Calibration of an automated grass height measurement tool equipped with global positioning system to enhance the precision of grass measurement in pasture-based farming systems

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Abstract

Irish and European pasture-based systems of farming rely upon precise grass measurement and allocation to (1) achieve optimal economic return, as grazed grass is the cheapest feed source, and (2) to maintain the regrowth of high quality grass in each subsequent grazing. On farms implementing an intensive grazing system, grass management is usually carried out by subjective visual measurement and intuitive decision-making. To add objectivity to this process an automated grass measurement tool has been developed which will increase the precision of grass measurement and allocation for pasture-based systems of farming. The aim of this study was to calibrate this tool, to provide a decision support tool (DST) for farmers capable of precise grass height measurement with global positioning system location information. The operation of the DST involves the use of a micro-sonic sensor that finds the distance from a module, placed on the shaft of a rising plate meter, to the plate, by recording the time difference between the transmission and its reflective return from the plate. The results of this study indicate that the absolute height measurement of the DST is similar to that of a 'gold-standard' rising plate meter.

Keywords: grass height measurement, decision support tool, rising plate meter

Introduction

Pasture-based systems of farming must rely on precise allocation of grass in order to maximize economic return. Grazed grass is the cheapest feed source available to ruminant farmers from temperate oceanic climates, a climate Ireland shares with much of North West Europe. Strict management is paramount to ensure high quality grass in future rotations. Dillon (2011) has shown that profit per hectare was increased by €160 for each additional Mg of grass utilized per hectare within Irish dairy systems. Thus the economic reward from a pasture-based system in dairy farming is heavily dependent upon accurate estimation of the herbage mass (HM) of each paddock on the farm and the subsequent correct allocation of herbage allowance (HA) to the herd. This means that the correct amount of grass is allocated to meet the energy demands of the dairy herd, and also ensures the correct grass residual after grazing, resulting in increased herbage quality in the paddock for subsequent grazing rotations (Lee *et al.*, 2008). However, grass management on farms is usually carried out by subjective visual assessment and intuitive decision-making. Tucker (1980) showed that visual estimation of HM is subjective and therefore may be prone to variation between observers. To add objectivity to this process an automated grass measurement tool has been developed, which will increase the precision of grass measurement and allocation for pasture based systems. The aim of this study was to calibrate this tool to ensure precise grass height measurement and allow it to represent a decision support tool (DST) which farmers could use on farm.

Materials and methods

Calibration of the automated grass measurement tool (namely the 'Grasshopper') for height measurement was conducted between September and November 2014. The Grasshopper may be described as a micro-sonic measurement device. It was manufactured by True North Mapping, Shannon, Co. Clare, Ireland. A tool called the Jenquip is a rising plate meter which has traditionally been used to measure grass height

(Figure1). This mechanical method measures grass height by measuring the displacement of the circular plate by the grass. The Grasshopper when placed on the shaft of the rising plate meter measures the height of the grass (or plate) by recording the time for the sonic transmission from the Grasshopper unit on the Jenquip shaft and its reflective return from the circular plate (Figure 1). The Jenquip has been considered the 'gold standard' for grass measurement (Sanderson *et al.,* 2001; Soder *et al.*, 2006). Thus, the Grasshopper was calibrated against the Jenquip. A PVC pipe was cut into 32 sections, each of exact lengths between 2.5 cm and 18 cm in increments of 0.5 cm. The height of each pipe section was measured on 150 occasions by both the Jenquip (plate displacement) and the Grasshopper (time for the micro-sonic transmission from the grasshopper on the Jenquip shaft to the plate of the Jenquip and its return). Each measure of pipe section by the Jenquip and Grasshopper was done simultaneously. Fifty (of the 150) measurements at each pipe section height was carried out by one of three operators (in order to investigate operator effect). The data was managed in Microsoft Excel. A Pearson's correlation coefficient was achieved using the PROC CORR procedure in SAS to assess the linear relationship between the height of the pipes with both the Grasshopper and Jenquip measured heights. To determine how close the Grasshopper and Jenquip measured heights fitted the regression line with the known pipe heights, the PROC REG procedure in SAS was used to achieve R^2 values.

Results and discussion

There is an economic incentive to achieving maximum grass utilisation in a spring grazing pasture-based system of farming, as grass is a low cost highly nutritious feed source to produce. Precise grass allocation and targeting a low post-grazing grass residual ensures the return of high quality herbage in subsequent grazing rotations (Lee *et al.*, 2008). The use of a rising plate meter to determine herbage mass is reliant upon the accurate measurement of grass height which is subsequently used in previously developed equations specific to country and season to estimate herbage mass in the paddock. This study compared the heights of 32 different solid PVC pipes, measuring each pipe height 50 times and this was done by three different operators to account operator variation. There was no significant difference between operators for the data analysed. When known pipe heights were compared to the Grasshopper and Jenquip measured heights the Pearson correlation coefficients (R) were 0.999 and 0.998, respectively. Therefore the precision of the Grasshopper in measuring the pipe heights was considered marginally better than that of the Jenquip. The coefficient of determination indicated a strong relationship between the Grasshopper and the pipe heights (R^2 of 0.9984) similar to the relationship between the Jenquip

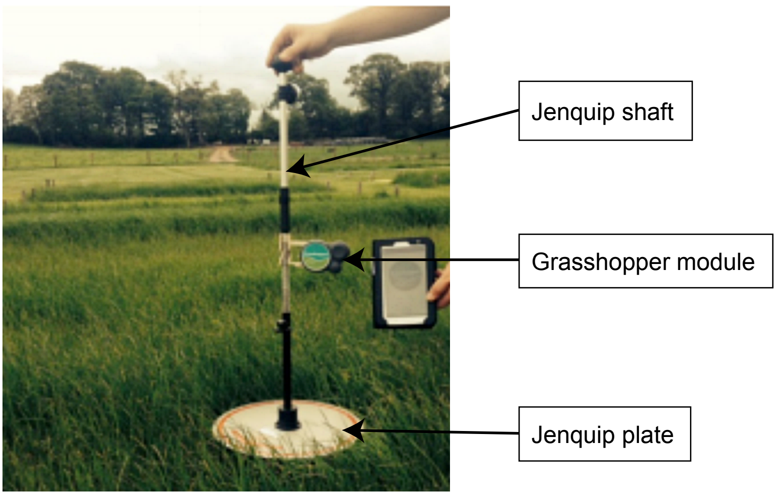

Figure 1. The Grasshopper module attached to the shaft of the Jenquip rising plate meter.

Table 1. Precision measures of pipe height recorded by the Grasshopper and Jenquip compared to actual pipe heights. Values represent the average of 32 different heights and 150 measures at each height.

Measurement tools	Measured pipe height standard deviation (cm)	Measured pipe height coefficient of variation	Measured pipe height difference from actual pipe height (cm)
Grasshopper	0.16	0.02	+0.37
Jenquip	0.18	0.03	-0.61

and the pipe heights (R^2 of 0.9979). The average standard deviation, coefficient of variation and height differences, across the 32 pipe heights, were lower for the Grasshopper compared to the Jenquip (Table 1).

Conclusions

The measurements of the pipe section heights recorded by the Grasshopper were marginally closer to the actual pipe heights than the measurements recorded by the Jenquip. As the Jenquip was considered to be the 'gold standard' in terms of height measurement, the Grasshopper could now be considered as calibrated successfully for height measurement. A future study will be conducted to calibrate the Grasshopper to measure compressed grass height at different herbage mass and dry matter contents.

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