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Measurement of Grassland Management Practice on Commercial Dairy Farms

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Contents

Summary

- Visual assessment (>4 cm) was found to be the preferred method of pasture mass estimation.
- Grass budgeting with the use of grass cover measurement, was found to be the most effective aid to good grazing management.
- Closing farm grass cover in late November/early December should be 350 to 450 kg DM/ha with a range in covers of 200 to 900.
- Target farm grass covers of 550 to 600 kg DM/ha at turnout at stocking rate of 2.75 cow/ha.
- Pre-grazing yields at turnout should not be less than 1000 kg DM/ha, giving daily grass allowance of not less than 5 kg DM/cow.
- The available grass supply in Spring should be budgeted so as to finish the first grazing rotation between the 10th-20th April (grass supply equal grass demand).
- During the main grazing season (May to August), grazing grass cover should be maintained at 900 to 1000 kg DM/ha or 200 to 240 kg DM/cow.
- Pre-grazing yield should be maintained at 1800 to 2000 kg DM/ha, with post-grazing residuals at 150 to 200 kg DM/ha (5.5 to 6.5 cm post-grazing height).
- Stocking rates of greater than 4.5 cow/ha on the grazing area in May/June mostly resulted in inadequate grass supply at some periods over that time.
- Rotation length can be increased from 21 days in mid/late August to 35 days in late September, allowing grass cover to increase to 1100 to 1300 kg DM/ha.
- Last rotation should be 25 to 35 days, with first paddocks rested from the 10th to 15th October.
- Greater use of grass measurements at farm level will allow dairy farmers to obtain a greater proportion of the dairy herd's feed demand from grazed grass, and higher cow performance.

Measurement of Grassland Management Practice on Commercial Dairy Farms

Introduction

The simplest and most financially rewarding system of milk production for Irish dairy farmers is that based on making the maximum use of grazed grass. With good grazing management Irish dairy farms can have a long grazing season of high quality feed at low cost. The CAP reform proposals may result in lower milk prices and, as a result, may compel dairy farmers to use new technology to maintain their incomes. One such technology will be more efficient use of grazed grass. Grassland management practices were studied on 12 intensive dairy farms with a total of 1600 cows and an average stocking rate of 2.7 cows/ha in the grazing period autumn 1995 to winter 1998.

Grassland Measurement

Pasture mass measurement techniques

A project was carried out at Moorepark in which a rising plate meter, sward stick, a single probe capacitance meter and visual assessment (5 observers) techniques were used to estimate herbage mass of swards which were rotationally grazed with dairy cows. Estimates were obtained on five occasions during the grazing season (spring, early summer, late summer, autumn and winter). Calibration regressions were obtained by simple linear regression for each predictor. The criteria used to establish the precision of the techniques was the residual standard deviation (RSD) and coefficients of variation associated with the calibration. On average 90.3% of the variation (R^2_{adj}) was explained with the visual assessment technique, with individual observers ranging from 84.2 to 88.9%. The plate meter and sward stick accounted for 78.4 and 66.9% of the variability in cut yield, respectively. The lowest R^2_{adj} was obtained with the pasture probe with only 21.4% of the variation explained. The results showed that the visual assessment of pasture yield is the preferred option and was the method used on farms.

Visits to farms
Each farm was visited once monthly from November to March and bi-monthly from April to September. At each visit, measurements included pasture cover (kg DM/ha >4cm), grass availability (kg DM/cow >4 cm), daily grass allowance (kg DM/cow/day >4 cm), pre- and post-grazing height, rotation length, cow condition score and level of supplementation. Milk production and herd reproductive performance was recorded using the Dairy Management Information System (DairyMIS).

Priority measurements
The measurements which were identified to have the largest influence are as follows:
a) Farm grass cover;
b) Post-grazing height; and
c) Pasture quality.

Farm Grass Cover

Farm grass cover is the total supply of available grass (>4 cm) on all paddocks for grazing. A dairy farmer requires a farm map with the area of each paddock and a knowledge of the amount of grass on each paddock to measure farm grass cover.

Farm map
It is essential that all intensive dairy farmers should have an accurate map of the area available for grazing. This should include individual paddock numbers and the corresponding areas. This can also be used as a grazing calendar and for fertiliser spreading, topping and spraying records.

Estimate of grass available on each paddock
The method used is based on visual assessment. The farmer or advisor can calibrated his own visual assessment during a farm walk. This entailed cutting a series of small quadrats and comparing the measured yield to the yield estimated prior to cutting. To obtain the measured yield, a 0.25 m^2 quadrat is cut to 4 cm. The herbage is placed in a plastic bag, weighed on a hand-held scales and the yield is then calculated, knowing the dry matter content. The calculated

yield can be compared to the estimated yield. If the DM content is not known this can be obtained by drying 50g of grass for 30 seconds in a microwave. The DM is then multiplied by 2 to get the DM content (%).

The yield per hectare was calculated as follows :

Yield (kg DM/ha) = Fresh weight (g) x DM % x 0.4

e.g. Size of quadrat = 0.25 m^2
Weight of grass in quadrat = 200 gr
Dry matter content of grass =15%
Yield (kg DM/ha) = 200 * 15 * 0.4 = 1,200 kg DM/ha

Note : If more than one quadrat is taken, one composite grass sample is sufficient for DM (%) content estimation. The following guide may be used for DM (%) content estimation.

- If the cut herbage has a large quantity of surface moisture then DM content is usually 10-13%.
- If the cut herbage has only a small amount of surface moisture then DM content is usually 14 to 16%.
- If the cut herbage has no surface moisture, then DM content is usually 16 to 18%.

A ready reckoner is provided in Appendix 1 for a range of quadrat weights and DM contents. Some dairy farmers found the concept of calibration difficult to understand initially; however, the concept can often be best explained or practised within a discussion group. Table 1 shows an example of a farm cover grass estimation. Appendix 7 shows the sources and prices of the equipment, for grass yield estimation.

See Table 1 overleaf

Table 1. Illustration of the method of recording pasture cover

Paddock Number	Paddock area (ha)	Estimated cover	Paddock cover
1	0.96	2200	2112
2	1.20	1950	2340
3	1.00	1750	1750
4	1.00	1850	1850
5	1.50	1100	1650
6	1.30	1300	1690
7	1.20	800	960
8	1.10	675	743
9	1.10	650	715
10	1.20	300	360
11	1.30	350	455
12	1.30	450	585
13	1.30	600	780
14	1.20	900	1080
15	1.30	1100	1430
16	1.20	950	1140
17	1.20	1150	1380
18	1.30	1500	1950
19	1.20	700	840
20	0.95	1500	1425
21	1.20	250	300
	25.0		25535/25
Pasture cover (kg DM/ha)			1021

Post-grazing sward height

Post-grazing sward height is the average height (cm) to which a paddock is grazed when the cows have finished grazing. The post-grazing sward heights include both dung pads and non-dung pad areas. These give the farmer an independent measurement of how well his cows are being fed. They can also be used as an indication of the residual grass yield left after grazing which, in turn, will have an effect on pasture quality, in the subsequent grazing rotation. Table 2 shows a range of post-grazing severity scores, the associated grass height and a description of the grazing severity.

Table 2. Post grazing severity score

Grazing Score	Grazing Height	Description
1	<4.5	grossly over-grazed
2	4.5-5.5	over-grazed
3	5.5-6.5	good grazing
4	6.5-7.5	under-grazed
5	>7.5	grossly under-grazed

Pasture quality

Pasture quality is a measure of the digestable energy content of the feed. There are high correlations between the quality of the pasture, as measured by either the proportion of live-leaf or organic matter digestibility (OMD), and its milk production potential. Factors which influence this are previous post-grazing heights, rotation length, pasture species and the degree of pasture topping being practised. It was found that the most practical measurement of pasture quality is the proportion of live-leaf in the sward directly ahead of the cows. It is desirable that the proportion of live leaf should not be less than 65% (Table 3).

Table 3 The relationship between the proportion of live leaf and organic matter digestibility.

Percentage live leaf	OMD (g/kg)
50	74
55	76
60	78
65	80
70	82
75	84
80	86

To convert (OMD) to dry matter digestibility (DMD) subtract 4 - 5 units from the OMD

Grassland Measurement Guidelines - Critical Periods

For grassland measurement guideline purposes, it was found that the grazing season can be divided into three distinct periods namely:

- Autumn/winter
- Spring
- Main grazing season

Autumn/winter (late August to December)
The aim is to maximise the amount of grass utilised in the period September to December while finishing the grazing season with the desired farm grass cover. The farm grass covers obtained over this period depend on stocking rate, level of supplementation, autumn nitrogen application, calving pattern and milk yield potential.
The following guidelines should be followed.

- Rotation length should be increased from 21 days in mid/late August to 30 - 35 days in late September.
- Aim for a pasture cover of 1000 -1100 kg DM/ha (at a stocking rate of 2.75 cows/ha) by late September.
- Pre-grazing yields should not exceed 3000 kg DM/ha and should be adjusted downwards for wetter type soils. Very high pre-grazing yields result in poor pasture quality and poor utilisation of this pasture by the grazing animals.
- The final grazing rotation of the year should be 25 to 35 days in length and resting of paddocks should begin from October 10 to 15.
- Avoid grazing very high pre-grazing yields (>2500 kg DM/ha) in the final rotation to avoid the problems outlined above. In addition, high pre-grazing yields in the final rotation were shown to have a detrimental effect on subsequent spring grass growth.
- The closing farm grass cover in late November/early December should be 400kg DM/ha, paddock cover should range between 200kg DM/ha (last closed paddock) to 900 kg DM/ha(first paddock closed).
- Pastures should be grazed well in the final rotation to encourage autumn/winter tillering. Aim for a residual grass yield of 200 kg DM/ha (5cm high) in paddocks as they are closed in the mid-October to mid-November period.

Spring (late February to late April)
The aim at this period is to maximise the amount of grazed grass in the cows diet while at the same time having a farm grass cover of >850 kg DM/ha by late April. The management factors which have the largest influence on the quantity of grazed grass consumed/cow over this period are overall stocking rate, calving pattern, autumn closing cover, silage ground availability and spring nitrogen application.

Appendix 2 shows how a feed budget may be used to reach the required targets on the farm. Weekly monitoring of grass cover is required with very variable spring grass growth rate. Appendix 3 shows the grass growth rates measured at five locations in the country.

The following guidelines should be followed:

- Aim for a farm grass cover of 550 to 600 kg DM/ha at turnout at a stocking rate of 2.75 cows/ha. Turnout at lower and higher cover is possible at lower and higher stocking rates, respectively.
- Pre-grazing yields at turnout should be greater than 1000kg DM/ha and daily grass allowance per cow should not be less than 5kg DM/cow/day.
- The available grass supply should be budgeted so that the first grazing rotation finishes at April 10 to 20.
- The target farm grass cover is 850 kg DM/ha in late April (at a stocking rate of 4.5 cows/ha on the grazing area).
- Excessively low post-grazing heights (<4.5 cm grass cover) should be avoided in this period as it will slow re-growths.
- Late turnout, with large farm grass cover, often leads to poor grass utilisation and subsequent poor pasture quality.
- Good grazing management practises, such as, block grazing and a good farm road network reduce the risk of soil damage during this period.

Main Grazing Season (May to August)
The objective over this period is to achieve high cow performance from grass with minimal or no concentrates supplementation. High cow performance is achieved by maintaining a consistent grass supply for the herd on a daily basis. Weekly monitoring of farm grass

cover will assist this. This will allow early alteration of grass supply, e.g., adjusting stocking rates and/or introducing supplements.

The key grassland management guidelines for this period are as follows ;

- Farm grass cover should be maintained at 900-950 kg DM/ha or 200 to 240 kg DM/cow on the grazing area during the main grazing season.
- Under normal grass growth rate conditions, a stocking rate of 4.5 cows/ha from mid- April to early June permits adequate feeding of cows at pasture at a grass allowance of 20 -21 kg grass DM/cow/day. Supplementation is required at higher stocking rates. Appendices 4 & 5 give examples of how to calculate daily grass allowance, intakes per cow and kg DM available per cow.
- Pre-grazing yields should be maintained at 1800-2200 kg DM/ha.
- Pastures with high post-grazing residues (>350 kg DM/ha) or high post-grazing heights (>7.5 cm) should be topped. Pasture topping should take place early (mid-May) rather than late in the season.
- Grazing to a very low post-grazing height (< 5 cm) will result in inadequate grass intakes and will result in reduced milk yields and protein content.
- Aim to maintain >65% of live leaf in the sward immediately ahead of the cows. Appendix 6 gives the method of calculating the percentage live leaf in the sward.
- Use grass measurements to identify grass surpluses or deficits.

The following conditions indicate a grass surplus:

- Pasture covers greater than 1100 kg DM/ha on the grazing area in the period from late-April to early August
- An extremely steep grass supply wedge pattern (350 to ≥3000 kg DM/ha) on the grazing area.
- Grazing large covers (>2500kg DM/ha) will often result in reduced milk production while topping large residuals often reduces grass supply in the following rotation.

There is a grass deficit when the farm pasture cover is less than 750 kg DM/ha (at a stocking rate >3.5 cow/ha on the grazing area) and when pre-grazing yields are less than 1500kg DM/ha.

Reducing grass covers to very low levels results in reduced grass growth rates on the total farm and generally results in underfeeding of the cows. Low farm grass cover can be alleviated by increasing the grazing area and/or introducing supplements while maintaining rotation length at 20 to 24 days.

Benefits to increased use of grass measurements on farms

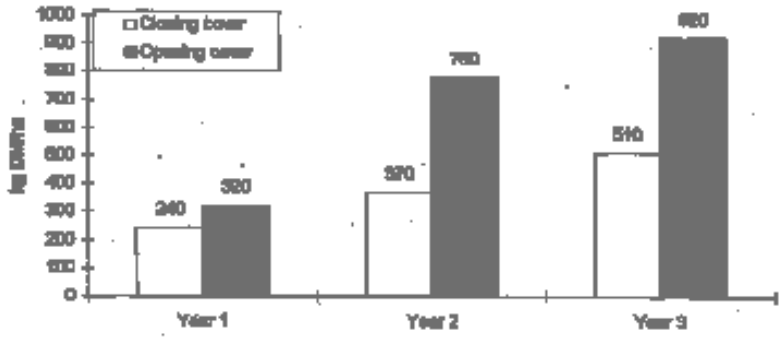
The study highlighted the following benefits obtained from more routine grass measurement on farms.

- Greater spring grass supply through improved autumn management.
- Optimum utilisation of spring grass.
- Identification of grass surpluses and deficits.
- Achieving higher performance from grazed grass.

Greater spring grass supply by improved autumn management

The study showed the importance of end of season grazing management and its large effect on spring grass supply. Figure 1 shows the increased grass covers at the end of the grazing seasons over the three years and its consequences for the following spring grass supply. The farmers in the study recognised this and changed their grazing management to obtain the benefit.

Figure 1: The average improvement in closing and opening covers over the three year period

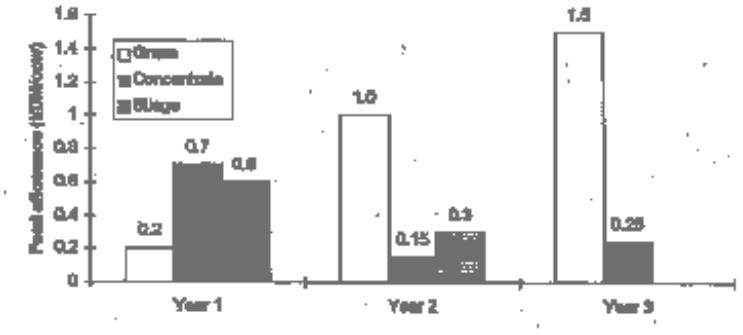


Optimum utilisation of spring grass

Research results have shown the large benefit to be obtained from early spring grass. Weekly monitoring of farm grass supply from late February to late April allowed the dairy farmers to maximise this benefit although circumstances differed on the farms, eg., stocking rate, calving pattern, grass supply, etc.

Figure 2 shows the increase, in one spring calving herd, in the proportion of grazed grass in the diet from turnout until the end of April over the three years. The combination of better autumn grazing management and better feed budgeting in spring allowed the farmer to increase the amount of grazed grass by 1.0 tonnes over the three years.

Figure 2: The increase in the early spring allowance of grazed grass in the diet of one spring calving herd



Identification of grass surpluses and deficits

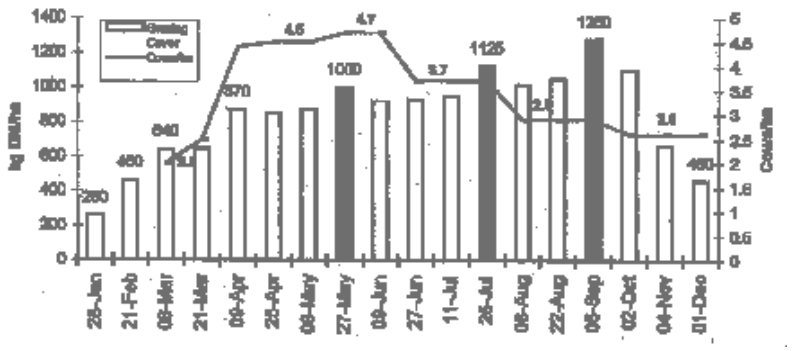
Frequent monitoring of grass supply during the grazing season allowed the dairy farmers to make earlier and better grazing management decisions. Allowing the grass supply to reduce to very low levels has been shown to reduce the total grass grown on a farm. Likewise, allowing very large grass covers to accumulate reduces milk production and increases the requirement for pasture topping. Excessive topping results in poor grass utilisation and probably reduces grass supply in the following rotation. Figure 3 shows how frequent monitoring of grass supply allowed one dairy farmer to make the decisions required to match feed supply to feed demand. Figure 4 shows the grass cover profile of a poorly managed grazing system, pasture cover was in deficit both at turnout and during the main grazing season.

Achieving higher performance from grazed grass

One of the main reasons for low performance being obtained from grazed grass on some farms in the study was an inadequate daily grass allowance.

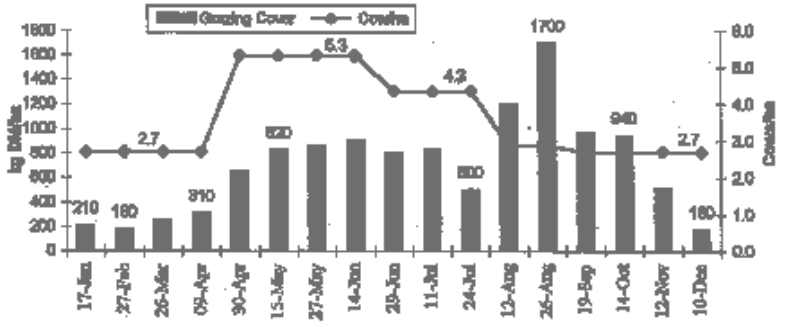
- This theory is supported by the very low post-grazing height, large reduction in milk yield, below optimum body condition score and reduced milk protein content of milk.
- A knowledge of pre-grazing yield and post-grazing height allowed dairy farmers to become more confident in achieving high performance from grazed grass. Figures 5 and 7 show daily feed allowance and milk production, respectively, over the grazing season for a well fed spring calving herd. Figures 6 and 8 show the daily feed allowance and the milk production, respectively, over the grazing season for a poorly fed spring calving herd.

Figure 3: Well managed grass cover over the grazing season



Grazing cover (Y axis on left of graph), stocking rate (Y axis on right of graph). Paddocks cut for silage: 3 paddocks on 27/5, 4 paddocks on 25/7 and 4 paddocks on 5/9

Figure 4: Shows the grass cover profile of a poorly managed grass cover. Pasture cover is in deficit both at turnout and during the main grazing season



Grazing cover (Y axis on left of graph), stocking rate (Y axis on right of graph).Paddocks cut for silage: 4 paddocks cut for silage 26/8.

Figure 5: Feed allowance of an adequately fed spring calving

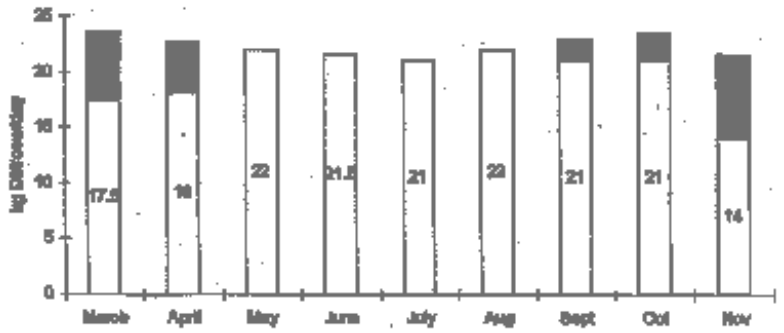


Figure 6: Feed allowance of an inadequately fed spring calving herd

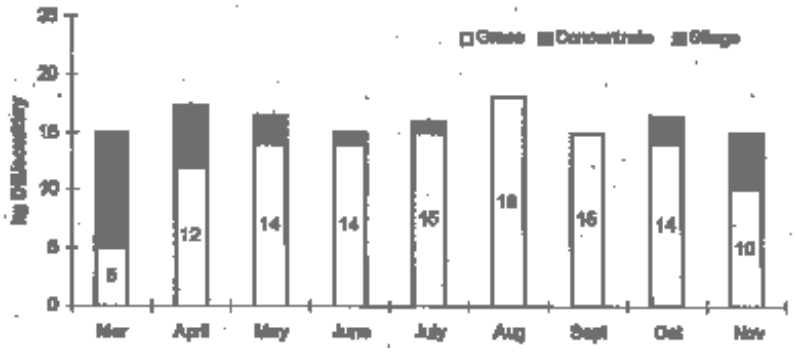


Figure 7: Milk yield and milk composition from the feed allowance shown in Figure 5

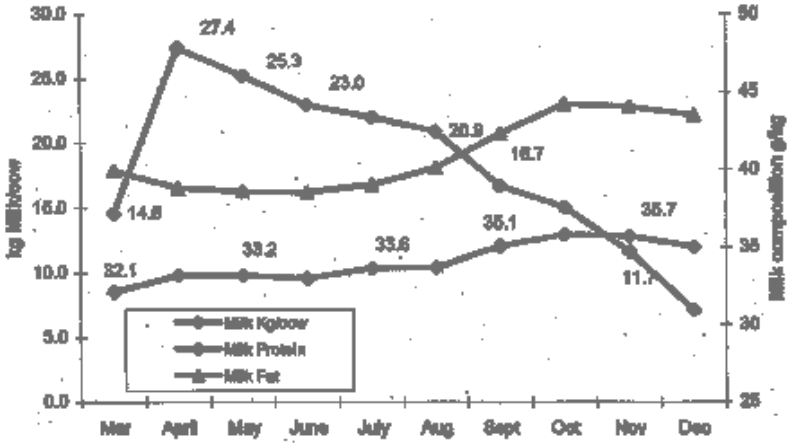
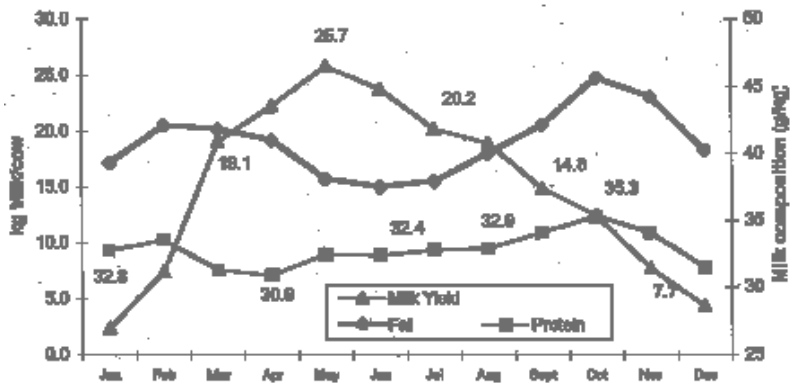


Figure 8: Milk yield and milk composition from the feed allowances shown in Figure 6



Conclusions

- Dairy farmers improved their grassland management when they frequently measured grass covers on their farms.

- It was possible to closely match grass supply to cows demand for grass by either closing off paddocks for silage when there was surplus grass or by the timely introduction of supplements when there was a grass scarcity.

- The best method of measuring grass supply was by visual observation. The farmers calibrated themselves by cutting quadrat samples and comparing their yield estimate to the actual cut quadrat yield.

- The critical grass measurements were pre-grazing grass yield, post-grazing grass height, farm grass cover and percentage live leaf in the sward.

- The last grazing before closing off the farm is most critical since it affects the subsequent spring grass growth.

- Dairy farmers with spring calving herds produced up to 80 % of milk from grass when they used the good grassland management techniques which were made possible by grass measurement.

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Appendix 1

GMs	DM	Yield	DM	Yield	DM	Yield	DM	Yield	DM	Yield	DM	Yield	DM	Yield	DM	Yield	DM	Yield
25	11	110	12	120	13	130	14	140	15	150	16	160	17	170	18	180	20	200
50	11	220	12	240	13	260	14	280	15	300	16	320	17	340	18	360	20	400
75	11	330	12	360	13	390	14	420	15	450	16	480	17	510	18	540	20	600
100	11	440	12	480	13	520	14	560	15	600	16	640	17	680	18	720	20	800
125	11	550	12	600	13	650	14	700	15	750	16	800	17	850	18	900	20	1000
150	11	660	12	720	13	780	14	840	15	900	16	960	17	1020	18	1080	20	1200
175	11	770	12	840	13	910	14	980	15	1050	16	1120	17	1190	18	1260	20	1400
200	11	880	12	960	13	1040	14	1120	15	1200	16	1280	17	1360	18	1440	20	1600
225	11	990	12	1080	13	1170	14	1260	15	1350	16	1440	17	1530	18	1620	20	1800
250	11	1100	12	1200	13	1300	14	1400	15	1500	16	1600	17	1700	18	1800	20	2000
275	11	1210	12	1320	13	1430	14	1540	15	1650	16	1760	17	1870	18	1980	20	2200
300	11	1320	12	1440	13	1560	14	1680	15	1800	16	1920	17	2040	18	2160	20	2400
325	11	1430	12	1560	13	1690	14	1820	15	1950	16	2080	17	2210	18	2340	20	2600
350	11	1540	12	1680	13	1820	14	1960	15	2100	16	2240	17	2380	18	2520	20	2800
375	11	1650	12	1800	13	1950	14	2100	15	2250	16	2400	17	2550	18	2700	20	3000
400	11	1760	12	1920	13	2080	14	2240	15	2400	16	2560	17	2720	18	2880	20	3200
425	11	1870	12	2040	13	2210	14	2380	15	2550	16	2720	17	2890	18	3060	20	3400
450	11	1980	12	2160	13	2340	14	2520	15	2700	16	2880	17	3060	18	3240	20	3600
475	11	2090	12	2280	13	2470	14	2660	15	2850	16	3040	17	3230	18	3420	20	3800
500	11	2200	12	2400	13	2600	14	2800	15	3000	16	3200	17	3400	18	3600	20	4000

*GMS = Amount of cut fresh material in the quadrant
*DM = Dry matter of cut grass
*Yield = Kg DM/ha

Note: This can be used as a quick method of establishing the yield of grass dry matter per hectare when the weight and dry matter of the quadrat sample are known.

Appendix 2: *Grass budget with an opening (turnout) cover of 600 kg DM/ha in early spring*

Date	No of Cows	Grass Allowance	S. Rate (cows/ha)	Demand per ha	Predicted Growth	Depletion (-) or Increase (+)	No days	Total Decline	Expected cover	Actual cover
	A	B	C	D (B x C)	E	F (E - D)	G	H (F X G)	(I)	J
										600
21-Feb	52	6	1.3	8	14	6	7	42	642	
28-Feb	59	8	1.5	12	17	5	7	35	677	
06-Mar	62	10	1.6	16	20	4	7	28	705	
13-Mar	66	12	1.7	20	22	2	7	14	719	
20-Mar	73	14	1.8	25	28	3	7	21	740	
27-Mar	79	15	2.0	30	35	5	7	35	775	
03-Apr	84	17	2.1	36	55	19	7	133	908	
10-Apr	92	17	4.5	77	65	-12	7	-84	824	
17-Apr	100	17	4.5	77	80	3	7	21	845	
24-Apr	100	20	4.5	90	90	0	7	0	845	
01-May	100	20	4.5	90	95	5	7	35	880	

*** If you are doing a grass budget for your own farm use the predicted growth rates in appendix three from the location nearest your farm or consult your Teagasc advisor.**

Appendices

Appendix 3: *Grass growth rates (kg DM/ha)*

	Moorepark	Wexford	Mullingar	Claremorris	Clones
5 Feb	6.0	4.5	2.3	2.3	2.3
19 Feb	11.5	8.5	6.0	6.0	6.0
4 Mar	15.3	15.3	11.5	13.5	11.5
18 Mar	19.5	19.5	14.6	16.6	14.6
1 Apr	29.6	29.6	26.6	26.6	26.6
15 Apr	56.5	56.5	51.0	51.0	51.0
29 Apr	83.0	83.0	74.7	74.7	74.7
13 May	98.6	93.7	93.7	93.7	93.7
27 May	93.9	89.2	89.2	89.2	89.2
10 Jun	87.4	81.3	81.3	81.3	81.3
24 Jun	84.6	78.7	78.7	78.7	78.7
8 Jul	64.6	61.4	61.4	61.4	61.4
22 Jul	55.0	52.3	52.3	52.3	52.3
6 Aug	60.6	55.1	55.1	55.1	55.1
19 Aug	46.6	42.4	42.4	42.4	42.4
2 Sep	40.1	36.9	36.9	36.9	36.9
16 Sep	37.6	34.6	34.6	34.6	34.6
30 Sep	32.6	29.9	29.9	29.9	29.9
14 Oct	22.7	22.7	19.5	19.5	19.5
29 Oct	13.5	13.5	11.6	11.6	11.6
11 Nov	7.4	5.0	3.9	3.9	3.9
25 Nov	1.3	0.9	.07	0.7	0.7

Appendix 4: *Calculating daily grass allowance and intake per cow*

a.) Allowance per cow

Example
100 cow herd.
Grazed on 1.2hectare paddock for one day.
Estimated pre-grazing grass cover on the paddock is 1800 kg DM/ha.
Total grass available to the cows for the day is 1800 x 1.2 = 2160 kg DM.
Daily grass allowance per cow = 2160/100 = 21.6 kg DM.

b.) Intake per cow

Example
Details as above with a post-grazing grass cover on the paddock of 250 kg DM/ha giving a total post-grazing grass cover on the paddock of (250 x 1.2) 300 kg of DM.
Daily herd grass intake is equal to 2,160 minus 300 = 1,860 kg DM.
Daily grass intake per cow = 1,860/100 = 18.6 kg DM

Appendices

Appendix 5: *Calculating kg of dry matter per cow*

(The method recording farm grass cover was outlined in Table 1)

Example

Farm grass cover = 900kg DM/ha
Stocking rate = 4.5 cows/ha
Farm grass cover per cow = Farm grass cover/stocking rate = 900/4.5 = 200 kg DM/cow

Appendix 6: *Calculating the percentage live leaf in a sward*

1. Take a range of grass samples from the sward (cut to 4cm).
2. From this range of samples take a 50 g subsample.
3. Divide this subsample into two samples, one consisting of live leaf and the other one consisting of all other vegetative material.
4. Dry both samples in a microwave oven.
5. Weigh the dried samples.
6. The live leaf is expressed as a percentage of the combined weights eg.,

Dried sample of live leaf	= 6.5g
Dried sample of all other material	= 2.5 g
Total weight =	= 9.0 g

Live leaf as a percentage of total weight is 72%

Appendix 7: *Equipment required for pasture estimation*

Grass shears

Hand scales: Salter Spring Balance S/S (1 kg x 5g) may be sourced from AGB Scientific: Contact Gerry Power Fax (01) 8309533. Cost £36

Quadrat: (0.25m^2) quadrat can be made by welding 0.5m iron segments together

Microwave: A650 watt Microwave £150 was used.

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