End of Project Report

MANIPULATION OF GRASS SUPPLY TO MEET FEED DEMAND

RMIS 4871

Beef Production Series No. 61

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ISBN 1 84170 464 4

2006

Introduction

Grazed grass is generally the cheapest form of feed available for beef and milk production in Ireland. Grass growth is variable during the year with a peak in May/June and a secondary peak in August. There is little net growth from December to February. Grass growth is also variable across the country with higher grass growth in the south and south-west (14 to 15 t DM/ha/year) compared with approximately 11 t DM/ha/year in the north-east (Brereton, 1995). There is poor synchrony between grass supply and feed demand on beef and dairy farms. The feed demand curve for a calf to two year old beef system shows feed demand decreasing as grass supply increases, and grass supply decreasing as feed demand increases. Similarly, the feed demand curve of a spring calving dairy herd shows poor synchrony with grass supply, with a surplus of grass from about mid-April to mid-August, and a deficit for the rest of the year. Traditionally surplus grass produced during May and June is conserved as silage or hay and fed back to cattle and dairy cows during the deficit times of the year.

This project examined the possibility of reducing the grass growth peak in May/June and increasing grass supply later in the year by altering nitrogen application pattern and extending autumn rotation lengths.

Experiment 1: The effect of closing date in the autumn and grazing date in the winter on dry matter yields during the winter and subsequent grass production

Objective

The objectives of the first experiment were to examine the limitations to providing grass for out of season grazing and the effects of autumn closing date and winter grazing date on subsequent grass production.

Materials and Methods

A long-term perennial rye grass sward (*Lolium perenne*) was divided into 64 plots (10m x 9m) at two sites. The sites were Grange Research Centre (52^0 N 7^0 W) and Moorepark Research Centre (50^0 N 8^0 W). There were four autumn closing dates - 10 August, 1 September, 20 September and 10 October and four winter grazing dates – 20 November, 20 December, 20 January and 20 February. There were four replicates of each treatment. The experiment commenced in July 2000 and continued to July 2003 at Grange (three years) and July 2002 at Moorepark (two years).

Pre-grazing DM yields were estimated on each autumn closing date and each winter grazing date and every four weeks from April to July. Dry matter yield was estimated by cutting a 5m x 0.55m strip in each plot using a lawnmower at Grange and an Agria at Moorepark. Post-grazing DM yield was estimated, conditions permitting, following each winter grazing by cutting a 5m x 0.55m strip in each plot using a lawnmower. A sub-sample of each cut was dried at 98^0C to estimate DM and a sample was also dried at 40^0C for 48 hours and milled for chemical analysis.

Prior to each winter grazing a sample of the pre-grazing herbage was divided into grass leaf lamina, stem/pseudostem and dead material and non-grass species to estimate the proportion of each component in the sward.

On 20 July of each year, 4 turves (10 cm x 10 cm) were removed from each plot and the species of each tiller was identified and counted. This was repeated on each plot on its respective winter grazing date and on all plots on April in year 1 (both sites) and year 3 (Grange).

Results

Winter DM yield

The earlier closing dates in the autumn had higher winter DM yields than the later autumn closing dates at both sites (Table 1 and Table 2). Winter DM yield decreased as grazing was delayed except on the 10 October closed plots, which maintained or showed a slight increase in DM yield over the winter. Winter DM yield was significantly affected ($P<0.01$) by autumn closing date, winter grazing date and year at both sites. Both sites recorded a significant interaction between autumn closing date and winter grazing date ($P<0.001$). There was a closing date x grazing date x year interaction at Grange but not at Moorepark.

Table 1. Effects of winter grazing date, autumn closing date and year on winter DM yield (kg DM ha^{-1}) at Grange.

Grazing Date	**Closing Date**	**Year 1**	**Year 2**	**Year 3**
20 November	10 August	4259	2732	2636
	1 September	3438	2129	2026
	20 September	1627	1807	1205
	10 October	527	985	434
20 December	10 August	2979	2634	2347
	1 September	2492	2334	2525
	20 September	1828	1966	1599
	10 October	1007	1614	374
20 January	10 August	2621	1782	2413
	1 September	2531	1554	1651
	20 September	1627	1391	1266
	10 October	583	1065	623
20 February	10 August	2334	1057	1847
	1 September	1913	898	1499
	20 September	1469	916	1043
	10 October	580	1260	595
	s.e.		190	
	Grazing Date (G)		***	
	Closing Date (C)		***	
	Year (YR)		***	
	G x C		***	
	G x C x Yr		*	

Table 2. Effects of winter grazing date, autumn closing date and year on winter DM yield (kg DM ha^{-1}) at Moorepark.

Grazing Date	Closing Date	Year 1	Year 2
20 November	10 August	3998	3920
	1 September	3443	3324
	20 September	2144	2780
	10 October	967	1666
20 December	10 August	2466	2695
	1 September	1801	2187
	20 September	1571	2360
	10 October	1181	1963
20 January	10 August	2464	1723
	1 September	1859	1459
	20 September	1761	1679
	10 October	1066	1605
20 February	10 August	1633	2334
	1 September	1877	1102
	20 September	1707	1795
	10 October	1201	1965
	s.e.	221	
	Grazing Date (G)	***	
	Closing Date (C)	***	
	Year (YR)	**	
	G x C	***	
	G x C x Yr	n.s.	

Proportion of leaf stem and dead material

The later autumn closing dates (20 September and 10 October) had a higher leaf proportion on all grazing dates during the winter than the two earlier closing dates (10 August and 1 September) (Table 3). The 10 August closed plots had the highest proportion of dead material at the beginning of the winter, in November, and this trend continued during the winter. Grazing date, closing date and year all had a significant effect ($P<0.001$) on leaf proportion and dead proportion at Grange. At Moorepark, winter grazing date did not have a significant effect on leaf proportion or dead proportion; both were maintained over the winter.

Table 3. Effect of autumn closing date and winter grazing date on the proportion of leaf, stem and dead material during the winter at Grange and Moorepark, averaged over three years at Grange and two years at Moorepark.

Grazing Date	**Closing Date**	**Grange**				**Moorepark**			
		Leaf	Stem	Dead	Weeds	Leaf	Stem	Dead	Weeds
20 November	10 August	0.61	0.15	0.21	0.04	0.38	0.23	0.39	0
	1 September	0.67	0.14	0.17	0.03	0.46	0.19	0.34	0
	20 September	0.84	0.06	0.10	0.01	0.69	0.17	0.14	0
	10 October	0.84	0.05	0.10	0.01	0.79	0.12	0.10	0
20 December	10 August	0.51	0.18	0.29	0.02	0.40	0.21	0.40	0
	1 September	0.60	0.16	0.23	0.01	0.44	0.20	0.36	0
	20 September	0.72	0.11	0.17	0.01	0.60	0.16	0.23	0
	10 October	0.80	0.07	0.13	0.01	0.66	0.15	0.19	0
20 January	10 August	0.44	0.17	0.38	0.02	0.40	0.18	0.42	0
	1 September	0.53	0.13	0.32	0.02	0.54	0.15	0.31	0
	20 September	0.68	0.10	0.21	0.00	0.58	0.13	0.30	0
	10 October	0.80	0.09	0.14	0.00	0.74	0.10	0.16	0
20 February	10 August	0.44	0.13	0.42	0.01	0.44	0.17	0.39	0
	1 September	0.48	0.14	0.36	0.02	0.50	0.18	0.32	0
	20 September	0.65	0.10	0.25	0.01	0.58	0.15	0.27	0
	10 October	0.77	0.08	0.15	0.01	0.65	0.17	0.17	0
	s.e.	0.029	0.016	0.022	0.005	0.033	0.013	0.030	
	Grazing Date (G)	***	*	***	*	n.s.	***	n.s.	
	Closing Date (C)	***	***	***	***	***	***	*	
	Year (YR)	***	***	***	***	***	***	*	
	G x C	n.s.	n.s.	*	n.s.	*	*	n.s.	
	G x C x Yr	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	

Table 4. Average DMD on four winter grazing dates over the winter on plots closed on four different closing dates in the autumn at Grange (3 years) and at Moorepark (2 years).

Grazing Date	**Closing Date**	**Grange**	**Moorepark**
20 November	10 August	0.715	0.725
	1 September	0.740	0.759
	20 September	0.791	0.803
	10 October	0.769	0.809
20 December	10 August	0.662	0.656
	1 September	0.700	0.685
	20 September	0.741	0.732
	10 October	0.728	0.732
20 January	10 August	0.627	0.636
	1 September	0.675	0.681
	20 September	0.737	0.715
	10 October	0.760	0.725
20 February	10 August	0.631	0.658
	1 September	0.681	0.719
	20 September	0.735	0.775
	10 October	0.756	0.770
	s.e	0.0095	0.0162
	Grazing Date (G)	****	***
	Closing Date (C)	***	***
	G x C	**	n.s.

Subsequent grass growth

Grazing date and closing date did not have a significant effect (P>0.05) on either April yield or total spring (April – July) yield at Grange (Table 5). Year had a significant effect on total spring yield at Grange (P<0.001). At Moorepark, grazing date, closing date and year all had a significant effect on April yield (P<0.001). Increasing autumn rotation length decreased April yield, as did delaying winter grazing. Grazing date and year had a significant effect (P<0.001) on total spring yield at Moorepark. Delaying grazing in the winter decreased total spring yield. There was some interaction (P<0.05) between grazing date and closing date on total spring yield at Moorepark.

Table 5. Effect of closing date in the autumn and grazing date in the winter on April DM yield (kg DM ha^{-1}) and total spring (April – July) DM yield (kg DM ha^{-1}) at Grange and Moorepark, averaged over three years at Grange and two years at Moorepark.

Grazing Date	**Closing Date**	**Grange**		**Moorepark**	
		April Yield	Spring Yield	April Yield	Spring Yield
20 November	10 August	579	5554	1763	13264
	1 September	728	6457	1850	13820
	20 September	642	6242	2059	13044
	10 October	640	6506	2103	13729
20 December	10 August	588	6469	1349	12369
	1 September	576	6538	1077	10653
	20 September	576	5994	1473	12456
	10 October	617	6458	1429	12735
20 January	10 August	515	6805	896	11046
	1 September	533	5655	940	10787
	20 September	629	6106	1081	11776
	10 October	629	6323	1441	12223
20 February	10 August	827	6918	945	11620
	1 September	616	6662	1130	12251
	20 September	692	6277	1089	11658
	10 October	594	6452	1328	12012
	s.e.	73	337	125	411
	Grazing Date (G)	n.s.	n.s.	***	***
	Closing Date (C)	n.s.	n.s.	***	n.s.
	Year (YR)	n.s.	***	***	***
	G x C	n.s.	n.s.	n.s.	*
	G x C x Yr	n.s.	n.s.	n.s.	n.s.

Perennial ryegrass tiller density

Delaying closing date in the autumn significantly ($P<0.001$) increased the perennial ryegrass (PRG) tiller density on all grazing dates (Table 6). As grazing date was delayed, PRG tiller density was significantly ($P<0.001$) reduced for all autumn closing dates. There was no significant effect of grazing date on the July PRG tiller density. At Grange, the later autumn closing dates tended to have higher PRG tiller density in July ($P<0.05$).

Table 6. Effect of closing date in the autumn and grazing date in the winter on perennial ryegrass tiller density in winter and July at Grange and Moorepark, averaged over three years at Grange and 2 years at Moorepark.

Grazing Date	**Closing Date**	**Grange**		**Moorepark**	
		Winter	July	Winter	July
20 November	10 August	4019	3785	4509	5525
	1 September	4956	4209	5424	5747
	20 September	6770	5722	5942	5016
	10 October	7167	4625	6137	4672
20 December	10 August	2903	3838	4387	4656
	1 September	4131	4166	5274	5600
	20 September	5501	4528	5470	4641
	10 October	6855	5072	5765	4441
20 January	10 August	2606	3541	3617	5628
	1 September	4042	3325	4234	5463
	20 September	4920	3491	4116	4853
	10 October	7040	4928	4102	5488
20 February	10 August	1952	3867	3272	6578
	1 September	3517	3997	4399	4694
	20 September	5024	4797	3697	5059
	10 October	6711	4391	5340	6228
	s.e.	371	683	426	570
	Grazing Date (G)	***	n.s.	***	n.s.
	Closing Date (C)	***	n.s	***	n.s.
	Year (YR)	***	*	***	n.s.
	G x C	n.s.	n.s.	n.s.	n.s.
	G x C x Yr	n.s.	n.s.	n.s.	n.s.

Conclusion

Suitable autumn closing dates and winter grazing dates differ from region to region. These variations are largely due to temperature, which affects the length of the grass growing season. Closing swards in early (Grange) to mid-September (Moorepark) can provide adequate DM yield (2 t DM ha^{-1} or greater) for winter grazing. Utilising swards while they have green leaf content greater than 0.65-0.70 of DM yield provides a good quality herbage with a greater crude protein content (> 210 g kg^{-1}) and higher dry matter digestibility (average 0.72) than the average of grass silage in Ireland. Very early autumn closing dates combined with delayed winter grazing reduced winter DM yield and tiller density.

There were no effects of autumn closing date and winter grazing date on subsequent grass DM production in the northeast, while in the south very early autumn closing can negatively impact on subsequent grass production, as can delayed winter grazing of heavy DM yields (>2 - 2.5 t DM ha^{-1}). However, strategic use of autumn closing and winter grazing dates will ensure that the supply of early spring grass is not compromised. Repeated early closing and winter grazing of the same area over a number of consecutive years (3 years at Grange and 2 years at Moorepark) does not appear to have resulted in sward deterioration. Although perennial ryegrass tiller density decreased during winter it recovered during the spring and summer and there was no effect of treatment by July.

Experiment 2. Effect of closing date in the autumn on tissue turnover during the winter in a perennial ryegrass sward

Objective

The objective of this experiment was to examine the effect of autumn closing date on tissue turnover during the winter in a perennial ryegrass sward.

Materials and Methods

This experiment was undertaken using a selection of the plots described in experiment 1. Tissue turnover was measured from mid-October 2001 to the end of January 2002 using a randomised complete block design for site and closing date with measurement period as a split plot on site and closing date. The treatments were two sites – Teagasc Grange Research Centre (lat. 52^0 long. 7^0) and Teagasc Moorepark Research Centre (lat. 52^0 long. 8^0); three closing dates – 1 September, 20 September and 10 October; and one grazing date - 20 February. Each treatment was replicated four times. Thirty tillers were selected at 0.15m intervals along a 1.5m transect at three random locations within each plot. The tillers were labelled using twists of coloured plastic coated wire. Tillers were measured at 3-week intervals from 15th October to 28th January. At each recording the length of green leaf lamina, stem and pseudostem were measured. Leaf extension rate (LER) (mm/tiller/day), leaf appearance rate (LAR) (rate of new leaf appearance/tiller/day) and leaf senescence rate (LSR) (leaf senescence rate/tiller/day) were calculated for three-week periods over the winter.

Results

Tissue Turnover

Table 7. The effect of closing date in the autumn on leaf extension rate (LER, mm/tiller/day)), leaf appearance rate (LAR, leaves/tiller/day), leaf senescence rate (LSR, mm/tiller/day) and leaf area index (LAI) over the winter in a perennial ryegrass sward at Grange and Moorepark

		Grange Closing Date			**Moorepark Closing Date**		
	Measurement Period	**1 Sept**	**20 Sept**	**10 Oct**	**1 Sept**	**20 Sept**	**10 Oct**
	15 Oct – 5 Nov	8.126	6.867	4.966	11.084	9.855	8.944
	5 Nov – 26 Nov	6.407	5.009	3.627	7.978	6.862	5.919
LER	26 Nov – 17 Dec	3.712	3.730	2.476	5.151	5.061	4.319
	17 Dec – 7 Jan	2.440	2.614	1.507	2.286	3.062	2.471
	7 Jan – 28 Jan	4.973	5.494	3.795	6.651	6.349	5.558
	s.e.		0.413			0.326	
	Closing Date (C)		**			n.s.	
	Measurement Period (MP)		***			***	
	C x MP		n.s.			*	
	15 Oct – 5 Nov	0.046	0.051	0.070	0.047	0.050	0.067
	5 Nov – 26 Nov	0.038	0.038	0.047	0.036	0.036	0.046
LAR	26 Nov – 17 Dec	0.025	0.028	0.029	0.030	0.032	0.130
	17 Dec – 7 Jan	0.017	0.019	0.017	0.015	0.021	0.080
	7 Jan – 28 Jan	0.039	0.044	0.047	0.050	0.047	0.191
	s.e.		0.002			0.002	
	Closing Date (C)		***			**	
	Measurement Period (MP)		***			***	
	C x MP		***			***	
	15 Oct – 5 Nov	8.34	6.56	3.91	15.385	5.813	1.689
	5 Nov – 26 Nov	6.86	4.64	2.75	11.920	2.976	1.831
LSR	26 Nov – 17 Dec	5.79	3.87	1.69	10.289	7.809	6.000
	17 Dec – 7 Jan	4.07	2.36	0.68	6.598	7.367	3.902
	7 Jan – 28 Jan	10.59	9.18	2.51	8.600	12.166	2.161
	s.e.		1.132			1.217	
	Closing Date (C)		**			***	
	Measurement Period (MP)		***			n.s.	
	C x MP		n.s.			***	
	Measurement Date						
	15 Oct.	2.17	1.46	0.16	5.60	2.64	1.13
	5 Nov.	1.80	1.70	0.43	5.47	4.02	2.82
LAI	26 Nov.	1.35	1.38	0.80	2.98	3.61	2.53
	17 Dec.	1.31	1.58	1.15	2.35	2.61	2.34
	7 Jan.	1.11	1.62	1.65	2.23	2.32	2.28
	28 Jan.	0.54	0.81	1.17	1.36	1.59	2.17
	s.e.		0.165			0.181	
	Closing Date (C)		**			***	
	Measurement Date (MD)		**			***	
	C x MD		***			***	

Leaf extension rate decreased at both sites to the start of January and then increased. Leaf extension rate was higher at Moorepark than at Grange (Table 7). Measurement period had an effect on LER at both sites. Autumn closing date had an effect at Grange but not at Moorepark. There was some interaction between closing date and measurement period (P<0.05) at Moorepark but not at Grange. Similarly to LER, LAR decreased to the start of January and then increased. Both autumn closing date and measurement period had a significant effect (P<0.001) on LAR at both sites. As LAR decreased, the number of days required to produce a new leaf increased from between 14 and 22 days in mid-October at Grange to between 53 and 59 at the start of January. At Moorepark, the number of days required to produce a new leaf increased from between 15 and 21 days in mid-October to between 48 and 67 days at the start of January. By the end of January, as LAR increased, the number of days required to produce a new leaf decreased to between 21 and 26 days at Grange and to an average of 21 days at Moorepark. Leaf senescence rate followed a similar trend to that of LER and LAR at Grange. At Moorepark LSR also followed a similar trend to LER and LAR on the 1 September closing date. However, the 20 September and 10 October closing dates at Moorepark showed an increase in LSR to mid-December, followed by a decrease to the start of January and then a further increase. Leaf senescence rate was affected by closing date (P<0.01), measurement period had a significant effect (P<0.001) at Grange and there was a significant interaction between closing date and measurement period at Moorepark. Leaf area index (area of leaf over area of ground) decreased during the winter (Table 7) as LER and LAR decreased and LSR was greater than LER. Leaf area index was greater at Moorepark than at Grange. Early autumn closing increased LAI compared to later closing (P<0.001) and LAI decreased as the winter progressed (P<0.001).

Conclusions

Earlier closing in the autumn increases winter LER and LAR. However, these decline rapidly during the winter and LSR continues at a higher level throughout winter than in later closed swards. Leaf extension and leaf appearance increase towards the end of the winter and as a result LSR increases as there is a greater quantity of green leaf material available to senesce. Closing swards before early September in the northeast and before the 20 September in the south results in the accumulation of large quantities of dead material in the sward, due to high LSR, as the winter progresses. This dead and ageing material has a lower photosynthetic capacity then new leaf material and so potential sward production is reduced. Low LAI at the end of the winter, as a result of large quantities of dead material and reduced tiller numbers, reduces the potential for early spring growth.

Experiment 3. Manipulation of grass supply by altering nitrogen application pattern

Objective

This experiment examined the effect of altering nitrogen (N) application pattern on grass supply under grazing conditions.

Materials and Methods

A perennial ryegrass (*Lolium perenne*) (cv. Spelga) sward was divided into 42 plots (200m^2 each) at Teagasc Grange Research Centre, Dunsany, Co. Meath (lat. 52^0 long. 7^0). There were three annual nitrogen (N) rates (50, 150, 250 kg N ha^{-1}) with two application patterns each with three replicates, set out in two grazing sequences differing in starting dates (first and third week of March), plus a zero nitrogen plot. Plots were grazed every four weeks by non-lactating cows. Cows were conditioned prior to grazing the plots by grazing in 0.4 ha paddocks receiving the same nitrogen application pattern and nitrogen levels as the grazing plots. Pre- and post-grazing herbage mass was determined in each plot by cutting a 5m x 0.55m strip to 0.05m using a lawnmower. The trial extended over three grazing seasons (March 2001 to October 2003). After the initial applications of 0.2 of total N (Table 7), there were two application patterns, regular (R) and irregular (I). The regular application pattern had 0.2 of total nitrogen applied at each of the second and third grazing, followed by 0.1 at each of the next four grazing. No nitrogen was applied at the second and third grazing in the irregular application pattern, after which there were four applications of 0.2 each of total nitrogen. Nitrogen was applied as calcium ammonium nitrate (CAN). Plots received phosphorus and potassium each March in the form of 100kg/ha of 0:10:20. Tiller density was measured in March, June and September by removing 4 turves (10 cm x 10 cm) from each plot and the species of each tiller was identified and counted.

Data for each month was pooled and analysed as a randomised complete block design for nitrogen application pattern with nitrogen level as a split plot on nitrogen application pattern and year as a split plot on N level.

Table 8. Nitrogen application pattern

		Proportion N applied	
Grazing	**Month**	**Regular**	**Irregular**
1	March	0.2	0.2
2	April	0.2	0.0
3	May	0.2	0.0
4	June	0.1	0.2
5	July	0.1	0.2
6	August	0.1	0.2
7	September	0.1	0.2

Results

There was no significant interaction between N application pattern, N level and year on herbage removed from the plots by grazing (Table 9). The higher removal of herbage from plots receiving the higher levels of N fertiliser reflects the higher pre-grazing DM yields on these plots. Altering the distribution pattern of N applied did not have a significant effect on annual DM production ($P<0.1$). This agrees with data reported by Frame (1992) from a study carried out in the west of Scotland.

The grass growth rate was reduced in period 1 and increased in period 2 on the plots receiving the irregular N application (Fig. 1). Grass growth was reduced by an average of 8 kg DM/ha/day in period 1 and increased by an average of 5 kg DM/ha/day in period 2. Overall grass growth for the three years was reduced by 0.7 kg DM/ha/day on the plots receiving the irregular N application pattern. There was no significant effect of N application pattern on growth rate over the grazing season (P>0.1).

Table 9. Herbage removed by grazing (kg DM/ha) on plots receiving regular N application (R N) and irregular N application (I N) for period 1 (April to June), period 2 (July to October) and for the grazing season.

		Period 1		**Period 2**		**Total**	
	kg N/ha	**R N plots**	**I N plots**	**R N plots**	**I N plots**	**R N plots**	**I N plots**
	50	2975	2688	2860	3175	5836	5863
Year 1	150	4544	4082	4114	4791	8658	8873
	250	5746	4548	5006	4987	10753	9535
	50	1444	1447	2735	3500	4178	4947
Year 2	150	1928	2495	3125	3427	5053	5922
	250	3039	3284	4118	3953	7157	7237
	50	2546	1132	2966	2200	5512	3332
Year 3	150	2470	3009	3163	3414	5632	6423
	250	4498	2704	3476	3369	7974	6074
s.e.		313		581		651	
N Application Pattern (A)		n.s.		n.s.		n.s.	
N Level (B)		***		*		***	
Year (C)		***		*		***	
A x C		**		n.s.		n.s.	
A x B x C		n.s.		n.s.		n.s.	

Table 10. Average herbage (kg DM/ha) removal for year 1 and 2 adjusted to organic matter content

	Period 1		Period 2		Total	
kg N/ha	**R N plots**	**I N plots**	**R N plots**	**I N plots**	**R N plots**	**I N plots**
50	2101	1942	2815	3304	4917	5247
150	3049	3112	3593	4109	6642	7220
250	4058	3647	4496	4505	8554	8153
s.e.	151		382		270	
N Application Pattern (A)	n.s.		n.s.		n.s.	
N Level (B)	*		*		*	
A x B	n.s.		n.s.		n.s.	

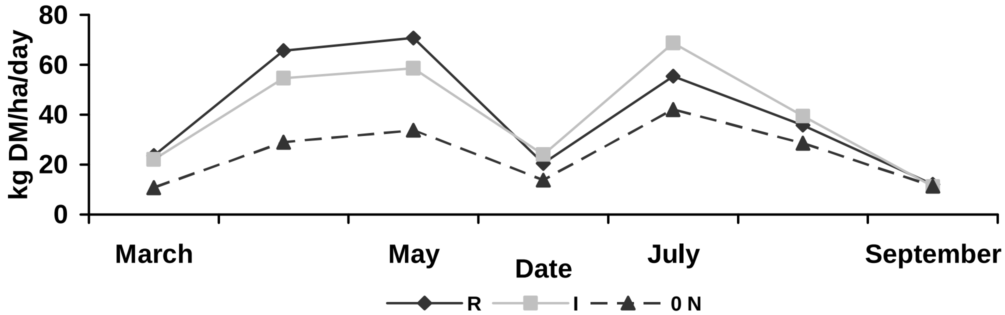


Fig. 1. Average Grass growth curve on plots receiving regular N application pattern (R), irregular N application pattern (I) and zero N (0N).

Conclusions

Although variable between years, this study demonstrates that the grass growth curve can be manipulated by altering the distribution pattern of nitrogen fertiliser during the growing season. Altering the nitrogen application pattern will help to improve synchrony between grass supply and feed demand without significantly affecting annual DM yield on grassland farms at low stocking rates (<2 LU/ha).

Experiment 4. The effect of altering nitrogen application pattern on DM yields and tiller production in a perennial ryegrass sward at two sites

Objective

The objectives of this experiment were (1) to examine the effect of altering the nitrogen application pattern on dry matter yields in a perennial ryegrass sward under a cut plot regime at two sites; and (2) to examine the effect of altering the nitrogen application pattern on the contribution of tillers to DM yield during the spring and early summer.

Materials and methods

A perennial ryegrass sward (*Lolium perenne*) (cv. Spelga) was divided into 28 plots (5m x 2m) at two sites, Grange Research Centre and Moorepark Research Centre in 2002 and 2003. There were 7 treatments replicated 4 times, set out in 2 cutting sequences. There were 3 N levels (50, 150, 250 kg DM/ha) applied in two application patterns (regular) and (irregular) (Table 7) plus a zero N plot. Nitrogen was applied as calcium ammonium nitrate (CAN). Herbage mass was measured every four weeks by cutting a strip (5m x 1.2m) to 5.5 cm using an Agria mower and calculating DM yield as described in experiment 1. There were two starting dates per centre (1st and 3rd week of March at Moorepark, and 2nd and 4th week of March at Grange), with two replicates at each starting date. Tiller density was measured in March, June and September by removing three turves (10 cm x 10 cm) from each plot. The species of each tiller in each turve was identified and counted. A different location at each site was used for each year. In year one 20 stand-alone tillers were marked in each plot using coloured plastic coated wire. Single tillers were randomly selected at 0.15m intervals along a 1.5m transect at two random locations within each plot. Prior to each cutting for herbage mass, the marked tillers were cut with a scissors, grouped together, dried and weighed. As new tillers appeared, they were marked with a different colour, cut and grouped together in their different appearance categories, and dried and weighed to give to the contribution of each tiller category to the dry matter mass of the swards in each rotation. At each cutting, recordings were made of new tiller appearance and of tiller death and the cause of tiller death. Tiller death due to cutting a reproductive tiller was determined retrospectively, as reproductive tillers will not re-grow after cutting if the apex is removed. In year two, thirty perennial ryegrass tillers were labelled in each of the 0N, 250 R and 150 I plots in the first cutting sequence in December. The tillers were labelled using coloured plastic coated wire. Any daughter tillers present were labelled with a different colour and classed as advanced or new based on number of leaves – new tillers have no leaves or one fully expanded leaf. Tillers were randomly selected at 0.15 m intervals along a 1.5m transect at two random locations within each plot. These tillers were left over the winter. Prior to cutting in March, the labelled tillers were cut with a scissors to 5.5cm, grouped according to their marker colour, dried and weighed. New tillers were labelled as they appeared with a different coloured wire, cut to 5.5cm, dried and weighed. This was repeated at each cutting date until heading had occurred. At each cutting, recordings were made of new tiller appearance, tiller death and cause of tiller death.

Data were pooled from the two cutting sequences and analysed as a randomised complete block design for nitrogen level with nitrogen application pattern as a split on nitrogen level.

Results

Year 1

Table 11. Dry matter yields (kg DM ha^{-1}) on plots receiving regular (R) and irregular (I) N application pattern at Grange and Moorepark in year 1

	Grange			Moorepark		
Treatment	**Period 1**	**Period 2**	**Total**	**Period 1**	**Period 2**	**Total**
50 R	5646	6038	11684	5110	3741	8850
50 I	5315	6653	11968	4490	3554	8044
150 R	7263	7396	14659	6579	4642	11221
150 I	5315	8334	13649	4840	5148	9988
250 R	7636	8022	15657	7274	4935	12209
250 I	5814	9561	15374	5300	5438	10737
0 N	5089	5259	10348	4243	3642	7886
s.e.	238	142	295	209	323	477
Treat	***	***	***	***	**	***

Table 12. Dry matter yields (kg DM/ha) on plots receiving regular (R) and irregular (I) nitrogen application patterns for period 1 (March – June), period 2 (July - October) and total DM yield at Grange and Moorepark in year 1.

	Grange				Moorepark			
	Regular	**Irregular**		**F value**	**Regular**	**Irregular**		**F value**
Period 1 (Mar – June)	5897	4659	(-0.21)	***	4674	3250	(-0.30)	***
Period 2 (July – Oct)	7152	8183	(+0.14)	***	4439	4713	(+0.06)	n.s.
Total	13048	12842	(-0.02)	n.s.	9113	7963	(-0.13)	n.s.

Table 13. Dry matter yields (kg DM/ha) on plots receiving regular and irregular nitrogen application patterns of 50, 150 and 250 kg N/ha for period 1 (March – June), period 2 (July - October) and total DM yield at Grange and Moorepark in year 1.

		Period 1		**Period 2**		**Total**	
	Kg N/ha	R N	I N	R N	I N	R N	I N
	50	4689	4429	3038	6653	10727	11082
Grange	150	6258	4616	7396	8334	13654	12950
	250	6743	4932	8022	9561	14765	14494
	s.e.	200		163		278	
N application pattern		***		***		n.s.	
	50	3479	2909	3741	3554	7219	6463
Moorepark	150	4934	3234	4642	5148	9577	8382
	250	5609	3606	4935	5437	10544	9044
	s.e.	158		317		392	
N application pattern		***		n.s.		**	

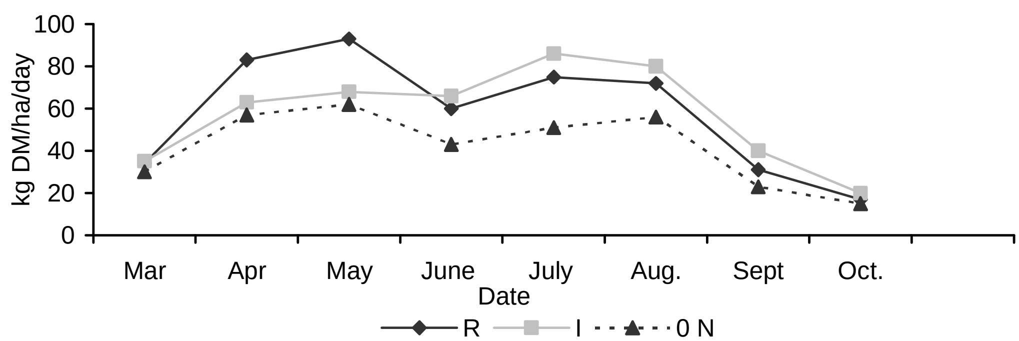


Fig. 2 Grass growth (kg DM/ha/day) on plots receiving 0 N, regular nitrogen application pattern (R) and irregular nitrogen application pattern (I) at Grange in year 1.

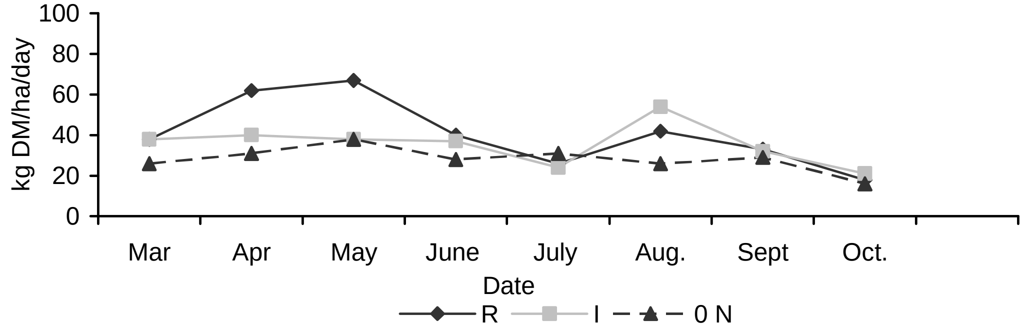


Fig. 3 Grass growth (kg DM/ha/day) on plots receiving 0 N, regular nitrogen application pattern (R) and irregular nitrogen application pattern (I) at Moorepark in year 1.

There was no significant effect of N level or application pattern on the contribution of tillers to DM yield at either site (Fig. 4 and 5). The contribution of tillers to DM yield was only affected by date, with the contribution of the over-wintered tillers decreasing as heading occurred. The over-wintered tillers and those produced in March and April contributed most to DM yield up to July.

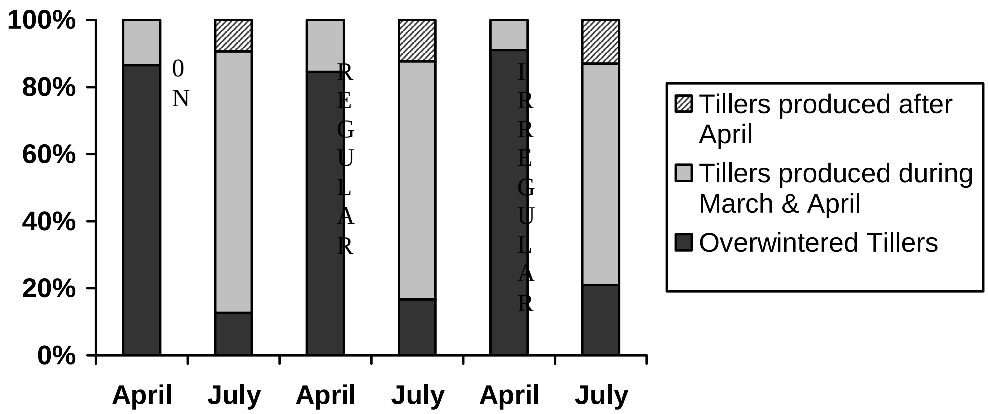


Fig. 4 Contribution of tillers to DM yield at Grange year 1.

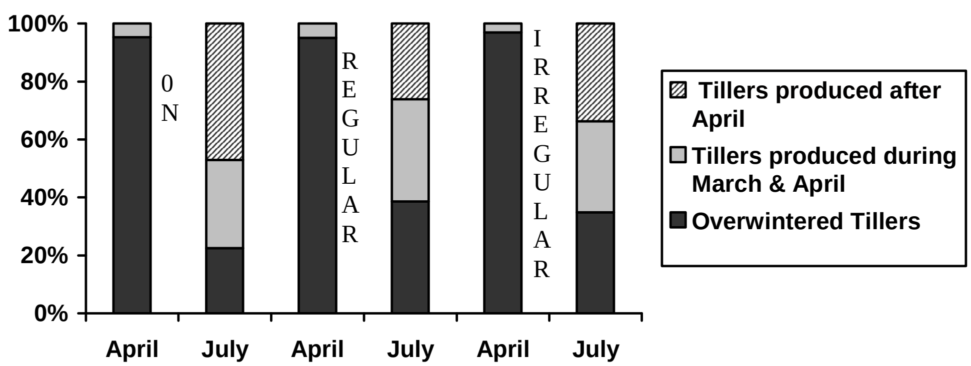


Fig. 5 Contribution of tillers to DM yield at Moorepark year 1.

Year 2

Table 14. Dry matter yields (kg DM/ha) on plots receiving regular (R) and irregular (I) N application pattern at Grange and Moorepark in year 2.

	Grange			Moorepark		
Treatment	**Period 1**	**Period 2**	**Total**	**Period 1**	**Period 2**	**Total**
50 R	3598	4106	7704	2899	2657	5556
50 I	3017	4421	7438	3292	3074	6366
150 R	5105	5705	10810	4101	4110	8211
150 I	3446	5935	9381	2888	4645	7532
250 R	6160	6231	12391	4516	5269	9784
250 I	4362	8534	12895	3682	6113	9795
0 N	2685	3336	6022	3055	2078	5132
s.e.	247	377	507	250	153	360
Treat	***	***	***	**	***	***

Table 15. Dry matter yields (kg DM/ha) on plots receiving regular (R) and irregular (I) nitrogen application patterns for period 1 (March – June), period 2 (July - October) and total DM yield at Grange and Moorepark in year 2.

	Grange				Moorepark			
	Regular	**Irregular**		**F value**	**Regular**	**Irregular**		**F value**
Period 1 (Mar – June)	4954	3608	(-0.27)	***	3838	3287	(-0.14)	*
Period 2 (July – Oct)	5347	6297	(+0.18)	*	4012	4611	(+0.15)	***
Total	10302	9905	(-0.04)	n.s.	7850	7898	(+0.01)	n.s.

Table 16. Dry matter yields (kg DM/ha) on plots receiving regular (R) and irregular (I) nitrogen application patterns of 50, 150 and 250 kg N/ha for period 1 (March – June), period 2 (July - October) and total DM yield at Grange and Moorepark in year 1.

		Period 1		**Period 2**		**Total**	
	Kg N/ha	**R N**	**I N**	**R N**	**I N**	**R N**	**I N**
	50	3598	3017	3961	4249	7560	7266
Grange	150	5105	3446	5465	5672	10569	9117
	250	6160	4362	5964	8185	12123	12547
	s.e.	299		407		642	
N application pattern		***		*		n.s.	
	50	2899	3292	2657	3074	5556	6366
Moorepark	150	4101	2888	4110	4645	8211	7532
	250	4516	3682	5269	6113	9784	9795
	s.e.	286		137		377	
N application pattern		*		***		n.s.	

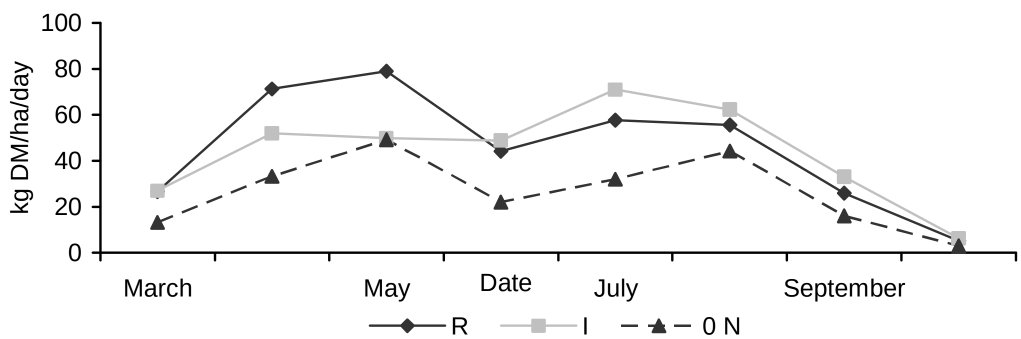


Fig. 6 Grass growth (kg DM/ha/day) on plots receiving 0 N, regular nitrogen application pattern (R) and irregular nitrogen application pattern (I) at Grange year 2.

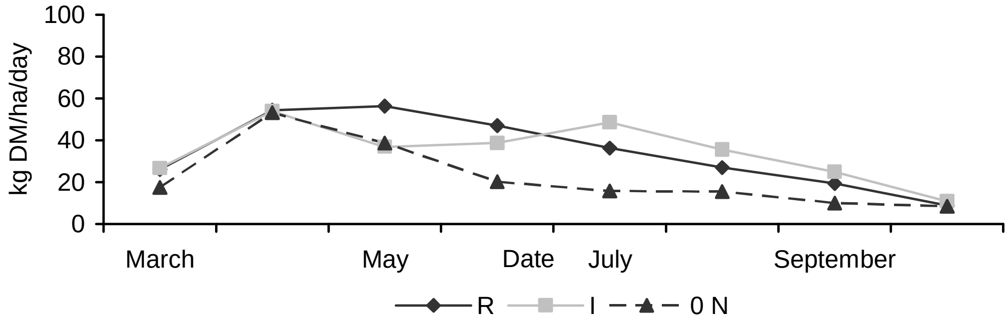


Fig. 7 Grass growth (kg DM/ha/day) on plots receiving 0 N, regular nitrogen application pattern (R) and irregular nitrogen application pattern (I) at Moorepark year 2.

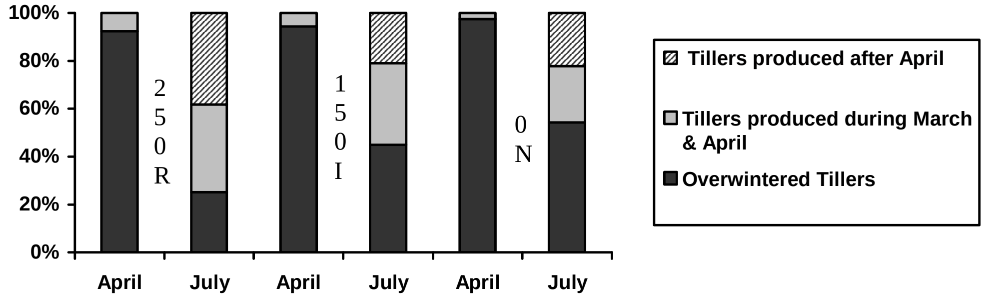


Fig. 8 Contribution of tillers to DM yield on plots receiving regular application of 250 kg N/ha/year (250 R), irregular application of 150 kg N/ha/day (150 I) and zero N (0N) at Grange year 2.

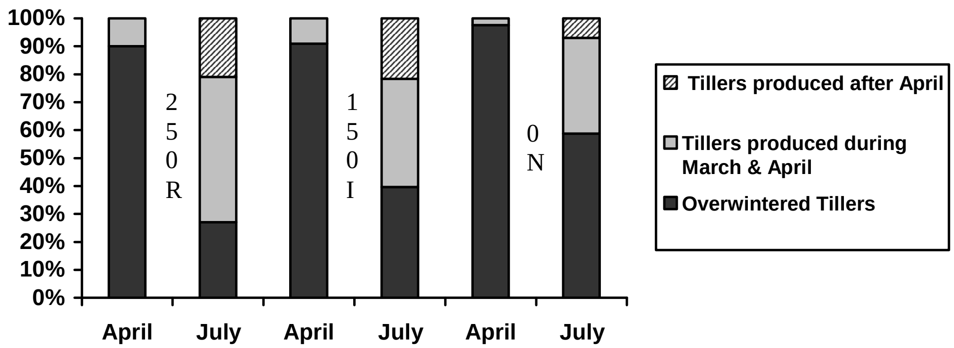


Fig. 9 Contribution of tillers to DM yield on plots receiving regular application of 250 kg N/ha/year (250 R), irregular application of 150 kg N/ha/day (150 I) and zero N (0N) at Moorepark year 2.

As in year one, there was a significant effect of date on the contribution of tillers to DM yield at both sites in year 2. At Grange, there was no effect of treatment on tiller contribution to DM yield but there was at Moorepark (<0.05).

Conclusion

Applying no N fertiliser in April and May and increasing the proportion of total N fertiliser applied from June to September improves the synchrony between the grass growth and feed demand curves. The peak in grass growth in May is reduced and grass growth is increased in the second part of the year. Overall, altering the N application pattern did not significantly reduce annual DM herbage production. Altering the N application pattern did not affect the crude protein content or the dry matter digestibility of the sward under cut plot or grazing systems.

Tillers present in the sward in March contribute most to the DM yield up to May after which March and April appearing tillers make up the greatest proportion of DM yield. The contribution to DM yield of tillers appearing after April is less than 0.25 of DM yield in July.

Tillers produced the previous autumn are most likely to be reproductive during the following spring. Some tillers produced after the months with temperatures considered suitable for floral induction are reproductive. The survival rate to September of tillers present in the sward in March is low, as most of these tillers are reproductive.

Experiment 5. Modelling winter grass growth and senescence

Introduction

Most grass growth models deal with the main grass growing season (March to October in the N Hemisphere), with little emphasis on grass growth during the winter (November to February), as net grass growth during the winter is low in temperate climates. However, tissue is continuously turning over (Hennessy *et al*., 2004) and the fate of herbage entering the winter is important in extended grazing season systems. The objective of this study was to model winter grass growth for a range of autumn closing dates (1 September, 20 September and 10 October) for the period 15 October 2001 to 28 January 2002, by modifying an existing model, so that the amount of green leaf could be predicted at intervals over the winter.

Materials and methods

The model of Johnson and Thornley (1983) was selected for modification. This is a vegetative grass growth model incorporating leaf area expansion and leaf senescence. The model suited the requirements of this study as it characterises leaves according to age (in line with tissue turnover concepts) and it was designed for an established vegetative grass crop supplied with unlimited nutrients and water. In winter, in Ireland, water and nutrients are generally not limiting and tillers are mainly vegetative. Mean daily air temperature and radiation are inputs to the model as are initial leaf area index (LAI) and DM weight of leaf in each age category. The model was run in Excel. As data was available from two sites, the data for tissue turnover from one site, Grange, Co. Meath, were used to develop coefficients to modify the model, while data from the second site, Moorepark, Co. Cork, were used to test the model. The output was prediction of leaf area index at intervals over the winter. Inputs to the model were daily meteorological data for the experimental period and latitude for the site, and initial lamina and sheath weight per unit area and LAI on the 15 October. The coefficients for leaf appearance rate (LAR) of the youngest leaf and leaf senescence rate (LSR) of the second and third youngest leaves were derived from data at Grange, based on the relationship between measured LAR or LSR of the second and third youngest leaves and temperature, by varying these coefficients and running the model until the output was similar to the actual LAI for each of the closing date treatments at Grange. The output of the modified model was tested against actual LAI measured at the Moorepark site. Measured and predicted LAI were compared using mean squared prediction error (MSPE). Mean prediction error (MPE) was also calculated.

Results

The trends in LAI predicted by the model for Moorepark at intervals during the winter for a range of autumn closing dates were generally quite close to those recorded in the experiment, including the rapid decline in LAI in the earlier closing date treatments (Table 17). In instances when the differences between actual and predicted were marked, they were short lived e.g. on 5 November on the two earlier closing treatments. A possible explanation for the marked differences on 5 November is that the model is slightly over predicting LSR at the end of October/start of November, as autumn moves into winter.

Table 17 Measured and predicted LAI over the winter for 3 closing dates for Moorepark (the validation site)

Closing Date	**1 September**		**20 September**		**10 October**	
	Measured LAI	Predicted LAI	Measured LAI	Predicted LAI	Measured LAI	Predicted LAI
5 Nov	5.47	4.14	4.02	2.76	2.82	2.11
26 Nov	2.98	3.37	3.61	2.72	2.53	2.61
17 Dec	2.35	2.67	2.61	2.46	2.34	3.04
7 Jan	2.23	2.22	2.32	2.20	2.28	3.06
28 Jan	1.36	1.11	1.59	1.26	2.17	2.58

MSPE* = 0.47; MPE = 0.25; R^2 = 0.65; $P<0.05$

*Mean square prediction error

Conclusions This study demonstrates that it is possible to model the flux in green leaf when swards are closed in autumn at a range of dates and at more than one sward state or site. This may be used to form the basis of a winter grass growth model.

Experiment 6. Increasing the quantity of grazed grass in the diet of a spring calving dairy herd stocked at 2 LU ha^{-1}

Introduction

Although the various studies described in this study were undertaken separately, a farming system could be developed to incorporate both the altered N application pattern and winter grazing. A desktop exercise was used to combine the two central concepts in this project (i.e. altered N application pattern and winter grazing) in a feed allowance budget and to examine their potential for use in a spring calving milk production system. The objective of the exercise was to investigate if the quantity of grazed grass in the diet of the dairy cow could be increased on farms with low stocking rates (<2 LU ha^{-1}) by using the combined effect of autumn grass accumulation and deferred nitrogen application strategy. A feed allowance budget (O'Donovan, 2000) was modified for a spring calving dairy herd (2 LU ha^{-1}) to include the altered grass growth curve (Experiment 4) and increased autumn rotation lengths (Experiment 1).

Materials and Methods

Two feed allowance budgets, conventional and modified, were devised for a spring calving dairy herd stocked at 2 LU ha^{-1}. Concentrate feeding levels remained constant in both systems and were fed from calving (1^{st} Feb.) until mid-April and from October to drying-off. The average grass growth rates on swards receiving 150 kg N ha^{-1} $annum^{-1}$ regularly or irregularly at Grange (Hennessy *et al.*, (2004a) were used in the conventional and modified feed allowance budgets, respectively. The conventional budget was based on current recommendations, including the housing of livestock from early November. The modified feed budget included grass in the diet until the end of December, cows were housed in January only and went to grass at calving.

Results

The conventional and modified feed allowance budgets are shown in Fig. 10. Both systems supply enough silage to meet their feeding requirements. Table 18 shows the spring turnout and winter housing dates, quantities of silage conserved, and the quantities of grass, concentrates and silage fed in the two different systems and the differences between the two.

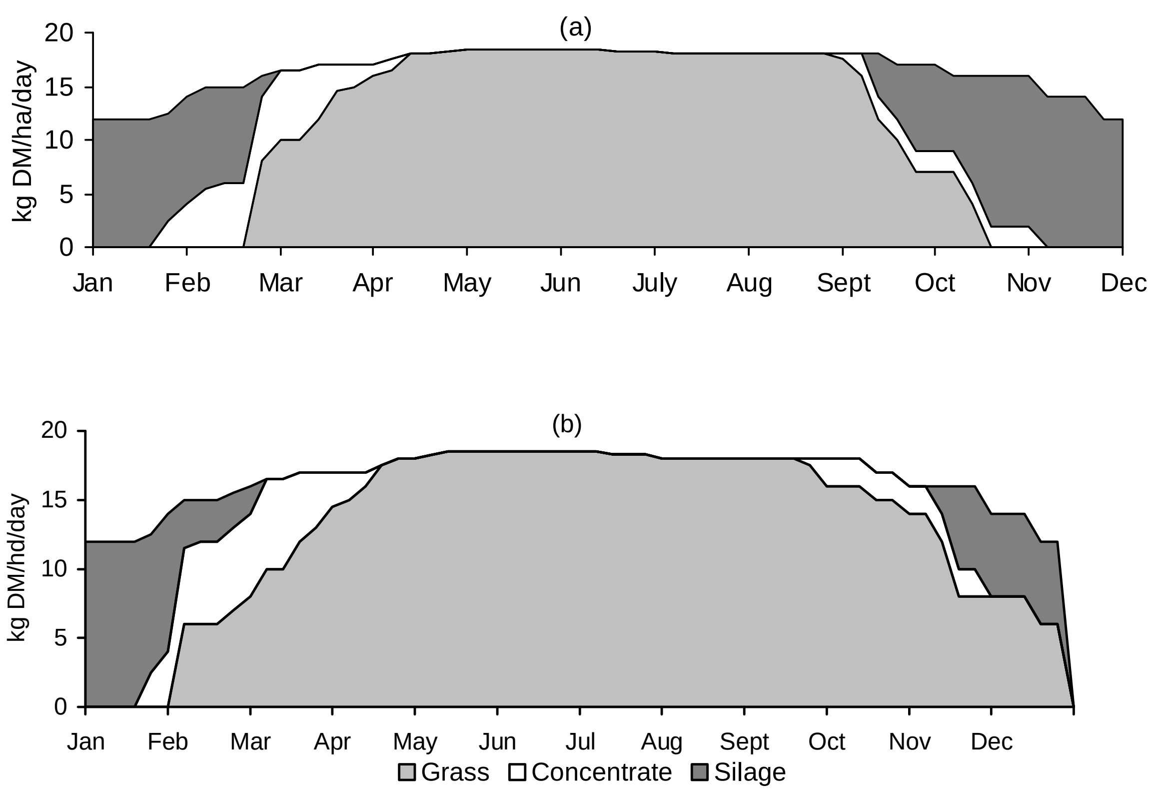
Table 18. Allowance of grass, concentrates and silage (t DM ha^{-1}) in a conventional and a modified dairy system on a 50 ha farm.

	Conventional	Modified	Difference
Stocking Rate	2 LU ha^{-1}	2 LU ha^{-1}	
Turnout	mid-Feb.	start Feb.	3 weeks
Housing	early Nov.	end Dec.	6 weeks
Silage conserved (t DM ha^{-1})	3.7	2.1	1.6
Grass (t DM LU^{-1})	4.0	4.8	0.8
Silage (t DM LU^{-1})	1.6	0.8	0.8
Conc. (t DM LU^{-1})	0.5	0.5	0.0

Conclusions

The modified feed allowance budget shows that it is possible to graze dairy cows for up to 11 months at low stocking rates (<2 LU ha^{-1}). For dairy farmers operating an extensive production system extended grazing *in-situ* in late autumn and into the winter may reduce feeding costs in terms of silage requirements and some overhead costs such as slurry storage and disposal.

Fig. 10 Feed allowance budgets for a spring calving dairy herd stocked at 2 LU ha^{-1} in (a) a conventional system and (b) a modified system receiving reduced N application in spring and increased N application from June to September, with increased rotation lengths from September.



Acknowledgements

The authors wish to acknowledge the contribution of many people to the project summarised in this report. At Grange our thanks are due to Pat Collins and other technical staff; staff in Grange Laboratories; Gerry Santry and Francis Collier; Pat Whelan and all the farm staff. At Moorepark our thanks are due to Flor Flynn, Joe Dwyer, Jim Nash, Mick Feeney and all the farm staff. Thanks are also due to research colleagues at Grange and Moorepark.

References

Brereton A.J. (1995) Regional and year-to-year variation in production. In: Irish grasslands – their biology and management. Eds. Jeffery D.W., Jones M.B. and McAdam J.H. Royal Irish Academy, Dublin

Frame J. (1992) Chapter 11. *Improved Grassland Management*, Farming Press Books, Ipswich, UK, pp. 101-118.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004a). The effect of altering nitrogen application pattern on the grass growth curve. In: Proceedings of the Agricultural Research Forum 2004, pp. 45.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004b). Effect of closing date and grazing date on winter DM yield and subsequent DM production. In: Proceedings of the Agricultural Research Forum 2004, pp. 89.

O' Donovan, M. (2000) The relationship between the performance of dairy cows and grassland management on intensive dairy farms in Ireland. Ph.D Thesis. The National University of Ireland.

Publications (to date from study 4)

Hennessy D., O'Donovan M., French P. and Laidlaw P. (Accepted) The effects of date of autumn closing and timing of winter grazing on herbage production in winter and spring. Grass and Forage Science.

Hennessy, D. (2005) Manipulation of Grass Supply to Meet Feed Demand of Beef Cattle and Dairy Cows. Ph.D. Thesis. The Queens University Belfast.

French, P and O'Donovan M. (2002). Winter grazing of autumn grown grass at two sites: effect of closing date and grazing date. In: Proceedings of the Agricultural Research Forum 2002, Tullamore. pp. 38.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2003). Effect of closing date on leaf extension rate and leaf appearance rate. In: Proceedings of the Agricultural Research Forum 2003, Tullamore. pp. 22.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2003). Grass Growth Curve Manipulation. In: Proceedings of the 7th Research Conference of the British Grassland Society, University of Wales, Aberystwyth, 1st – 3rd September 2003. pp27-28

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004). Effect of closing date and grazing date on winter DM yield and subsequent DM production. In: Proceedings of the Agricultural Research Forum 2004, Tullamore.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004). The effect of altering nitrogen application pattern on the grass growth curve. In: Proceedings of the Agricultural Research Forum 2004, Tullamore.

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004). Manipulation of grass growth by altering nitrogen application. EGF 2004

Hennessy, D., French, P., O'Donovan, M. and Laidlaw, S. (2004). Tissue turnover during the winter in a perennial ryegrass sward. EGF 2004

Hennessy, D., O'Donovan, M., Laidlaw, S. and French, P. (2005) Increasing the quantity of grazed grass in the diet of a spring calving dairy herd stocked at 2 LU ha^{-1}. Proceedings of the Agricultural Research Forum 2005, Tullamore, pp. 111.

Hennessy, D., Laidlaw, S., O'Donovan, M. and French, P. (2005) Modelling winter grass growth and senescence. XX International Grassland Conference 2005, Dublin. pp.872.

Hennessy, D., Laidlaw, S., O'Donovan, M. and French, P. (2005) Modelling winter grass growth and senescence. Proceedings of a satellite workshop of the XXth International Grassland Congress, July 2005, Cork, Ireland. pp. 197.

Hennessy, D., O'Donovan, M., French, P. and Laidlaw, S. (2006). Effects of closing date and grazing date on *Lolium perenne* tiller density. Proceedings of the Agricultural Research Forum 2006, Tullamore. PP 114.

Hennessy, D., O'Donovan, M., French, P. and Laidlaw, S. (2006). Altering nitrogen fertilizer application strategy: effects on herbage crude protein content and dry matter digestibility. British Grassland Society 8th Research Conference 4-6 September 2006, Royal Agricultural College, Cirencester, England.