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A Standardized Plate Meter for Estimating Pasture Mass in On-farm Research Trials

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scale descriptions. This is apparent in the percentages of dry matter in the grain presented in the correlation of the BBCH and Hanway scales in the grain ripening phase (Table 1).

The scientific goal of developing universally applicable crop scales conflicts with the programming goal of providing maximal error checking. We chose to make the SCALES 2 programs applicable over a wide variety of conditions, thus relying on the user to supply accurate inputs. As standardization of crop development scales progresses, and more crops and staging systems are added to computerized staging systems, error checking may become even more difficult to accomplish without restricting the user to common conditions.

As more crops and staging scales are included in scale conversion programs, it may be desirable to combine them into a single computer program. We chose not to do so, because the existing scales for corn and small grains are so different that the code diverged immediately after the user indicated the crop. Retaining both types of crops in a single computer program would result in more lengthy and confusing code with no gain in efficiency.

Specifications, Documentation, and Availability

SCALES 2 is written in ANSI standard Fortran 77. The program is designed for IBM-compatible microcomputers running DOS version 3.3 or greater.[2] A hard disk and math coprocessor are not required.

SCALES 2 is available from the Soil and Water Conservation Research Unit, 119 Keim Hall, University of Nebraska, Lincoln, NE, 68583-0934. The source code, executable program, and documentation are distributed on 3.5-inch diskettes.

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[2] Mention of a trademark or proprietary product does not constitute an endorsement by the authors, the University of Nebraska, or the USDA.

A STANDARDIZED PLATE METER FOR ESTIMATING PASTURE MASS IN ON-FARM RESEARCH TRIALS

Edward B. Rayburn* and Susan B. Rayburn

Abstract

A plate meter for estimating pasture mass (PM) was constructed of 5.6-mm-thick acrylic plastic cut into a 46-cm square and fitted with a 3.8-cm center hole. (The acrylic is stable under varying humidity, readily available, inexpensive, and easy to work.) A meter stick through the center hole measures the plate height (PH) resting on the pasture canopy. The meter was tested on six rotationally grazed pastures (0.2–2.4 ha), measured before eight grazing events. Each pasture was double-sampled for PH and clipped PM at 10 to 30 locations. The calibration regression slope was 452 kg (ha cm)$^{-1}$, with a residual standard deviation (RSD) of 753 kg ha^{-1} and an r^2 of 0.52. The high RSD is typical of forage stands, which vary widely in forage bulk density. The relatively low r^2 was probably due to the uniform height of these rotationally grazed (as opposed to continuously grazed) pastures resulting in a small range in PH. The validation regression had a slope of 0.72 and a RSD of 808 for individual samples and a slope of 1.11 and RSD of 155 for means of 20 samples. The reduction in RSD with increasing sample size points to the need to take 15 to 30 measurements when calibrating the plate meter or sampling rotationally grazed pastures, to have an estimate within 10% of the mean PM. This simple plate meter provides as accurate a measure of PH and PM as the more sophisticated metal plate meters, is practical for carrying in the field, and in 1996 cost $12.

Reliable and inexpensive estimates of pasture mass are necessary when studying the effects of grazing management or planning and implementing grazing systems. When applying pasture management research on farms a practical, low-cost, readily available tool is needed for measuring pasture mass.

Several methods are available for estimating pasture mass. These include ground cover (2,3,5,7), canopy height (3,5,7,8), the product of ground cover and canopy height (2,3,5), the bulk height of the forage canopy compressed by a weighted disk or board (1,3,5,8,9), and an electronic capacitance meter (6). The ground cover method predicted pasture mass of low-yielding bluegrass (*Poa pratensis* L.) pastures, but it was less accurate in more productive mixed orchardgrass (*Dactylis glomerata* L.) and clover (*Trifolium* sp.) pastures (7). In alfalfa (*Medicago sativa* L.), there was a high correlation between forage height and dry matter yield, and the correlation was improved by using forage height compressed by a weighted disk (3). The weighted plate or weighted disk meter appears to account for differences in sward density between sites.

Abbreviations: PH, plate height; PM, pasture mass; RSD, residual standard deviation.

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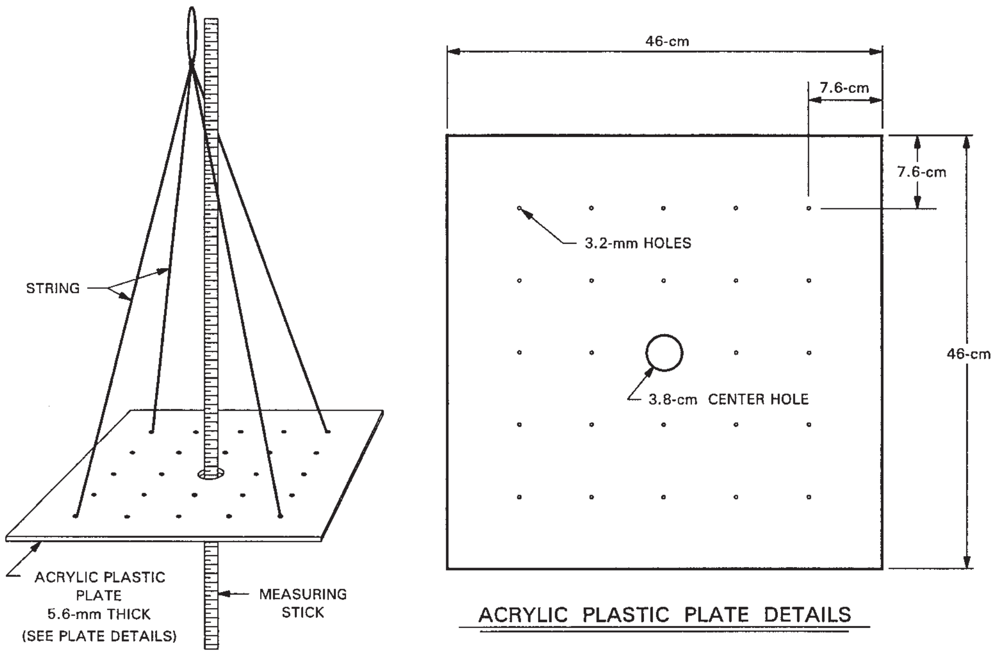

Fig. 1. Schematic diagram of the plate meter made from acrylic plastic, used to measure the bulk height of pasture canopies.

Weighted disk meters are made from disks of sheet metal, with etched metal measuring rods (1,3,9). Plywood and acrylic plastic have also been used (5,8). The effects of different disk sizes and disk weights (1,3) and of season and harvest (1,3,9) on the performance of these meters have been reported. Bransby et al. (1) found that a 0.20-m^2 disk, with a weight from 5 to 15 kg m^{-2}, provided regression slope standard errors equal to 5 to 12% of the slope for summer and fall pasture with residual standard deviations ranging form 406 to 1012 kg ha^{-1}.

To determine pasture mass in a cooperative regional, multifarm pasture project in the U.S. Northeast, the weighted disk meter was chosen as a research-proven tool. The commercial forms of metal disk meters described in the literature were too expensive to purchase in large numbers, so there was a need for an alternative construction that would accomplish the same results.

The purposes of this study were to design an inexpensive, weight-stable plate meter, one easy to construct from materials readily available across the region, and to calibrate the plate meter for use under rotational grazing. Acrylic plastic sheeting was chosen, since it is inexpensive, does not absorb water, and is readily available from local glass distributors.

Materials and Methods

A 46-cm square (0.21 m^2) was cut from 5.6-mm-thick acrylic plastic sheeting (Fig. 1). A 3.8-cm-diameter hole was cut in the center of this plate to allow the insertion of a meter stick for measuring the plate height above the ground when the plate is set on the sward (Fig. 2). The edges of the center hole were smoothed with a wood rasp to prevent rough edges from catching on the meter stick. An additional 24 holes, 3.2-mm in diameter, were drilled along five lines set at 7.6-cm intervals starting 7.6 cm from the plate's edge. These holes allow the use of the plate as a point quadrat for estimating ground cover in thin stands or stubble aftermath or for measuring the occurrence of forage species under the plate. The plate was carried and lowered to the pasture surface using a piece of string tied through four of the 3.2-mm holes, with the string held by a finger of the hand holding the measuring stick (Fig. 1).

The plate meter was tested on six cool-season, grass–legume pastures before eight rotational grazing events. Four of these grazing events were used for calibration and four were used for validation of the calibration. Pastures ranged from 0.2 to 2.4 ha in size and were grazed for 0.5 to 6 d. These pastures consisted of orchardgrass, timothy (*Phleum pratense* L.), redtop (*Agrostis gigantea* Roth; syn. *Agrostis alba* L.) and other *Agrostis* spp., sweet vernal grass (*Anthoxanthum odoratum* L.), and white clover (*T. repens* L.). The pastures were located on three farms in western New York and all data were collected by one person.

The plate meter was calibrated using paired samples from 10 to 30 locations per pasture, depending on pasture size (Table 1). Ten sample points were taken at 3-m intervals along a randomly located 30-m transects. Transects were used due to the needs of a concurrent selective grazing study being conducted. Calibration samples are normally taken by selecting a range of plate heights, to improve the calibration r^2

Fig. 2. The acrylic plastic plate meter being used to measure the bulk height of a grass–clover pasture.

value, as recommended by Bransby et al. (1). The plate meter was placed gently on the forage until the canopy supported the plate. The plate height of the pasture canopy was measured from the ground to the top of the plate, using a meter stick through the plate's center hole. A quadrat (46-cm square) was used for the calibration clipping. The quadrat was placed over the sample site after the plate height was measured and the plate meter removed. The forage was separated along the edges of the quadrat, allowing the quadrat to lie on the ground. The forage was cut as close to ground level as possible, using 10.2-cm-wide battery-powered lawn edgers. An alternative method used was to clip two strips, 46 cm long, within the area measured with the plate meter. The harvested area was the total length of cut times the clipper width. The forage was weighed wet in the field using 500-g capacity spring scales. The 10 samples from each transect were composited for dry matter determination. The samples were frozen, then dried in screen-bottom trays with ambient air and later oven-dried by the Northeast Dairy Herd Improvement Forage Testing Laboratory in Ithaca, NY. Dry matter yield per hectare was calculated based on the forage dry matter harvested in the clipped sample, using ambient and oven-drying moisture losses, and the clipped area.

The plate meter was calibrated using linear regression of the paired plate height and pasture mass values from the calibration data set (4). The calibration was validated using the paired samples from the validation data set. For each data point, the pasture mass (PM) was predicted using the calibration equation and sampled plate height (PH). The predicted PM was compared with the measured PM using linear regression to estimate the error of prediction of individual samples. The calibration was also validated for sample means, using 61 sample means obtained by randomly sampling the validation data set for 20 data points per mean. The mean predicted PM was compared with the mean measured PM using linear regression.

Results and Discussion

The calibration equation for the plate meter was PM = 452 PH + 3, with an r^2 of 0.52 and a residual standard deviation (RSD) of 753 (Fig. 3). The standard error was 49 for the slope and 246 for the intercept. This relatively low r^2 value is due in part to the uniform height of the pastures used. Bransby et al. (1) reported r-values between 0.79 and 0.94 (0.62–0.88 r^2) and showed that the r-value obtained in calibrating a plate meter increases as the range in plate heights used in the calibration increases. Vartha and Matches (9) reported r^2 values ranging from 0.09 to 0.84 for pastures

Table 1. Description of the six rotationally grazed pastures sampled over eight grazing events used to calibrate and validate the calibration of the plate meter.

Pasture			Plate height			Clipped pasture mass	
ID	Date	Size	N	Mean	SD	Mean	SD
		ha	no.	—— cm ——		— kg ha^{-1} —	
			Calibration data set				
R2	10 July	2.4	30	14.0	2.8	2331	954
R2	30 Aug.	2.4	30	7.9	1.8	1621	589
B1	2 Oct.	0.2	10	13.2	3.6	2904	780
F4	5 Oct.	0.2	10	11.7	2.0	2895	571
			Validation data set				
R3	17 July	2.4	30	17.8	4.1	3096	1276
R3	2 Sept.	2.4	30	8.6	1.8	1903	684
B3	4 Oct.	0.2	10	14.5	3.6	3018	1327
F1	2 Oct.	0.2	10	15.5	4.6	4517	1112

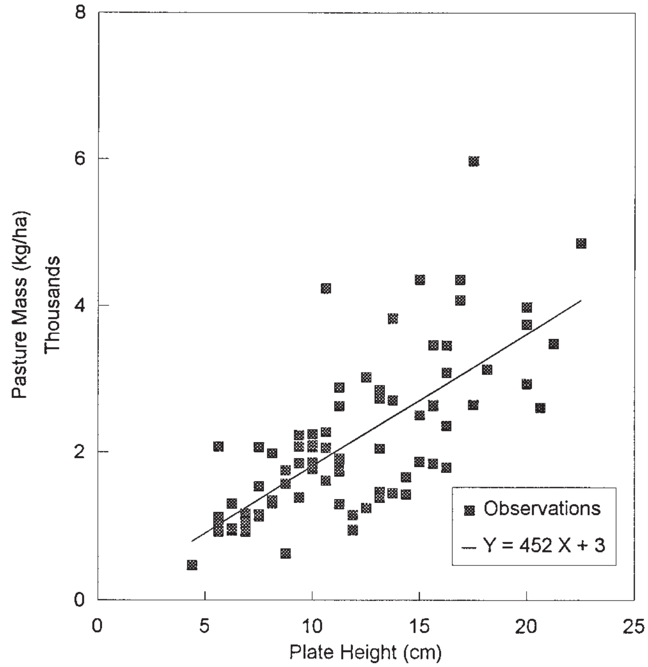

Fig. 3. Calibration data set regression and individual data points.

while Griggs and Stringer (3) reported r^2 values as high as 0.94 for alfalfa stands sampled over the entire growth period.

The calibration RSD is comparable to that found by Bransby et al. (1) and Vartha and Matches (9). These high RSD values are due to the large variability in forage density (PM per unit PH) at the one-quarter square meter scale and show the need to take a large number of samples during calibration.

For these pastures, which were rotationally grazed to a short residual height, the intercept was not significantly different from zero. This is likely due to little thatch buildup in the paddocks which if present would add to a regression intercept.

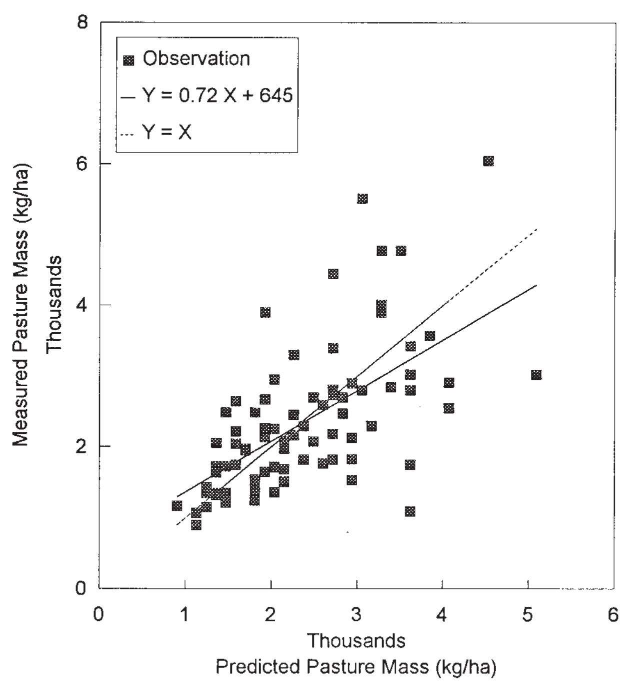

Fig. 4. Validation regression using individual data points.

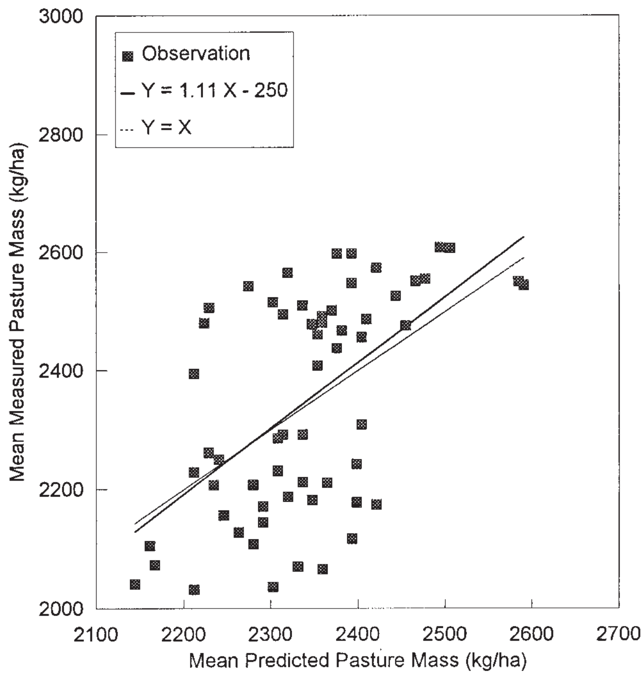

Fig. 5. Validation regression using means composed of 20 subsamples from the validation data set per data point.

When the calibration was validated using individual data points the regression was $PM_{measured} = 0.72\ PM_{predicted} + 645$ with an r^2 of 0.38 and a RSD of 808 (Fig. 4). This shows that there was some bias in the calibration model when applied to the validation data set. When the calibration was validated using 61 means of 20 data points each, the validation regression was $PM_{measured} = 1.11\ PM_{predicted} - 250$, with an r^2 of 0.32 and a RSD of 155 (Fig. 5). This magnitude of the RSD of predicted means is very satisfactory for research and on-farm management purposes. As the number of samples in a PM mean increases, the RSD of the predicted mean decreases (1). When using the validation data set to compare the effects of number of observations in a mean on the RSD of the predicted PM, the RSD decreased from 400 to 100 as the number of observations increased from 5 to 30 (Fig. 6). When using 30 observations in a mean, this validation set produced a lower RSD than that reported by Bransby et al. (1), which is probably due to the more uniform sward found in these rotationally grazed pastures compared with the set stocked pastures worked with in their study.

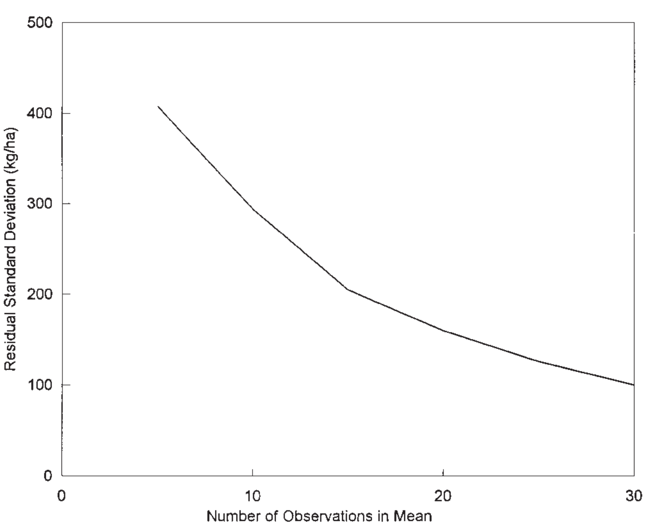

Fig. 6. The effect of increasing the number of observations per mean on the residual standard deviation of the estimated mean using the validation data set.

For practical on-farm use of the plate meter, additional calibrations are needed over pastures differing in species composition, season of the year, and regrowth age. These calibrations could be used to determine different calibration domains and to see if pastures can be easily described for placement in an appropriate calibration domain, so that calibration clippings would not have to be made for each pasture.

This simple plate meter provides as accurate a measure of plate height and pasture mass as the more sophisticated metal plate meters. The r^2 values and RSD of individual samples in this study were similar to those found in previous research. The magnitude of the RSD emphasizes the need to take 20 to 30 paired samples per calibration and 30 or more observations when predicting pasture mass, in order to obtain an estimate within 10% of the mean. This plate meter, which is easily carried in the field, is proving to be a practical, low-cost ($12, in 1996) alternative to metal disk meters for use in quantitative pasture assessment and management and is being used by farmers, extension agents, and researchers in the U.S. Northeast to measure pasture mass.

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