Measuring grass yield by non-destructive methods

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Abstract

Accurate assessment of forage mass in pastures is a key to budgeting forage in grazing systems. Different non-destructive techniques for measuring pasture yield, except remote sensing, are considered. All methods reviewed were associated with a moderate to high error, and some techniques are appropriate only under certain conditions. In general terms, no method was found to be the most appropriate. Best results were found by modifying general methods under local calibrations and under local conditions. In order to give farmers the best way to manage adequately their own grazing systems, researchers must select the most suitable technique considering the scale of operation, the desired accuracy and the resources available.

Keywords: estimation methods, forage mass, non-destructive measuring, pasture yield.

Introduction

During the past 70 years, many indirect non-destructive methods for the rapid estimation of forage mass have been proposed and evaluated. Traditionally, estimates from manually or mechanically clipped quadrats have been used to estimate herbage mass. Many authors agree that clipping provides accurate measures of biomass; however it is expensive, time-intensive and may require numerous samples to obtain reliable pasture estimates. Moreover, the time and labour required constrain the number of samples that can be collected realistically. As alternatives to clipping, sampling procedure methods that use double sampling techniques are commonly used to increase the precision of estimations and minimise the amount of work. These methods function by developing a regression relationship of standing crop to predictive values, such as plant height, leaf area, vegetation density, canopy, age, cover, visual obstruction or remote sensing data. However, such estimations are usually associated with a moderate to high experimental error, because the relationship between production and pasture variables depends on numerous factors that can interact mutually. This paper considers the application of different techniques that may be useful in measuring forage production or standing crop.

Results and Discussion

The most simple instruments are the pasture ruler and the sward stick, which measure plant height rather than compressed sward height. However, canopy height can be difficult to measure due to the subjectivity associated with which plant or plant parts should be considered to form the mean height measure (Heady, 1957), so researchers have added several types of discs or plates to the rule in order to incorporate an area dimension to the measurement and thereby increase the sampled point area. Visual obstruction techniques (Robel *et al*., 1970), have been considered in some comparative studies to be good methods for non-destructive estimation in comparison with the previously described techniques (Benkovi *et al*., 2000; Harmoney *et al*., 1997; Michalk and Herbert, 1977; Vermeire *et al*., 2001). However, there are few references in the literature and investigations on the performance of this method in different vegetation types are limited (Ganguli *et al*., 2000).
More complex electronic instruments are the electronic capacitance meter (Fletcher and

Robinson, 1956) and sonic sward stick (Hutchings *et al*., 1990). Readings from these instruments are, however, affected by water in the vegetation, including litter, and often such instruments come with standard equations that are not adjusted to the particular localities and conditions (Frame, 1993). Sanderson *et al*. (2001) suggested that an error level up to10% could be statistically acceptable, but economically inappropriate. Given the inherent spatial and temporal variability of pastures, it may be difficult for a producer to achieve an error lower than the proposed 10%; however, some authors have found that local calibrations can reduce error to about 10% (Rayburn and Rayburn, 1998).

Experimental error due to the sampling method also constitutes an important source of variation. Thus, the accuracy of an instrument varies with the spatial work scale, the sampling area and the modus operandi (Hutchings, 1991). Aiken and Bransby (1992) observed significant differences in measurements of the same grass bulk measured by four different observers, and in the selection of the representative sampling area also, showing that the observer himself also constitutes another source of variation. Significant variability between observers was also reported by Earle and McGowan (1979), and they recommended that meter readings on calibration and in pasture measurements should be taken by the same operator. In Table 1 a comparison is given between regression models obtained from several authors in various types of pasture meters. The usual regression model is linear; however, some studies with plate meters showed an exponential response in highest values of disk meter values (Baker *et al*., 1981; Bransby *et al*., 1977). This mathematical trend has been observed in capacitance meters also (Greathead *et al*., 1987; Stockdale and Kelly, 1984; Terry *et al*., 1981; Vickery *et al*., 1980). Data given in Table 1 show that the best mean coefficients of determination (r^2) were found in manual instruments, from higher value of visual obstruction technique (r^2 = 0.78), followed by plate meters (r2 = 0.74), pasture rulers (r2 = 0.72) and sward sticks (r^2 = 0.69). Worst correlations were found in electronic meters, from canopy analysers (r^2 = 0.49), to capacitance meters (r^2 = 0.68) (but note that for canopy analysers only two data were found).

Table 1. Mean values of the best regression coefficients found in the literature for forage mass estimations by the most widely used measurement techniques.

Meter	Mean R^2	N
Canopy analyser	0.49	2
Capacitance meter	0.68	18
Pasture ruler	0.72	8
Plate meter	0.74	37
Sward stick	0.69	11
Visual obstruction	0.78	4

Reviewed from Bransby *et al*. (1977), Carton *et al*. (1989), Duru and Bossuet (1992), Earle and McGowan (1979), Ganguli *et al*. (2000), González *et al*. (1990), Griggs and Stringer (1988), Harmoney *et al*. (1997), Hoden *et al*. (1991), L'Huillier (1988), Mayne *et al*. (1988), Michalk and Herbert (1977), Michell and Large (1983), Mosquera *et al*. (1997), Murphy *et al*. (1995), O'Sullivan *et al*. (1987), Rayburn and Rayburn (1998), Robel *et al*. (1970), Sanderson *et al*. (2001), Terry *et al*. (1981), Vickery *et al*. (1980).

Conclusions

Many studies have shown that non-destructive biomass estimations in grasslands are statistically acceptable when there is both the choice of an accurate system for measurement and the development of a correct model. The choice depends of the work scale, resources available and precision required. Remote sensing data have shown a potential use, but not in the context of exact management of agricultural system, due to restrictions derived from spatial resolution and technical limitations. Modern systems and information accessible by networks and international programs are increasing the research possibilities needed to provide farmers with improved knowledge for the management of grazing systems.

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