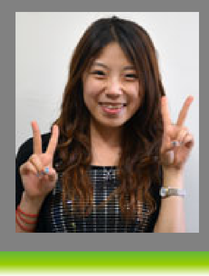
Ground-based camera system for monitoring herbage biomass in Italian ryegrass field



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Introduction

Background

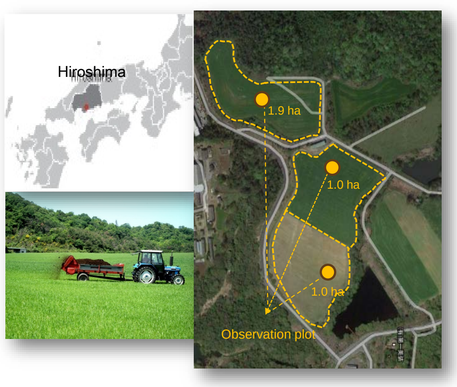
- Italian ryegrass is one of the most important and widely used winter forage crop (approx. 61 000 ha) in Japan.
- Monitoring seasonal changes of herbage biomass (BM) and nutrient status of forage crop is important for practical fertilizer management and yield prediction.

Purpose

- Develop a simple and cost-effective sensing system using V-NIR camera as a ground-based remote sensing device.
- Investigate seasonal changes of herbage BM in an Italian ryegrass field with the time-series image data.

Materials & Methods

Study site and field measurements



Location

Setouchi Field Science Center, Hiroshima University (34º 23' N, 132º 43' E)

- Annual mean temperature: 13.6 ºC
- Annual precipitation: 1453.5 mm

Field measurements

- eight times measurements in Jan–May, 2013 (Number of sample: n = 114)
- Aboveground biomass (BM, g m^{-2})
- Surface sward height (SSH, cm)

V-NIR camera system

- Observation period: Jan 1-May 13, 2013.
- Exposures: 10:30, 12:00 and 13:30 in a day.
- Sensor: Red (R), green (G), blue (B) and NIR (2592 ×1944 pixels [8-bit], JPEG)
- Spatial resolution: 0.625 mm
- Experimental design: 2.5 m nadir view; 1.6 m × 1.2 m footprint
- Cost: approximately 80 000 JPY

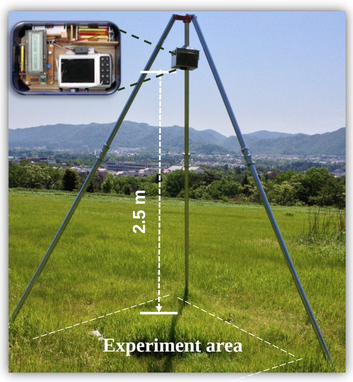
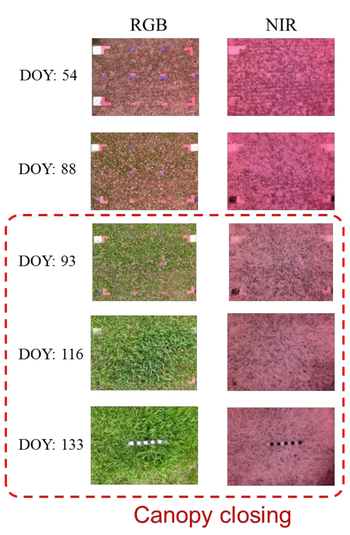


Image processing and statistical analysis



Time-series image processing

- Extract digital number (DN) from daily image (12:00)
- Average DN value within region of interest (ROI)
- Calculate color intensity by normalized algorithm
- Software: Matlab version 7.14 (Mathworks Inc., Sherborn, MA, USA)

Regression analysis to estimate BM

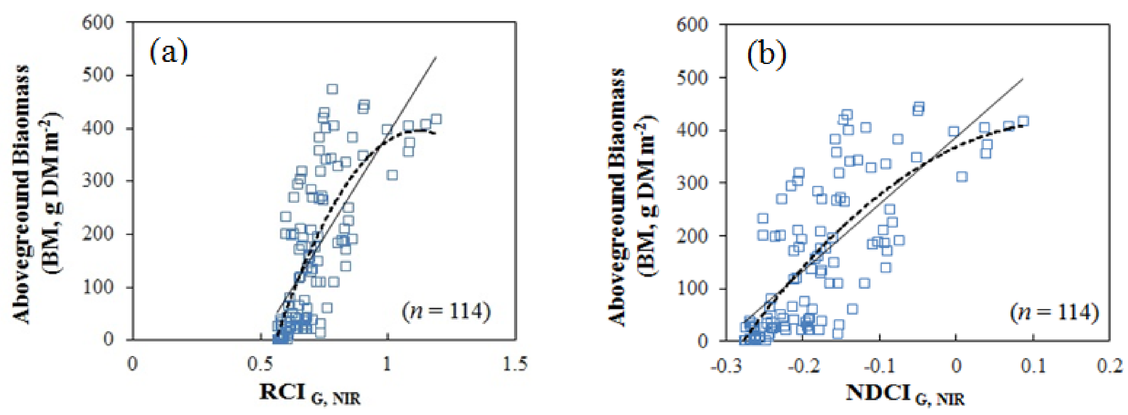
- Polynomial regression: Ratio color index (RCI) and Normalized difference color index (NDCI)
- Predictive accuracy: Coefficients of determination (R^2) and Root-mean-squared error (RMSE)

Smoothing and quick growth stage detection

- Smoothing: HANTS (Harmonic ANalysis of Time Series) algorithm based on Fourier analysis (Verhoef 1996)
- Quick growth stage (QGS): The peaks of second derivative values of BM seasonal change identify the start and end of QGS.

Results

Regression model for BM estimation



R^2 = 0.54 RMSE = 96.59 | R^2 = 0.55 RMSE = 94.47

Figure 1: Polynomial regression based on (a) RCI ($RCI_{G,NIR}$) and (b) NDCI ($NDCI_{G,NIR}$) using G and NIR channels.

Seasonal changes of 4 color channels and BM

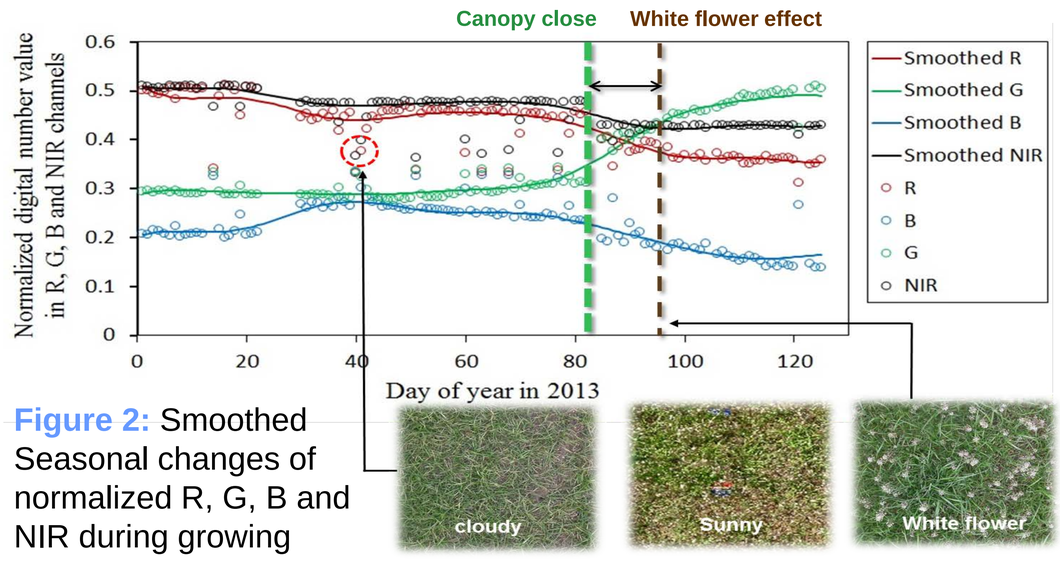


Figure 2: Smoothed Seasonal changes of normalized R, G, B and NIR during growing season.

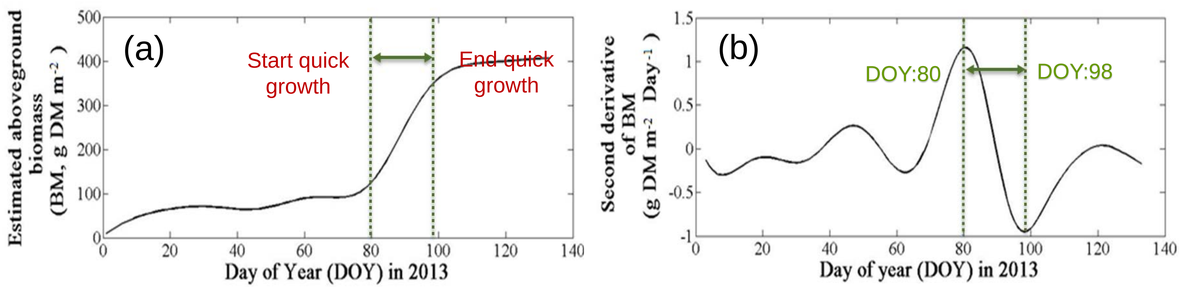


Figure 3: Seasonal changes of (a) BM and (b) its second derivative value in 2013. Vertical lines indicate start (DOY 80) and end (DOY 98) of QGS.

Messages

The NDCI using G and NIR channels showed the best predictive accuracy to estimate BM (Figure 1). Using the model, seasonal changes of BM and its quick growth stage could be calculated (Figure 3). We expected that these information include useful insights for farmer to determine appropriate timing of fertilizer application and cutting.

Acknowledgements

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