ESTIMATION OF RICE PLANT HEIGHT FROM LASER *POINT* CLOUD DATA

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ABSTRACT

Rice crop should be carefully monitored for food security in Asian countries. Nowadays, laser scanners have proved to be applied to collect large amounts of crop information in a relatively short time in precise agriculture. For this study, rice canopy was observed in the early rice growth stages by a line laser scanner SICK LMS 200 in 2013. Five test plots were established with different planting densities and geometries. From this, the capability of deriving plant height from laser data was investigated. The top of rice plant was identified at the 1st percentile of scanning points (D^1) and the ground surface position (D_G) was computed form the bare ground data. The laser data-derived plant height was computed as the vertical distance from D_G to D^1. As a result, laser data-derived plant height get well correlation to plant height.

1. INTRODUCTION

In Asian countries, population consumes rice for every daily meal. Rice is the main food and the main income of farmers. Rice production directly affects the social security. Recently, good quality of rice is prime of concern; therefore, it is necessary to monitor the rice growth. Farmers validate the rice growth status basing on the plant height, number of stems and leaf color. Then, they change the cultivated factors to maximize rice crop growth. Three mentioned parameters have been popular measured by fieldworks. The measuring process is monotonous and labor-intensive. However, the measuring results depend on the technician. In fact, the collected data may contain human errors such as misreporting or mislabeling. Therefore, remote sensing techniques are widely utilized in agricultural production to save time and labor works (Atzberger, 2013).

Nowadays, dense and accurate spatial data can be collected in the short time by laser scanner (Lichti et al., 2002). Many researchers have been applied terrestrial laser scanner (TLS) in precision agriculture for many purposes such as estimating the vertical plant area density profile (Hosoi et al. 2009 and 2012), crop height monitoring (Ehlert et al. 2006, 2010 and 2013; Zhang et al. 2012; Kaizu et al. 2012; Tilly et al. 2012, 2013 and 2014). In general, the used survey grade laser scanners in the mentioned studies are expensive. It will contribute to the overall crop price, which affects consumers. Therefore, the non-survey grade laser scanner is suggested to be used for monitoring the rice plant height. To carry out this study, the field observations were conducted in the growing season of 2013 with line laser scanner SICK LMS 200. In detail. The laser scanner was mounted on a special rack to observe the rice canopy from above in vertical direction.

2. FIELD ESTABLISHMENT AND DATA ACQUISITION

For establishing the field, the seedlings of Koshihikari rice variety were transplanting to the paddy in the Niigata Agricultural Research Institute, Japan on May 15th, 2013. Three levels of planting densities corresponding to 11.2, 15.1, and 21.2 plants/m2 respectively, were applied with different planting geometries (Table 1). For collecting laser scanning data, a line laser scanner, SICK LMS 200 was chosen. This device was mounted on as special rack and could move along a rail under motorized power for approximately 1 m at a speed of 2 cm/s to collect the data in nadir viewing (Fig. 1a). The field of view of laser scanner was set at 50^0, with the angular resolution of 0.25°

The field observations were carried out 9 times between June and July. The observing period corresponded to the vegetative phase of rice growing season, in which rice plant height and rice plant stem number rapidly increased. The extra observation was performed to collect the surface information (bare ground data) right after harvesting the rice crop. A total station was also used to measure the elevation of the four corners of the target area in each plot. For the result of these measurement the position of ground surface was identified. Moreover, rice plant height and the number of stems were also manual measured several times.

Table 1. Planting density and geometry

Plot	**Planting density (Plant/m^2)**	**Planting geometry**	**Planting direction relative to scanning plane**
A	21.2	30 cm × 16 cm	Perpendicular
B	15.1	30 cm × 22 cm	Perpendicular
C	11.2	30 cm × 30 cm	--
D	21.2	22 cm × 30 cm	Parallel
E	15.1	16 cm × 30 cm	Parallel

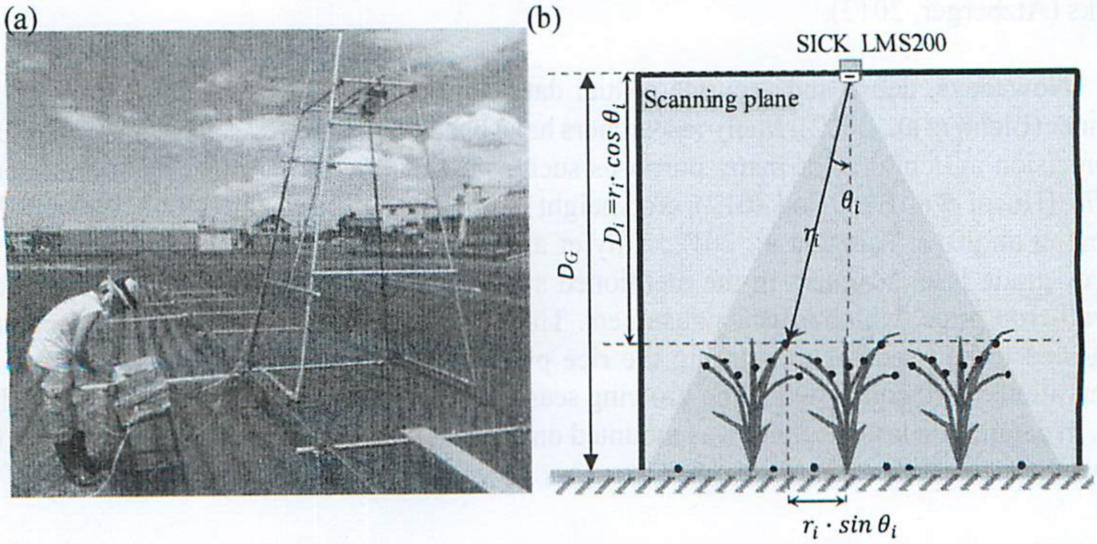

Figure 1. A schematic of the instrument (a) Laser scanner instrument and (b) position of the laser-scanning point on the scanning plane

3. RESULTS AND DISCUSSION

3.1 Manual measurement results

The change of plant height and number of stem are displayed in Fig. 2. According to these results, rice plant height (H) increases linearly over time. However, there is insignificant variation in plant height detected among five plots. Biswas et al. concludes that plant height does not differ significantly with differing planting geometries. In general, the similar conclusion is confirmed based on the manual measurement results in this study.

In case of stem number, it is increasing after transplantation and significant different among plots with various densities (Fig. 2b). Tillering activity results in a slightly increase in rice plant stems. When the tillering stage is completed, non -effective tillers arev destroyed; therefore, the number of stems slightly decreases.

3.2 Data extraction

In order to reduce the effects of incident angle, small target areas (90 cm by 60 cm) are selected inside each test plot within ± 8° inclination angles. The laser point clouds corresponding to the target areas are then extracted. Then, the range data is converted to vertical distances (D) representing the distances between the scanning points and the installation height of the laser scanner by using Equation 1 (Fig. 1b).

$$D_i = r_i \cdot cos\theta_i \quad (1)$$

Where, D_i represents the vertical distance of the laser scanning points, θ_i is the inclination angle at the i^{th} position in the scanning line, r_i is the range from the sensor to the target at the i^{th} scan angle. The distributions of laser point clouds are displayed in Fig. 3. In this figure, changes in the histogram shape indicate rice growth with time.

3.3. Laser data-derived plant height

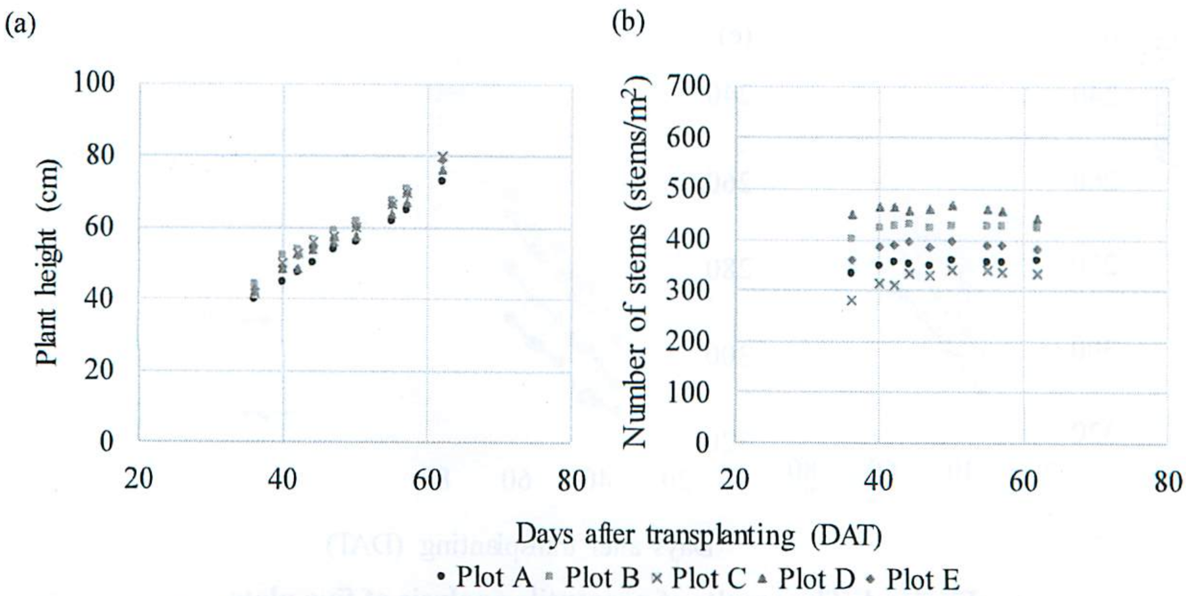

Figure 2. Results of manual measurement (a) plant height and (b) number of stems

For identifying the bottom position of rice plant, the data of the extra observation was used. The average vertical distance to scanning points (D_G) of bare ground data was computed. D_G implies the distance from the ground surface to laser scanner. Moreover, D_G was also computed from data collected by the total station. The difference of 1 mm in D_G between the two measurement methods is showed good agreement.

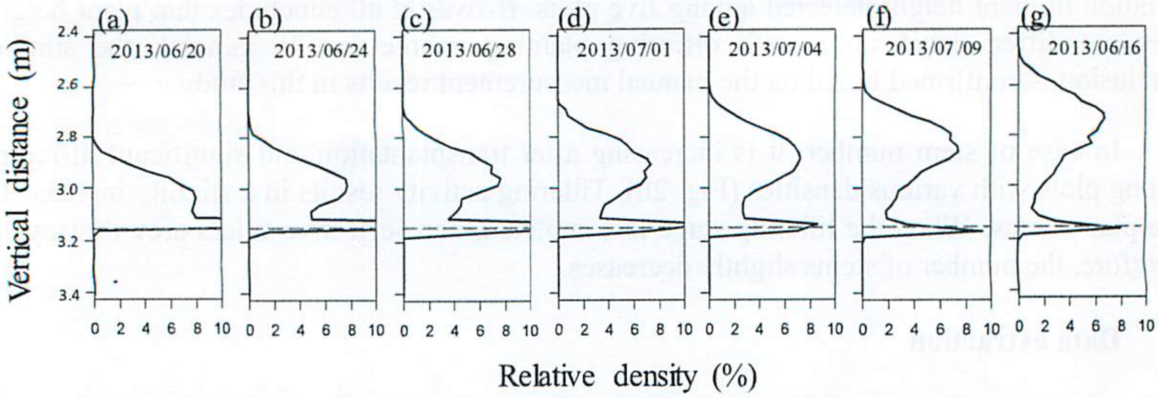

Figure 3. Histograms of point cloud data from plot 2. Red- dash line implies the value of D_G

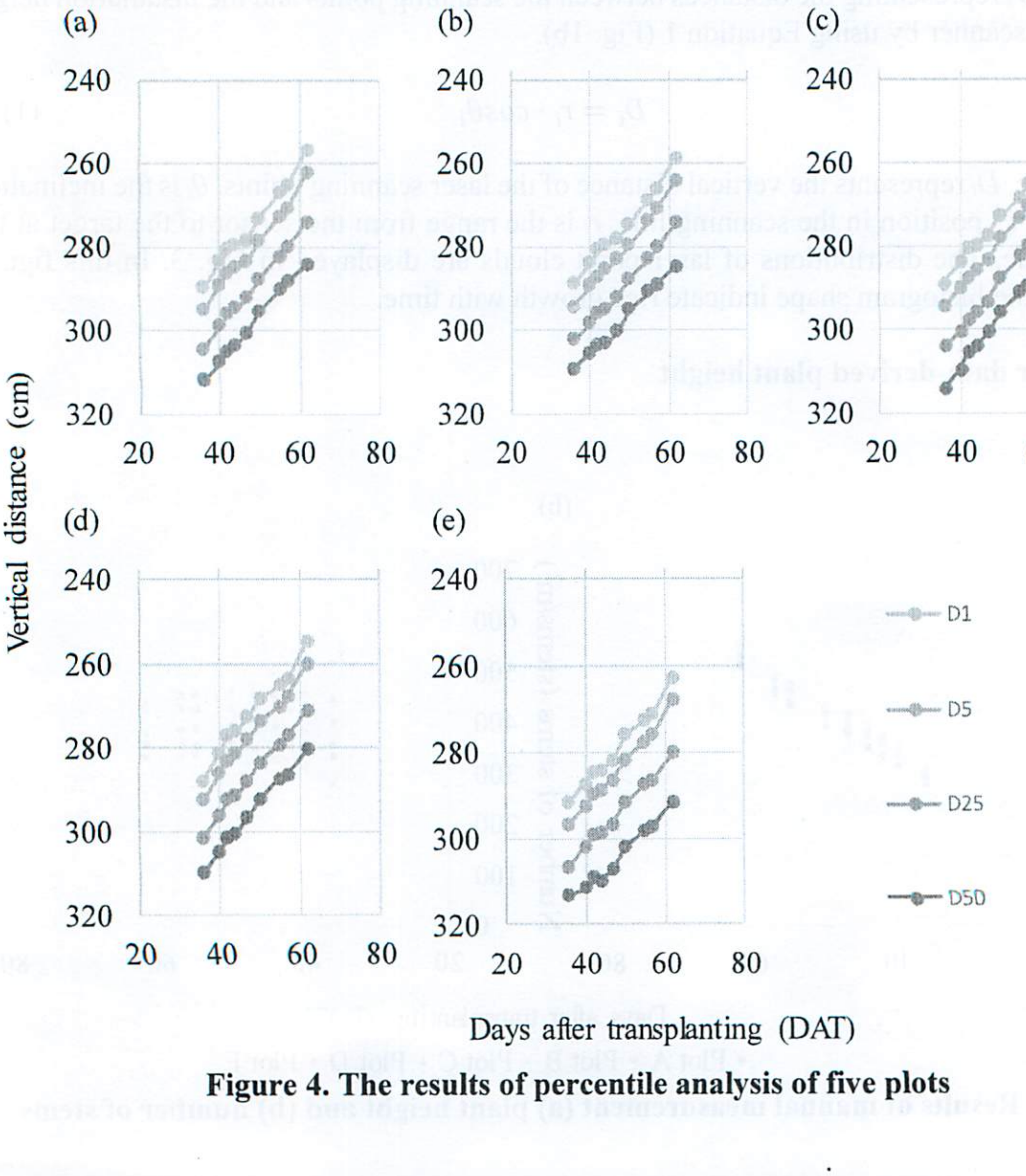

Figure 4. The results of percentile analysis of five plots

For identifying the top position of rice plant, the percentile analysis is conducted. The vertical distance of point clouds is computed at several special percentile ranks p (p= {1st, 5th, 25th, 50th}). We assume that less than 1.0 percent of scanning points is error points caused by wind, insects, or small particles in the air. According to the results, there is the bias between the vertical distance of the different percentile ranks over the experiments. Moreover, the vertical distance at 1st (D^1) is far away from the ground surface and insignificant changed between test plots (Fig.4). Therefore, D^1 is expected to re-present for top of rice canopy.

Laser data-derived plant height is the vertical distance from the ground surface to the identified top of rice plant. Thus, these values were computed by taking the difference between D_G and D^1. The results of this step are displayed in Fig. 5. According to this result, laser data-derived plant heights are always smaller than plant height and insignificant change between five plots. There is well correlation between plant height and laser data-derived plant height (R^2=0.92).

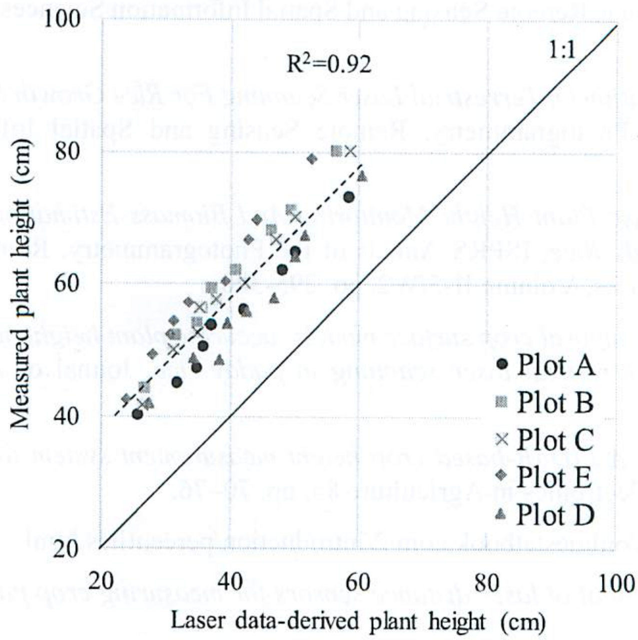

Figure 5. Measured plant height and Laser data-derived plant height

4. CONCLUSION

In this study, the rice crop is monitored with line laser scanner SICK LMS 200. According to the results, the ground surface position is computed from the laser scanning data of the last observation. The top position of rice plant insignificantly depends on planting density and planting geometry. The laser data-derived plant height is computed as the difference between the top position of rice plant to the ground surface. As a result, laser data-derived plant height gets well correlation to plant height (R^2=0.92).

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