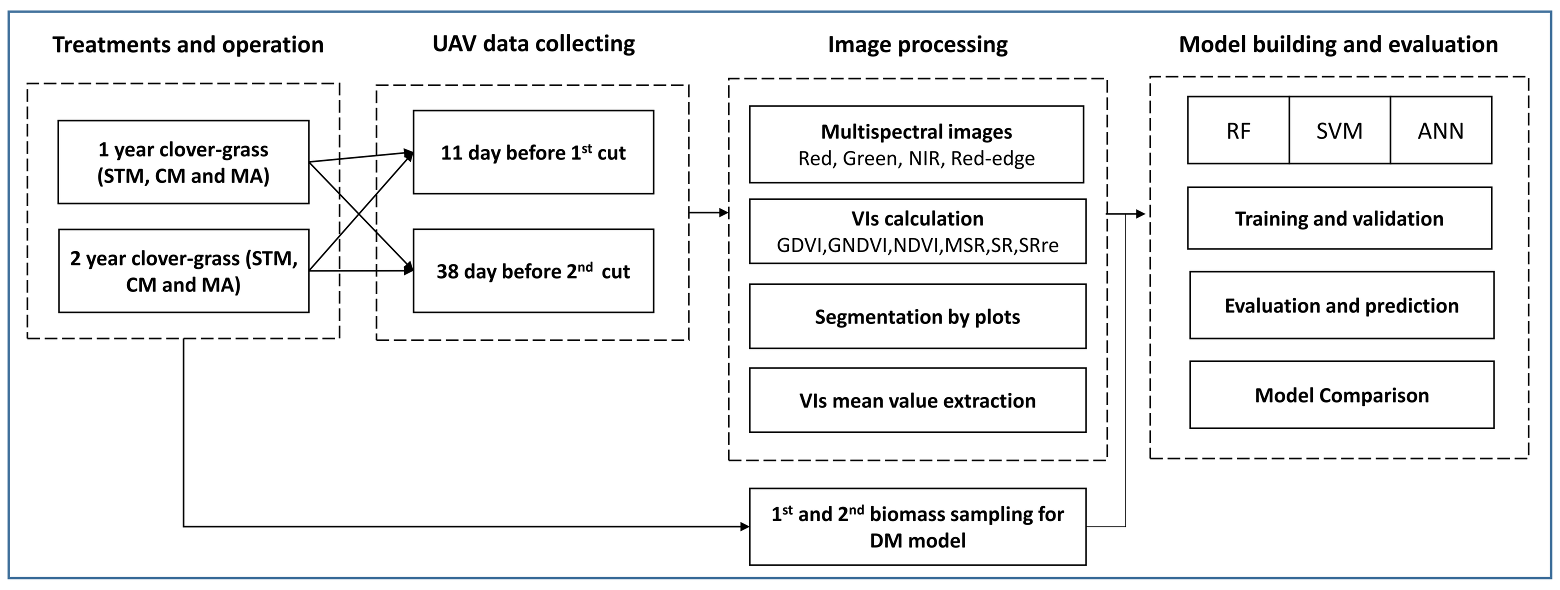

Fig 2. Flowchart of the red clover-grass mixture DM modeling. UAV data collected by eBee with Parrot Sequoia sensor, image processing was conducted by Pix4D v.4.3.31 and ArcGIS pro 2.6.2, model building in Python 3.9.0.

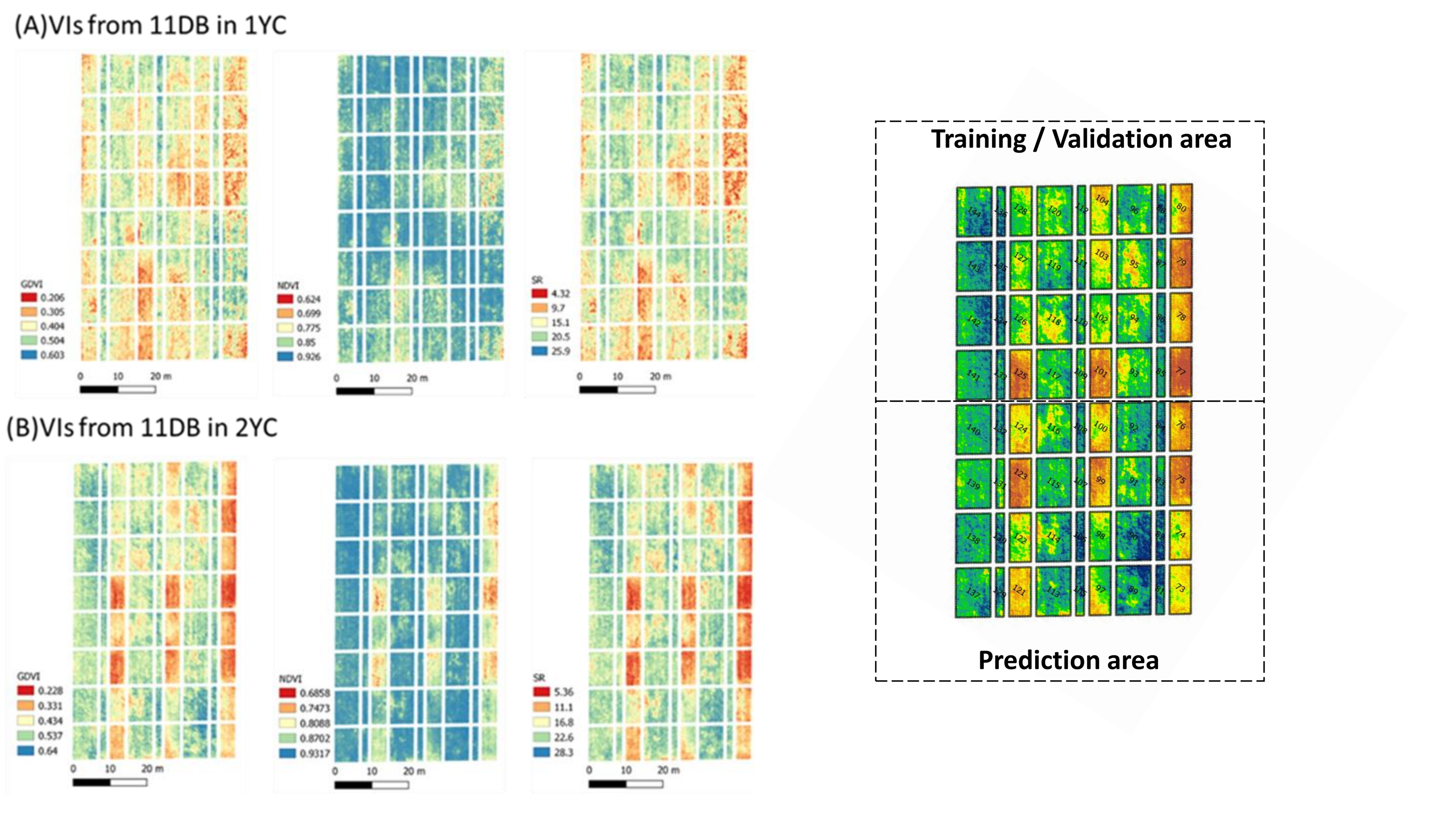

Fig 3. The demonstration of VIs in 1YC and 2YC from 11 days before harvesting (11DB) within the region of interest (ROI). The extracted mean values were divided into training and prediction area for DM modelling.

Study area

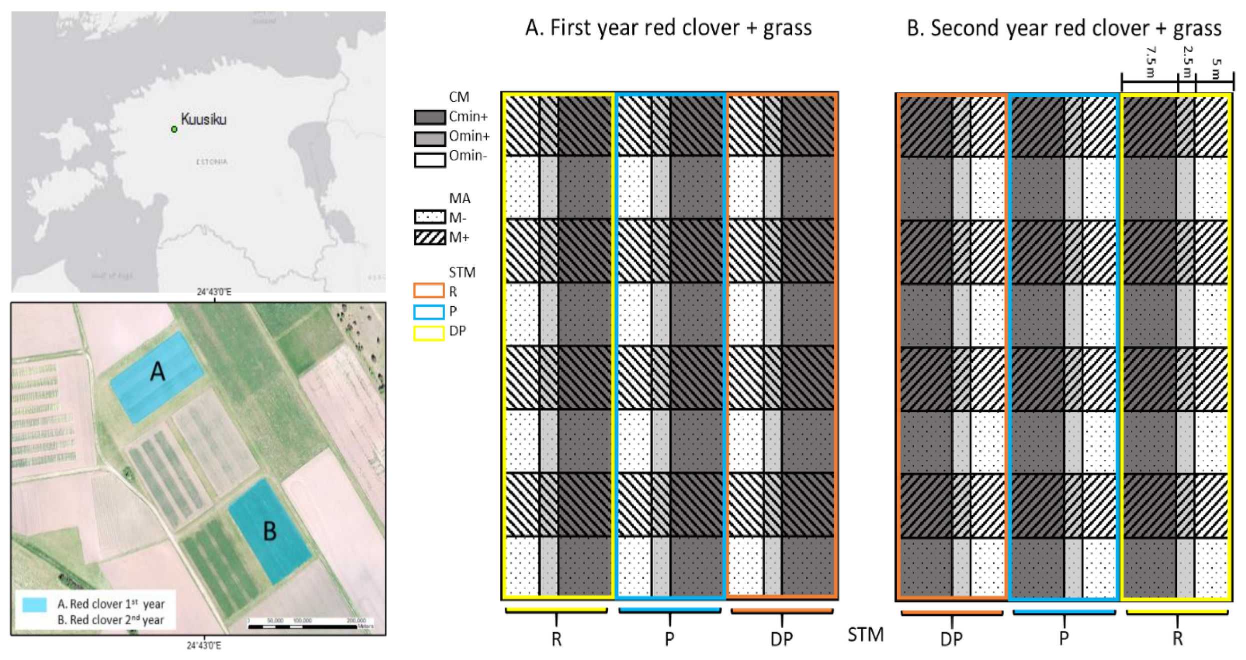

Fig 1. The Agricultural Research Centre (ARC), Kuusiku, Estonia and experiment layout containing three experimental factors, 1. soil tillage method (STM) 2. cultivation method (CM), and manure application (MA) in 1-year cultivation (1YC) in Field A, and 2-year cultivation (2YC) in Field B.

Result

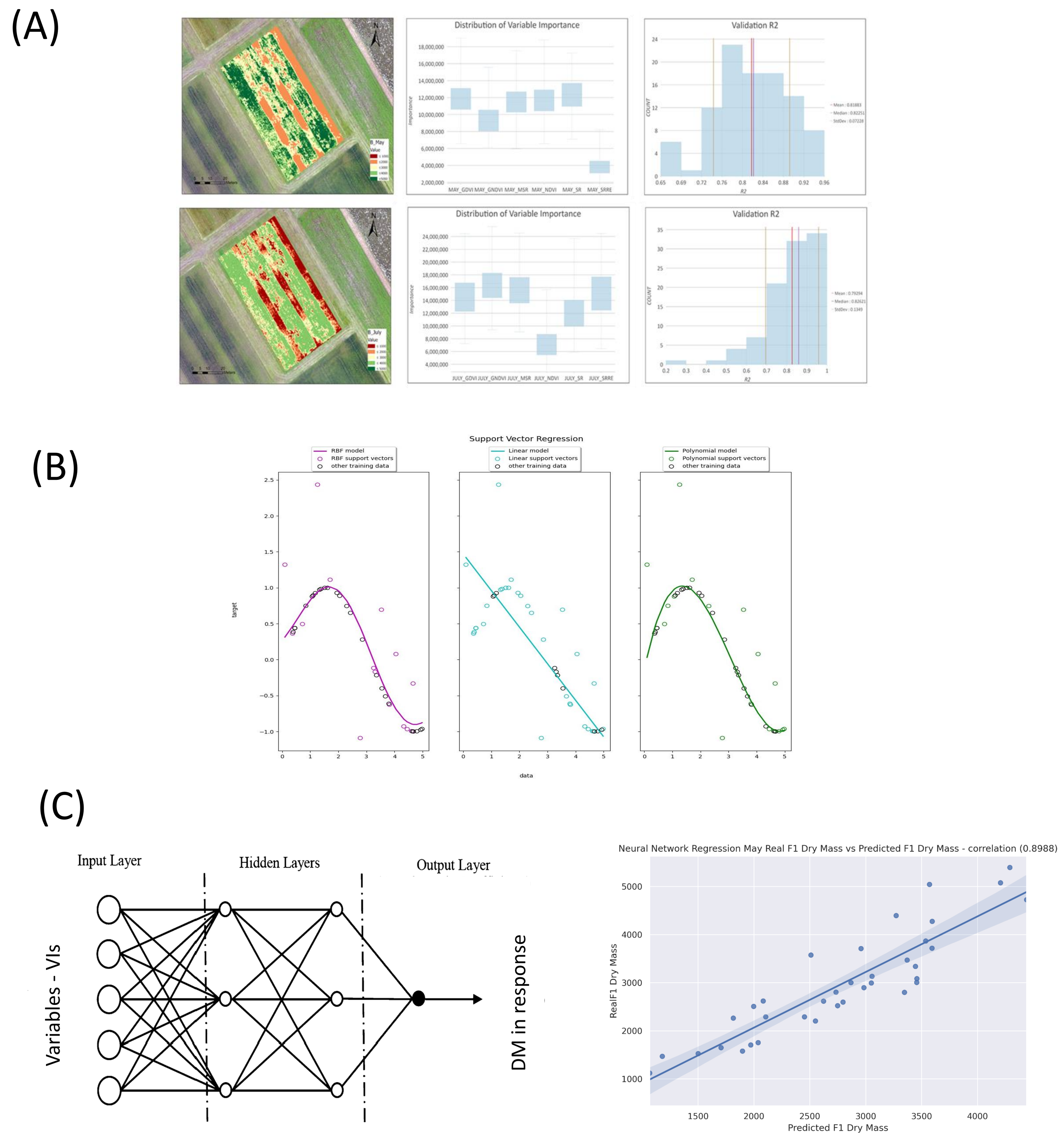

Fig 4. The DM prediction models from six VIs (A) RF with variable importance, and validation R^2 (B) SVM with linear, Radial basis function (RBF), and polynomial regression. (c) ANN model with R^2

Further Study

We will compare the prediction capabilities of multispectral, hyperspectral, and canopy height model (CHM) made with RGB images to create more accurate DM modelling and support diverse agri-environment schemes and construct a field-based phenotyping system for forage legume crops in Estonia.

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