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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目：
Title of Dissertation

Estimate SPAD values of naked barley leaves in the field by color-based vegetation index from UAV-derived RGB images
（ドローンのRGB画像から計算されたカラー指標に基づく裸麦の葉のSPAD値の推定）

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Barley is one of the oldest cultivated crops in the world. The additional fertilization is essential during the naked barley growth. The nitrogen content of crops is essential for the management of nitrogen fertilizer during growth. The chlorophyll content in the crop leaves is related to the nitrogen content in the crop leaves. The soil plant analysis development (SPAD) value strongly correlates with the leaf chlorophyll content. The SPAD value can be used as a fertilizer indicator during crop management. However, a SPAD meter is a time-consuming and labor-intensive tool for use on a large scale. Unmanned Aerial Vehicles (UAV) can derive the canopy image of crops in a high temporal and spatial resolution for a large area. Therefore, we investigated the potential of using RGB images of a naked barley canopy taken by a UAV to estimate SPAD values in the field. First, linear regression models for estimating SPAD values were constructed using RGB values measured by a chroma meter with a stable internal light source at the leaf level. Second, the potential of using these models in the field was evaluated using RGB values estimated from images at the canopy level taken under sunlight by a UAV at different growth stages of the naked barley. The results suggested that SPAD values could be estimated from UAV canopy images using regression models for estimating SPAD values that were constructed for the leaf level. The *SPAD(g, b)* multivariate linear regression model could be regarded as the optimal model for estimating the SPAD values of naked barley leaves at both the leaf and canopy levels in our study.

Moreover, we investigated whether the RGB images captured by the UAV mounted with a commercial camera could be used in retrieving SPAD values of naked barley leaves under unstable photography conditions. We related 21 color-based vegetation indices (VIs) calculated from UAV images acquired from two flight heights (6.0 m and 50.0 m above ground level) in four different growth stages with SPAD values. Our

results indicated that vegetation extraction and naked barley ears mask could improve the correlation between image-calculated vegetation indices and SPAD values. The VIs of ‘L*,’ ‘b*,’ ‘G-B’ and ‘2G-R-B’ showed significant correlations with SPAD values of naked barley leaves at both flight heights. The validation of the regression model showed that the index of ‘G-B’ could be regarded as the most robust vegetation index for predicting the SPAD values of naked barley leaves for different images and different flight heights.

Our study indicated that it was possible to estimate SPAD values of naked barley leaves from canopy RGB images in the field on a large scale using the regression model constructed for the leaf level. Our study also showed the great potentiality of the UAV-mounted with commercial digital color camera in retrieving SPAD values of naked barley leaves under inconsistent photography conditions. It is significant for farmers to take advantage of the cheap measurement system to monitor the crops.