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Measuring pasture yield for livestock management on farms

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ABSTRACT

Measuring pasture yields to achieve management goals on farms, or in regions, distant from research stations requires techniques both practical and sensitive to localised factors such as soil type, pasture species, and adapted management technology. In addition, such techniques must be compatible with any quantitative comparisons which need to be made between the farm and the distant research station. Pasture dry matter (DM) yield on a paddock scale is measured by a 2-stage process of yield estimation, and calibration to DM. Using data collected in Northland, this paper shows how the methods of DM yield asessment vary according to the end-use. For example, a cursory eye estimate without calibration is suitable for assessing DM for wintering livestock at high grazing pressure, while, for farm cover assessment, detailed yield estimation allied with detailed quadrat cutting could be necessary. The index of total DM used on research stations can be provided on farms by cutting techniques which measure only to a trimmed level and do not include the stubble component to ground level. The stubble component can be an abstract value provided by an expert skilled in comparing different pastures.

Keywords Pasture dry matter; yield estimation; calibration.

INTRODUCTION

Pastoral farmers in New Zealand are encouraged to measure their pasture yields to assist with controlling of livestock feeding, for long-term planning (feed budgeting), and for managing pastures by grazing according to dry matter (DM) yield standards (Scott *et al.*, 1979; Milligan and smith, 1984; Milligan *et al.*, 1987; Sheath *et al.*, 1987). The common index of pasture yield is total DM; other synonymous terms include pasture mass (Nicol, 1987) herbage mass (Hodgson, 1979), residual DM, and looser terms of a colloquial nature such as pasture cover, pasture DM, and pasture yield. Total DM includes all herbage (Thomas, 1980), dried to zero moisture content, measured on a paddock or grazing area by a 2-stage process of yield estimation and calibration.

Total DM standards for livestock feeding and pasture management, and DM yield assessment and calibration methods have been derived on research stations, the use of yield estimates to provide total DM has raised 4 problems:

1. Appropriateness of different yield assessment methods and their relation to ground level.
2. Need for cutting and washing samples to derive a basis for calibration.
3. Interrelation between local and regional data derived by trimming and research station data derived by ground level methods.
4. Practicality of absolute total DM due to differing soil types, seasonal and regional differences in plant species and morphology combined with cutter and laboratory variability.

This paper summarises research in Northland on solutions to those problems. In this paper the *index of total DM is split into a trimmed or grazable* component (Piggot, 1986), and a stubble component, after the approach of t'Mannetje (1978).

METHODS

In this research, measurements are expressed as kg DM/ha of either total DM, trimmed or grazable DM (Piggot, 1986) and stubble such that:

total DM = trimmed DM + stubble DM.

Trimmed DM was sampled within 0.25 m^2 quadrats cut by hand shears for up to 10 min, depending on pasture length, but without collecting any soil in the sample. Stubble DM was sampled within 0.1 m^2 quadrats at the level of the crowns of tufted grasses such as ryegrass, or beneath unrooted stolons for clovers or kikuyu grass. Northland soils can be high in clay and organic matter, with soil swelling consequent on variable moisture content dictating a more *plant-related* definition of ground level than might be relevant elsewhere. Stubble yields were always cut by only 1 operator within any experiment, or comparison, to ensure uniformity of cutting height. Regular standardising exercises were conducted with operators cutting different experiments.

Information for this paper is derived from the following research:-

Comparison of Methods for Estimating Yield

Throughout the year, 10 quadrats in any paddock were cut for trimmed and stubble yield after assessing yield by visual estimation, pasture height, rising plate meter readings, and air-corrected capacitance meter (probe) readings. Three pasture types were assessed:

1. Temperate dairy pastures pre- and post-grazing on 6 farms.
2. Temperate sheep pastures at 3 grazing heights on 3 aspects on a research farm.
3. Kikuyu grass pastures, long and short, on 3 dairy and 3 beef-sheep farms (Piggot, 1986; Piggot and Morgan, 1987).

Pasture Production Studies

Regrowth patterns in Northland pastures have been studied in a multi-site trial where both trimmed DM and stubble DM data have been taken (Piggot *et al.*, 1986).

Farm Monitoring Exercises and Technique Evaluations

Research into farmer attitudes and acceptance of total DM and feed budgeting concepts has been conducted on dairy farms. (Piggot *et al.*, 1986; Piggot and Morgan, 1985; Piggot, 1986).

RESULTS

Yield Assessment

The error with which the yield assessment methods estimate DM varies between pasture type in Northland (Table 1). Although there was a natural bias favouring visual assessment in these results (since the quadrats were selected by eye), no method was significantly more accurate for temperate dairy pastures, with the plate being least accurate for temperate sheep pastures and visual assessment the most accurate for kikuyu grass pastures.

The methods are apparently not able to discriminate the stubble component of total DM. This is indicated by the significant relationships between intercept values for each group of 10 quadrats, and the mean stubble values for these quadrats for all except the height measurement of temperate sheep pastures (Table 2). Although this finding cannot be interpreted to infer that the methods are unable to discriminate between differing post-grazing residues in any paddock the accuracy with which the methods discriminate post-grazing yields is worse than for pre-grazing yields (G.J. Piggot, unpublished).

Trim DM *v* Total DM

The key features related to measuring trim DM compared with total DM from the Northland work are those of the error of measurement indicated by the residual standard deviation of the regression line relating yield method and DM. The absolute error was lower for trim DM (Table 3) with an average of 62% the error of total DM. The precision of the estimate of DM is indicated from the coefficient of variation (Table 3), which did not differ between trim DM or total DM. These trends were similar to the results from the other yield methods tested.

In a small study of cutter variation in measuring trim DM conducted during 1982 on temperate dairy pastures of 3 lengths on 2 occasions on a single dairy farm, 6 cutters (Piggot and Morgan, 1985) showed similar variation to the results of Smeaton and Winn (1981). When their variation in trim DM was expressed as a percentage of total DM, the standard error of trim DM yield over all cutters averaged 5%.

Thus, trim DM is more accurate with no loss of precision for the calibrated paddock estimate, compared with total DM.

TABLE 1 Average residual standard deviation (kg DM/ha) and, in brackets, the coefficient of variation (%) from linear regressions of estimates of yield by 4 methods on trim DM for 3 pasture types in 2 seasons.

Pasture type	Season	Method			
		Visual	Height	Plate	Probe
Temperate dairy	Winter	190(15)	220(18)	230(19)	240(19)
	Summer	410(21)	470(24)	410(21)	420(21)
Temperate sheep	Winter	150(15)	160(17)	200(21)	160(16)
	Summer	210(15)	290(22)	350(26)	290(20)
Kikuyu grass	Winter	190(13)	240(17)	240(17)	270(19)
	Summer	600(14)	690(16)	720(17)	740(17)

TABLE 2 Correlation coefficients between the intercept values for deriving total DM for each group of 10 quadrats by 4 methods and the mean stubble value over 2 years for 3 pasture types.

Pasture type	No. of paddocks	Method Visual	Height	Plate	Probe
Temperate dairy	156	0.60***	0.54***	0.50***	0.50***
Temperate sheep	72	0.68***	0.17 NS	0.47***	0.67***
Kikuyu grass	72	0.74***	0.73***	0.71***	0.72***

TABLE 3 Average residual standard deviation (kg DM/ha) and, in brackets, the coefficient of variation (%) from linear regressions of trim DM and total DM on visual estimation of pregrazing yield for 3 pasture types in 2 seasons.

Pasture type	Season	DM measurement Trim	Total
Temperate dairy	Winter	240(12)	380(12)
	Summer	370(15)	510(12)
Temperate sheep	Winter	180(12)	390(13)
	Summer	220(11)	380(10)
Kikuyu grass	Winter	230(11)	460(10)
	Summer	620(12)	780(9)

TABLE 4 mean ± standard deviation and range for stubble DM yield (kg DM/ha) pre- and post- grazing for 3 pasture types in 2 seasons.

Pasture type	Season	Mean stubble yield Pre-graze	Post-graze	Range Pre-graze	Post-graze
Temperate dairy	Winter	1340±290	1370±350	1980	2110
	Summer	1960±350	1870±380	2150	1910
Temperate sheep	Winter	1580±250	1810±320	470	570
	Summer	1540±330	1610±150	640	290
Kikuyu grass	Winter	2300±560	2560±670	1580	2040
	Summer	3290±1320	3030±1210	3690	3130

Stubble

Stubble measurements in Northland show a large variation between pasture type, seasons, and between sites with similar pastures (Table 4; Fig. 1; Piggot *et al.*, 1986). The factors contributing to the large stubble variation include dead matter build-up and decay cycles, grazing management effects on dead matter content, plant species differences in morphology, and variations in soil levels caused by moisture-induced swelling or contraction of clay minerals and organic matter.

Calibration

Ideally, the error of the chosen yield estimation and calibration method should match the error in the end-use. The error of any double sampled DM estimate can be calculated using the McIntyre (1978) equation. This equation is based on combining the error in the yield estimate and the error in the calibration method (Michell, 1982; Stockdale, 1984). The error of yield estimation on a paddock scale is normally within the range of 10 to 60% of the mean DM yield and can be minimised by increasing the number of independent yield estimates. It is, therefore largely, under the assessor's control. Calibration errors however, although important, are limited for a range of pastures, farms, and farmers. A generalised way of providing error estimates is to note the effect of pooling of data from experimental evaluations on the error, and then to equate the various levels of sophistication in calibration to each stage in the sequence of pooling (Table 5). Using the data from Table 5 in the McIntyre equation for pre-grazing pasture in winter it can be shown that a well

TABLE 5 Average residual standard deviation (kg DM/ha) pooled over 3 methods (height, plate, probe) for a progressive sequence, on temperate dairy pastures during winter (June-July), pre- and post-grazing, from regressions of yield estimates on trim DM.

Pooled sequence	n	Residual standard deviation Pre-grazing	Post-grazing
Within farms	10	250	200
Within months	60	320	260
Within years	120	330	270
Within seasons	240	360	280
All data	780	580	450

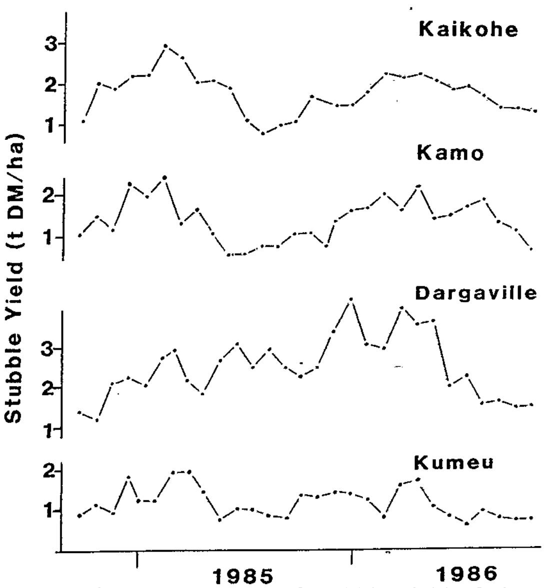

FIG. 1 Seasonal pattern of stubble yield of sheep pastures at 4 sites. Dargaville, kikuyu grass; Kaikohe, Kamo and Kumeu, temperate grass species.

calibrated assessment of a paddock involving on-site cutting would have an error of 100 to 200 kg DM/ha; a moderately calibrated assessment such as the use of seasonal equations (Piggot, 1986) would have an error about 300 kg DM/ha; and a poorly calibrated *guesstimate* would be in the 400 to 500 kg DM/ha range for a mean paddock yield of 2000 to 2500 kg total DM/ha.

The choice between calibration methods then depends on the end-use. The 3 primary end uses are:

1. Animal feeding: Errors in published feed demands or intake values are assumed to be 15% (Joyce *et al.*, 1975; Scott *et al.*, 1979), so the DM error at grazing is dependent on number of animals, feeding level, grazing pressure, and efficiency of utilisation. For example, for a herd of 100 cows wintered at 10 kg DM/head/d the error is 150 kg DM. Long pasture grazed under dry conditions in winter could provide 3,000 kg DM/ha; of utilisable DM by grazing 3,500 kg DM/ha down to 500 kg DM/ha. The herd requirement is thus provided by 1/3 ha requiring a DM estimation method precise to 450 kg DM/ha. A single, poorly calibrated visual estimate could provide this level of precision. In contrast, if the soil was wet and only 1,500 kg DM/ha could be utilised from the same paddock, a more accurately calibrated DM assessment would be required since precision to 220 kg DM/ha is then required.
2. Post-grazing or residual DM: The method of yield assessment needs to be capable of discrimination between the ranges recommended to farmers (Milligan, 1981; 1982; Armstrong, 1982) with a precision of 200 to 300 kg DM/ha. This level of precision can be achieved at a moderate level of calibration such as comparison of eye estimates with a skilled operator, or use of locally derived equations for height or probe estimates.
3. Farm cover: A farm cover estimate is normally used for comparing with a target value, and taking action if the cover falls short. The course of action determines the precision of the DM estimation method. An example is the use of nitrogen in late winter on dairy farms, where if the target is 2,000 kg DM/ha on a 50 ha farm, then the use of 1 tonne of nitrogen (NZ Dairy Board, 1982) would gain 10 kg utilised DM/ha, to increase the aggregate DM or farm cover by about 10%. Thus the DM estimate method, supporting a decision to apply nitrogen, must distinguish differences of less than 200 kg DM/ha in farm cover. A calibration regime using cutting would be necessary to provide this level of accuracy, and methods such as those of representative transects (Piggot and Morgan, 1985) or long and short paddock averages (Piggot, 1986) should be favoured.

The above comments refer to trim DM yields, not total DM yields. If total DM yield must be measured, more accurate calibration techniques would be required for any end-use because the error of total DM measurement is much higher (Table 3). In cases where very precise farm cover estimates, or intake estimates at very low grazing pressures are required, total DM yields cannot be estimated accurately enough on farms with a reasonable labour or time input.

DISCUSSION

The measurement of pasture DM yields on a paddock scale ultimately requires 2 steps; yield assessment, and calibration of yield to DM. This paper makes the case for a choice of yield assessment method to be made after considering the pasture type, calibration based on trimmed DM yield and not total DM yield, total DM values obtained at the individual farm level by adding an abstract stubble value to trimmed DM data and for the method to be determined by the use to which the yield data is to be put.

When choosing the yield assessment method, data such as that of Table 1 can be used as a guide. Preference for a less accurate method can be justified if sufficient extra independent yield assessments are made. To calibrate the yield assessment, the use of trim DM as the index for discriminating between DM yields is more relevant to commercial farms than total DM because it is easier to measure if cutting techniques are used, the precision of its measurement is similar to total DM, the absolute error is less, only the trim DM component of total DM is discriminated by the common yield measurement methods and it does not contain a stubble component which varies markedly between farms and pasture types.

For extending total DM information from research stations to farms or distant regions, an abstract stubble value could be added to the measured trim DM values. Such a stubble value could be provided by an extension worker or regional agronomist. Alternatively, where no cutting is undertaken, published calibration equations provide total DM directly, essentially declaring the stubble value as the intercepts from the equations (Piggot, 1986; L'Huillier and Thomson, 1988). Abrstract stubble values can be varied to link on-farm assessment with different research stations, since feeding standards and pasture management re-commendations can differ between research stations solely because of differences in pasture assessment techniques (Thomson, 1986). Ultimately, however, the choice of calibration method can only be made if the end-use is known. Accurate farm management analyses requre DM yield data derived from accurate calibration with on-farm cutting techniques. Poorly calibrated assessments are not without their uses nonetheless, such as for controlled feeding at high grazing pressures.

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