EM 29

Monitoring of Crop Plant Height Based on DSM Data Obtained by Small Unmanned Vehicle Considering the Difference of Plant Shapes

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Introduction

Plant height (PH) is an important indicator for farmland management as it directly relates to crop growth status.However, traditional methods of PH measurement are time- and labor-consuming because of its requirement for mass sampling. In the past decade, the rapid development of Unmanned Aerial Vehicle (UAV) has provided an efficient, labor-saving, and precise approach to monitor crop biophysical parameters. Due to its ability of frequent aero photography, UAV has been also considered a suitable tool for crop PH monitoring. The method to detect crop PH using crop surface models (CSMs) generated with UAV-based imaging has been proved available.

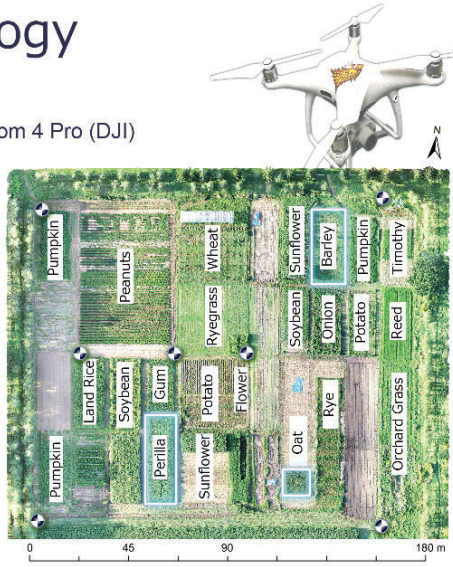
Purpose

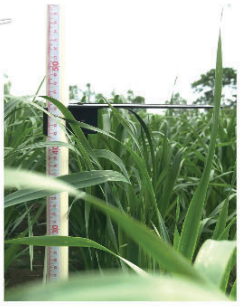
However, no study has yet evaluated the estimated PH for crops with significant differences in plant shapes using UAV photographs taken under same flight conditions, and no study has discussed the effect on estimation accuracy of PH caused by differentplant shapes. Thus, the objectives of this study are: (1) to determine the PH estimation accuracy for three subjects with different plant shapes; and (2) to evaluate the effect on PH estimation accuracy caused by plant shapes.

Methodology

①Field Survey

UAV Equipment: Phantom 4 Pro (DJI)
Flight Date:
2019.5.31-10.10,
weekly
Flight Application:
Pix4D Capture
Camera Angle:
70° from horizon
Type of Flight Route:
Double Grid
Flight Height:
50 m above ground
Ground Resolution:
1.4 cm
Stable Flight Speed:
4.8 m/s
Flight Area: 3 ha

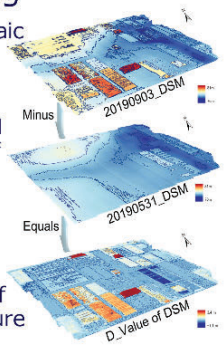




Ground surveys to obtain the measured PH were conducted after each flight. A self-made PH measure was used to obtain the optimal value of PH under natural state.

②Data Processing

A. Condusting Orthomosaic and DSM using SfM calculating software (Metashape, Agisoft)
B. Calculating the D-DSM DSM of plant - DSM of flat field (ArcGIS Pro, Esri)
C. Locating the measure points using ortho-mosaic
D. Extracting the value of D_DSM of each measure points
E. Confirming the correlation between the value of D_DSM and measured PH
F. Creating the estimate formula of PH based on the value of D_DSM using the least squares algorithm
G. Evaluating the performance of the estimate formula with R^2 and RMSE



Results & Discussion

Fig.1 shows the comparisons of the time series between the measured and estimated PH for the three crops. In the barley field, a lodging of spikes caused by rain happened on July 2 and continued until harvest. In the oat field, a soiling, which refers to the cutting of the leaves of crops for green feed in the middle of the growth stage, was carried out on July 24. In the perilla field, a thinning, which refers to the removal some plants of crop to make room for the others, was carried out on July 26. These natural or man-made phenomena were also reflected in the time-series of both estimated and measured PH.

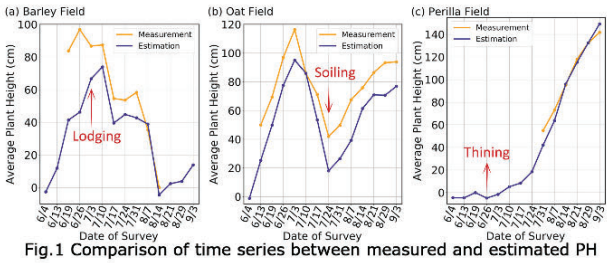


Fig.1 Comparison of time series between measured and estimated PH

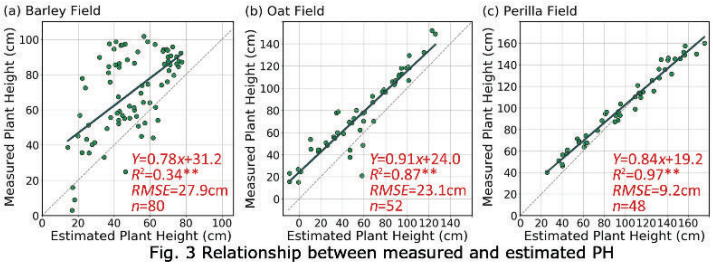


Fig. 3 Relationship between measured and estimated PH

The relationship between the measured and estimated PH for each crop are shown in Fig.2. A low correlation (R2=0.43) and an RMSE of 27.9 cm were observed in the barley field. A high correlation (R^2=0.87) and an RMSE of 23.1cm were found in the oat field. An extremely high correlation (R^2=0.97) and a much lower RMSE of 9.2 cm were perceived in the perilla field. In view of the above, the estimated PH based on DSMs performed most satisfactorily for perilla, which is a dicotyledon crop. Between the other two varieties which are both monocotyledon crops, the estimated PH performed better for oat than for barley.

In the barley field, the vegetation cover (VC) increased pronouncedly after the lodging from 88.9% (26th June) to 97.1% (3rd July), while in the perilla field, the VC increased gradually from 90.4% (31th July) to 100.0% (3rd September).
The relationship between the measured PH and the estimated PH corrected by VC is shown in Fig.3. In the barley field, the performance of the estimated PH after correction by VC (R^2=0.57, RMSE=20.9 cm) was shown to be more accurate than before correction. In the perilla field, the estimation accuracy was slightly increased (R^2=0.97, RMSE=7.9 cm) after it was corrected by VC.

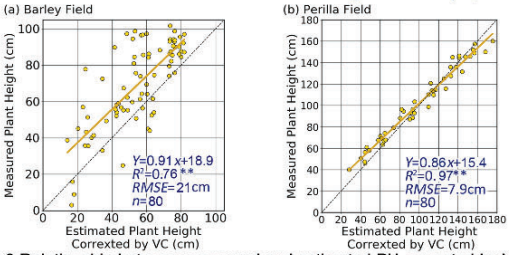


Fig.3 Relationship between measured and estimated PH corrected by VC

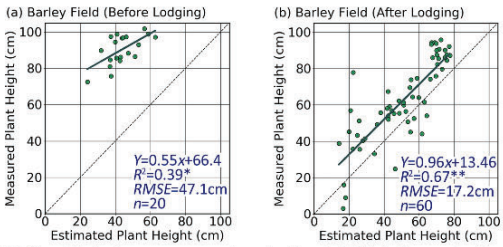


Fig. 5 Relationship between measured and estimated PH before and after lodging

Furthermore, between the two monocotyledons used in this study, the estimated PH of oat performed better than barley. The reason for the low estimation accuracy of barley is considered to be the shape of the spikes. Barley produces peculiar, outward spikes with long, prickly awn (10 cm-15 cm) above the ear of grain. The height of the spikes was included in the measured PH. However, it is considered to be ignored during the DSM generation because it was too small to be recognized. To verify this possibility, the relationship between the measured and estimated PH before and after the lodging of spikes were calculated which are shown in Fig.4.

Conclusion

In this study, the accuracy of estimating PH based on DSM data generated from UAV photographs for three crops with different plant shapes were compared. For both barley and oat plants, the estimated PH were lower than the measured PH, because the DSM provided the average height of all factors within one pixel. However, the estimated PH for perilla was more accurate than the other subjects and surpassed the measured PH late in the growth stage due to its luxuriant plant shape.