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MAXIMIZING ANNUAL INTAKE OF GRAZED GRASS FOR BEEF PRODUCTION

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1. SUMMARY

1.1. Introduction

Grass is by far the most important crop grown in Ireland. Well-managed grassland supports high levels of animal performance, and the production of high quality produce. Grazed grass is a relatively cheap feed source for beef production (O'Kiely, 1994). Grazed grass does not always match feed requirements in efficient beef production systems. Supply tends to exceed demand in the late spring and summer whereas deficiencies in feed supply occur in late autumn and during the winter and early spring. The objective of the present series of experiments was to examine the potential to increase the utilization of grazed grass in beef production systems. There are two aspects to this: one relates to the utilization of grass *in situ;* the second relates to the strategic approach to grass utilization, i.e. matching feed requirements with supply of grazed grass and silage conservation during the year.

The first two experiments presented in this report examine the utilization of grass *in situ*. The effects of pre-grazing pasture mass and nitrogen (N) fertilization on the production and subsequently the utilization and digestibility of the grass under grazing by cattle were examined. A third experiment and examines the effect of pre-grazing pasture mass on performance of beef cattle during a grazing season. The fourth experiment investigates the role of perennial ryegrass cultivars in supplying grass for grazing during the spring, and for the production of high nutritive value first cut silage.

1.2. Experiments 1 and 2: The effect of nitrogen fertilizer and pasture mass on the intake of grazed grass

The accumulation of grass dry matter (DM) is inversely related to the frequency of defoliation and positively related to applied N. The objective of the present two experiments was to investigate the effect of pre-grazing pasture mass and N fertilization on the utilization of grass by grazing animals. The first experiment was carried out in 1997. It included three N application levels (100, 250 and 400 kg N ha^{-1}) and four target pre-grazing pasture masses (1000, 2000, 3000 and 4000 kg DM ha^{-1}) arranged in a randomized complete block design replicated four times. The second experiment, in 1998 included four levels of N fertilization (0, 88, 166 and 250 kg N ha^{-1}) and two target pre-grazing pasture masses (2000 and 4000 kg DM ha^{-1}) arranged in a randomized complete block design replicated four times. Heifers (350-500 kg live-weight) were assigned at random to plots, receiving a pasture allowance (available pasture DM above 4 cm) of approximately 2% of live weight per 24 hours, for a pre-determined time period of between 24 and 48 hours. Plots were repeatedly grazed between early April and late October in both experiments. Pasture mass was measured pre- and post-grazing. The difference between these two measurements was taken as the level of intake achieved. Increasing pre-grazing pasture mass at each grazing within the range of 2000 kg DM ha^{-1} to 4000 kg DM ha^{-1} increased the quantity of grazed pasture digestible organic matter (DOM) ha^{-1} year^{-1} by approximately 20% in both experiments. Within the above range (common to both experiments) annual yield increased from a mean of 8600 kg DOM ha^{-1} year^{-1} to 10600 kg DOM ha^{-1} year^{-1}. Increasing pre-grazing pasture mass at each grazing also increased the percentage utilization of pasture DM on offer above 4 cm in both experiments. Utilization of pasture was approximately 57% of pre-grazing mass where swards were grazed at 2000 kg DM ha^{-1} increasing to 74% of pre-grazing mass where swards were grazed at 4000 kg DM ha^{-1}. In general there were no clear differences in the organic matter digestibility (OMD) of the pasture on offer above 4 cm. Swards that were grazed at 2000 kg DM ha^{-1} had an average OMD of 770 g kg^{-1} compared an average of 769 g kg^{-1} on swards grazed at 4000 kg DM ha^{-1} throughout the grazing seasons in both experiments. Increasing pre-grazing pasture mass resulted in decreasing crude protein concentration in the pasture on offer above 4 cm. Combining both experiments, crude protein concentrations in pasture DM declined from a mean of 248 g kg^{-1} in swards grazed at

2000 kg DM ha^{-1} to 224g kg^{-1} in swards grazed at 4000 kg DM ha^{-1}. Increasing pasture mass increased N offtake in grazed pasture in the experiment conducted in 1997 but not in the experiment conducted in 1998. Increasing N fertilization increased the quantity of grazed pasture DOM ha^{-1} $year^{-1}$ in both experiments, although this trend was clearer in the experiment conducted in 1998 than in the experiment conducted in 1997. Increasing N fertilization had no clear effect on the OMD of pasture on offer above 4 cm in both experiments. Increasing N fertilization increased the crude protein concentration in the pasture on offer above 4 cm in both experiments. Increasing N fertilization increased N offtake in grazed pasture in both experiments.

1.3. Experiment 3: The effect of pre-grazing pasture mass on the performance of beef cattle

Swards with a pre-grazing pasture mass of over 2500 kg DM ha^{-1} (above 4 cm) are not generally recommended for beef cattle. The objective of the present experiment was to examine the performance of beef cattle grazing two target pasture masses of 2000 kg and 3500 kg DM ha^{-1}. There were two replications per treatment. Twenty-one ha of grassland was divided into 84 paddocks of 0.25 ha each in spring 1998 and 42 were then assigned to each replication. Twenty-one of these were then randomly assigned to the two treatments within each replication. Sixty-eight steers with a mean live-weight of 479 kg were weighed off silage on two consecutive days. These were paired on the basis of source, weight, breed and age. One of each pair was then randomly assigned to each treatment. The cattle were turned out to pasture on 18 March and grazed through to 2 November. Pre- and post-grazing pasture mass (harvested to 4 cm) were measured weekly. Surplus grass was removed from both treatments and recorded. Mean pre-grazing yields during the experiment were significantly ($P \leq 0.001$) different (2037 v. 3192 kg DM ha^{-1}, s.e. 69.7). There were no significant differences in post-grazing yields (906

v. 850 kg DM ha^{-1}, s.e. 25.7) or heights (6.0 v. 6.2 cm, s.e. 0.07). The higher pre-grazing pasture mass treatment resulted in higher percentage utilization at each grazing during this experiment. There was no difference in the OMD concentration in the DM of pasture on offer above 4 cm between treatments in this experiment. Similar quantities of surplus grass were removed from both treatments (3310 v. 3544 kg DM ha, s.e. 151). High levels of animal performance were recorded in this experiment: mean of 236 kg live-weight gain per animal over a 225 day grazing season. There were no significant differences in cattle live-weight gains, carcass weights (388 v. 385 kg, s.e. 2.9), kill out percentage (~ 54%), carcass conformation score (~ R) or carcass fat score (~ 5). The absence of any difference in animal performance indicates that a wide range of pre-grazing pasture masses are suitable for beef cattle.

1.4. Experiment 4:
Effects of perennial ryegrass cultivar mixture on grazed grass supply in spring and on first-cut silage

Harvesting grass close to its mean heading date is an important aspect of making high-digestibility silage. Typically, in Ireland, re-seeded swards tend to be composed of intermediate-heading perennial ryegrass cultivars, and the aim is to ensile highly digestible grass in mid- to late-May. There are now a number of late-heading perennial ryegrass cultivars with heading dates close to mid-June. Their use could allow adequate yields of grass to accumulate between grazing in spring and a harvest date in mid-June, thereby providing an opportunity to maintain silage quality and reduce production costs. However, late-heading cultivars are generally associated with the production of relatively low grass yields in the early spring compared to the best intermediate-heading cultivars. Thus, they might not be suitable for early grazing. The objective of the present experiment was to examine the potential to optimize the yields of grass for spring grazing and the yield and quality of first-cut silage by using a new strategy of late-heading ryegrass cultivars and delaying silage harvest until mid-June.

This was a 4 factor experiment with 2 (grass cultivar type) x 3 (spring grazing options) x 4 (silage harvest date) x 2 year, (1998 and 1999) , factorial arrangement of treatments within a randomized complete block design, with four replications. There were two perennial ryegrass mixture treatments: intermediate-heading vs. late-heading cultivars. The intermediate-heading cultivars used were Respect, Spelga and Napoleon (heading dates between 21 - 24 May; spring growth index ~ 131). The late-heading cultivars were Tivoli and Condesa (heading dates between 9 - 10 June; spring growth index ~ 101). There were three spring grazing treatments: (1) no grazing, (2) grazed once in the spring, and (3) grazed twice in the spring. Swards were grazed, to a stubble height of 6 cm, as soon as target pasture masses had accumulated on relevant treatments. The first grazing was taken at a pre-grazing pasture mass of approximately 1200 kg DM ha^{-1} and took place on a mean date of 16 March across years. The second grazing was taken at approximately 2000 kg DM ha^{-1} and took place on a mean date of 21 April across years. Pre- and post-grazing harvests were taken to a height of 4 cm using a lawn mower. Pasture samples were analyzed for OMD in both years. There were four silage harvest dates (mean dates across years were 20 May, 30 May, 9 June and 19 June). Plots were harvested to a height of 5 cm using a Haldrup. Grass harvested for silage was analyzed for DM digestibility (DMD) in 1999 only.

Perennial ryegrass cultivar mixture had no significant effect on pre-grazing mass of DM or organic matter (OM) on offer to cattle at the first or second grazing in the spring. These results are in accord with Brereton and McGilloway (1999). There was a significant ($P < 0.001$) interaction between cultivar mixture and year on the OMD of pasture on offer during the first grazing with higher OMD on offer for the late heading cultivars (764 vs. 793 g kg^{-1}) in 1998 but not in 1999 (818 vs. 818 g kg^{-1}) s.e. = 3.7 g kg-1. However, the OMD of pasture on offer during the second grazing was not significantly different between cultivar mixtures across both years (817 vs. 822 g kg^{-1}; s.e. = 2.9 g kg^{-1}). Yields of grass for silage were affected by a significant ($P < 0.01$) interaction between perennial ryegrass cultivar mixture, spring grazing treatment, silage harvest date and year. Swards that were not grazed in the spring had higher yields of grass for ensiling than swards that were grazed once and the latter swards had higher yields than swards that were grazed twice. Silage yields tended to increase substantially with delayed harvest date. Generally speaking, the late-mixture tended to have lower yields of grass for ensiling than the intermediate-mixture at a given silage harvest date. The DMD of grass harvested for ensiling was affected by significant interactions between cultivar and spring grazing ($P < 0.05$) and between cultivar and silage harvest date ($P < 0.001$). In general, the late heading cultivars had higher DMD than the intermediates, especially with increased grazing frequency in the spring. In both mixtures, the DMD of grass increased with increased grazing frequency in the spring. Furthermore, in both mixtures, the DMD declined with later silage harvest date, the rate of decline being more pronounced for the intermediate mixture.

If both sward types were not grazed in the spring, harvesting the late swards 10 days later than the intermediate swards resulted in grass yields (between 7.0 and 9.2 t DM ha^{-1}) and DMD (between 768 and 756 g kg^{-1}) that were similar, if not higher, than grass yields (between 6.2 and 8.0 t DM ha^{-1}) and DMD (between 769 and 738 g kg^{-1}) of intermediate swards harvested between 20 and 30 May. If swards composed of late-heading cultivars were grazed once in the spring, delaying silage harvest date by 20 days resulted in similar grass yields (between 6.2 and 8.2 t DM ha^{-1}) of similar DMD (between 796 and 747 g kg^{-1}) as swards composed of intermediate cultivars, not grazed in the spring and harvested for silage between the 20 and 30 May (see above). Grazing silage ground twice in the spring greatly reduced grass DM yields for silage even where the harvest date was deferred until 19 June. Grazing silage swards composed of late-heading cultivars twice in the spring and harvested for silage on 19 June will resulted in higher first-cut silage making costs compared to swards composed of intermediate-heading cultivars, ungrazed in the spring and harvested for silage on 20 May. Nevertheless, grazing silage swards composed of late-heading cultivars twice in the spring supplies substantial quantities of high-quality grass during a period when there is risk of grass shortage on the farm. When this is taken into account, the overall costs involved in grazing silage swards composed of late-heading cultivars twice in the spring and harvested for silage on 19 June are unlikely to be substantially different from swards composed of intermediate swards, not grazed in the spring, harvested for silage on 20 May and grazed subsequently in late June. Furthermore, grazing the late-heading cultivars in the spring is also likely to improve overall animal performance. From an overall systems point of view, there are very clear advantages associated with having late-heading cultivars (heading date close to mid-June) on farms where early turnout to grass is seen as a priority.

2. Experiment 1: The effects of pasture mass and nitrogen fertilizer on pasture intake by grazing cattle

2.1. Introduction

Nitrogen (N) dominates plant nutrition. No nutrient is needed in larger quantities and, in most environments, no nutrient is in such limiting supply (Grindlay, 1997). Therefore the timely application of N fertilizer is usually the most effective means of substantially increasing grass production on grassland farms (Browne, 1966; Ryan, 1974; Le Clerc, 1976; Murphy, 1977; McFeely, 1978; van Burg *et al.*, 1981; Bahmani *et al.*, 1998; Hemingway, 1999). In a study of grass DM production responses under cutting on 26 sites around Ireland, Ryan (1974) showed that, on average on all soils, there was little worthwhile response from N levels in excess of 310-336 kg N ha^{-1}. However, Ryan et al. (1984) pointed out that levels of response to, and recovery of, N under cutting are not applicable to those that are intensively grazed. On one hand, the grazing animal can reduce pasture production and utilization by (1) causing damage to the sward by treading and poaching and (2) fouling of the sward by deposition of excreta as faeces and urine (Wilkins and Garwood, 1986). Smell initially from fresh faeces and then from decomposition products cause rejection of the pasture by the grazing animals. This may be succeeded by secondary effects through the maturation and fall in nutritive value and acceptability of the pasture growing in areas where it was originally rejected because of smell (Marsh and Campling, 1970). On the other hand, substantial quantities of nutrients are recycled annually in dung and urine. For example, Haynes and Williams (1993) pointed out that, in an intensively grazed pasture, approximately 100 kg N ha^{-1}, 38 kg K ha^{-1}, 34 kg P ha^{-1} and 14 kg S ha^{-1} are excreted per year in dung. Furthermore, Jarvis *et al*. (1989) demonstrated that even higher quantities in the form of urine with in the region of 200 kg N ha^{-1} year^{-1} being returned to swards receiving 420 kg N ha^{-1} was. Therefore recycled N in dung and urine have the potential to make a substantial positive contribution to the N requirements of pasture depending on circumstances: Deenen and Middelkoop (1992) observed that at lower rates of fertilizer N application, the positive effects of recycled N promoted uptake of N by the sward. However, at very high fertilizer N application rates, the negative effects exerted by grazing animals, such as treading damage, was observed to have a relatively greater impact on production.

Where response to N fertilizer has been examined in grazing experiments, the response to applied fertilizer N tends to be lower than that recorded in cutting experiments (Browne, 1966; Frame and Hunt 1971; Deenen and Lantinga, 1993). For example, in the Netherlands Deenen and Lantinga (1993) examined the responsiveness of grass DM production to annual fertilizer N applications ranging between 0 to 700 kg ha^{-1} under cutting (harvested at four weekly intervals) and under grazing. This experiment was carried out over a three-year period on a sedimentary calcareous silty loam soil reclaimed form the sea for 30 years and under grass for 20 years. They demonstrated that optimum fertilizer N application rate on was approximately 500 kg N ha^{-1} year^{-1} under cutting. However, mean optimum fertilizer N application rate was approximately 310 kg N ha^{-1} year^{-1} under grazing, although there was great variation in optimum application rates between years. In the first year of the experiment, the optimum value was 475 kg N ha^{-1} year^{-1}. In the second the optimum was 160 kg N ha^{-1} $year^{-1}$ and in the third the optimum was 290 kg N ha^{-1} $year^{-1}$. This great variation in responsiveness to N was attributed to differences from year to year in soil N availability, length of the growing season and sward quality. Nevertheless, differences in responsiveness to fertilizer N under cutting compared to grazing were attributed to recycling of excretal N (Deenen and Lantinga, 1993) similar to that noted by Frame and Hunt (1971).

Growth of leaves, in the sward canopy, is a key determinant of plant N demand. The photosynthetic function of leaves requires large quantities of N compared to other tissues of the plant (Novoa and Loomis, 1981). Three quarters of the N in the leaf may be connected with photosynthesis (Field and Mooney, 1986). Nitrogenous components associated with photosynthesis form such a large proportion of N in leaves that there is a relationship between photosynthesis and leaf N content (Evans, 1983; Field and Mooney, 1986). As the canopy expands, the N-use efficiency of the leaf (daily rate of carbon gain per unit N) increases to a maximum. It then begins to decline before the value of leaf N per unit leaf area that maximizes leaf net photosynthesis has been reached, because of the diminishing returns in extra photosynthesis (Hirose and Werger, 1987; Hikosaka and Terashima, 1995). In grazed grassland, where swards are repeatedly defoliated at regular intervals, response to applied fertilizer N will depend on the inter-defoliation interval. Le Clerc (1976) and Wilman and Pearse (1984) have pointed out that longer inter-defoliation intervals give the best responses to applied N, while McFeely (1978) found no interaction between inter-defoliation interval and N application level. In contrast, Holliday and Wilman (1965) showed highest response to applied N with more frequent cutting.

It is important to accurately assess the N requirements of grassland, not just for economic reasons, but also because the risks to the environment from the over-application of N-fertilizers, in particular the problem of nitrate leaching (Addiscott *et al.*, 1991). Most of the comparative work has been in terms of DM production under cutting. A major criticism of this methodology is that swards are not subjected to the animal influence, treading and the return of dung and urine (Gately, 1984). The objective of the present experiment was to investigate the effect of pre-grazing pasture mass and N fertilization on the production and utilization of pasture by grazing animals.

2.2. Materials and Methods

This experiment included three N application levels (100, 250, and 400 kg N ha^{-1}) and four target pre-grazing pasture masses (1000, 2000, 3000 and 4000 kg DM ha^{-1}) arranged in a randomized complete block design replicated four times. Plot size was 15 m x 12 m. Pasture mass on each plot was estimated every three to four days, from 15 March onwards, using a rising-plate meter. As soon as the relevant target pre-grazing pasture mass were achieved heifers were assigned at random to plots. Heifers (350-500 kg LW) were allocated a pasture allowance (available pasture above 4 cm on a DM basis) of approximately 2% of live weight per 24 hours. Heifers remained on the plots for a pre-determined time period of no less than 24 hours and no more than 48 hours. Seven heifers were the maximum number assigned to a plot at any one time. Pasture mass was measured using a lawn-mower pre- and post-grazing (cutting height 4 cm). The difference between these two measurements was taken to be the level of intake achieved. Percentage utilization was calculated as follows:

Utilization (%) = (intake of grazed grass - pre-grazing pasture mass) x 100

2.3. Results

Pre-grazing pasture mass substantially increased the annual intake of grazed pasture in terms of intake of dry matter (DM), organic matter (OM) and digestible organic matter (DOM) although these relationships were each affected by significant interactions with N fertilizer application (Table 1). The effect of N fertilizer on intake of DOM displayed no clear trend within the interaction between N fertilizer application levels and pre-grazing pasture mass.

Table 1. The effect of nitrogen fertilizer and pre-grazing pasture mass on the annual intake of grazed grass in terms of dry matter (DM), organic matter (OM), and digestible organic matter (DOM)

	Target pre-grazing pasture mass (kg DM ha^{-1})							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
			Annual Intake (kg DM ha^{-1})					
100	10176	12892	13625	15419	13028	Mass (M)	***	154
250	10320	12548	14223	16271	13341	Nitrogen (N)	NS	133
400	10695	11688	13584	16291	13064	M x N	*	266
Mean	10397	12376	13810	15994				
			(kg OM ha^{-1})					
100	9320	11709	12147	13927	11776	Mass (M)	***	141
250	9479	11258	12877	14603	12054	Nitrogen (N)	NS	122
400	9850	10357	12625	14625	11864	M x N	**	245
Mean	9550	11108	12550	14385				
			(kg DOM ha^{-1})					
100	7694	9309	9785	11029	9454	Mass (M)	***	117
250	7740	8978	10469	11537	9681	Nitrogen (N)	NS	102
400	8199	8313	10295	11559	9591	M x N	**	203
Mean	7878	8867	10183	11375				

Mean pre-grazing pasture masses over the grazing season were reasonably close to target masses and reasonably consistent across N fertilizer application levels (Table 2). The pre-grazing pasture masses were above target for the 1000 kg DM ha^{-1} treatment. The 1000 kg DM ha^{-1} target was difficult to sustain throughout the grazing season. Mean post-grazing pasture masses throughout the grazing season were affected by a significant interaction where post-grazing masses tended to increase both with increasing pre-grazing pasture mass and with increasing N fertilizer application (Table 2). As with annual intake, mean DM intake at each grazing increased substantially with increasing pre-grazing pasture mass, although this relationship was again significantly affected by an interaction with N fertilizer application levels (Table 2). There was a tendency for DM intake to decrease with increasing N fertilizer application level at the lower pre-grazing pasture masses but not at the higher pre-grazing pasture masses.

Table 2. Actual mean pre-grazing pasture mass, post-grazing pasture mass, dry matter intake at each grazing and percentage utilization of pasture as influenced by nitrogen fertiliser application and target pre-grazing pasture mass (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
		Pre-grazing pasture mass (kg DM ha^{-1})						
100	1201	1878	2946	3889	2479	Mass (M)	***	24
250	1221	2023	2928	3969	2535	Nitrogen (N)	NS	21
400	1199	2028	2894	3985	2526	M x N	NS	41
Mean	**1207**	**1977**	**2923**	**3948**				
		Post-grazing pasture mass (kg DM ha^{-1})						
100	510	624	823	884	710	Mass (M)	***	15
250	634	770	933	961	825	Nitrogen (N)	***	13
400	676	900	1037	952	891	M x N	*	26
Mean	**607**	**765**	**931**	**932**				
		DM Intake (kg DM ha^{-1})						
100	691	1255	2123	3005	1768	Mass (M)	***	22
250	587	1253	1995	3008	1711	Nitrogen (N)	***	19
400	536	1128	1858	3033	1639	M x N	*	39
Mean	**605**	**1212**	**1992**	**3015**				
		Utilization (%)						
100	57.5	66.8	72.1	77.2	68.4	Mass (M)	***	0.5
250	48.0	61.9	68.1	75.8	63.5	Nitrogen (N)	***	0.4
400	44.7	55.6	64.2	76.1	60.1	M x N	***	0.9
Mean	50.1	61.4	68.1	76.4				

Percentage utilization of pasture was significantly affected by an interaction between pre-grazing pasture mass and N fertilizer application (Table 2). Percentage utilization increased substantially with increasing pre-grazing pasture mass, however, it tended to decline with increasing N fertilizer application levels at the lower pre-grazing pasture masses but the extent of this decline was less at the higher pre-grazing pasture masses and no decline was evident at the highest pre-grazing pasture mass.

The effect of treatments on the number of grazings and the mean inter-grazing interval in each treatment are presented in Table 3. Mean inter-grazing interval increased substantially with increasing pre-grazing pasture mass and N fertilizer application levels tended to have little influence on inter-grazing interval except at the 1000 kg DM ha^{-1} target pre-grazing pasture mass treatments where inter-grazing interval decreased with increasing N application levels.

Table 3. The effect of nitrogen fertilizer and pre-grazing pasture mass onthe number of grazings per year and the length of interval between grazings (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})				
kg N ha^{-1}	**1000**	**2000**	**3000**	**4000**	**Sig.**
	Number of grazings (year-1)				
100	**15**	**11**	**7**	**6**	
250	**18**	**10**	**8**	**6**	
400	**20**	**11**	**8**	**6**	
	Mean inter-grazing interval ± SE (days)				
100	**15.1 ± 1.2**	**20.6 ± 1.4**	**32.4 ± 1.8**	**37.8 ± 2.0**	
250	**12.6 ± 1.1**	**22.7 ± 1.5**	**28.4 ± 1.7**	**37.8 ± 2.0**	*******
400	**11.4 ± 1.1**	**20.6 ± 1.4**	**28.4 ± 1.7**	**37.8 ± 2.0**	
Mean	**13.0**	**21.3**	**29.7**	**37.8**	

The ash concentration in pre-grazing pasture was significantly affected by pre-grazing pasture mass (Table 4). The 4000 kg DM ha^{-1} treatment had lower ash concentration in the pasture than the other treatments. The ash concentration in the pre-grazing pasture increased significantly with increasing N fertilizer application levels (Table 4).

The ash concentration in the post-grazing pasture was significantly affected by an interaction between treatments (Table 4). There was a tendency for ash concentrations to increase with increasing pre-grazing pasture mass and with increasing N fertilizer application levels.

Table 4. The effect of nitrogen fertilizer and pre-grazing pasture mass on the ash concentration of pasture pre- and post-grazing (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
			Pre-grazing Ash (g kg-1)					
100	135	139	135	127	134	Mass (M)	***	1.0
250	140	140	138	133	138	Nitrogen (N)	***	0.8
400	143	143	143	136	141	M x N	NS	1.6
Mean	139	141	139	132				
			Post-grazing Ash (g kg^{-1})					
100	196	225	185	220	207	Mass (M)	**	6.3
250	192	204	217	229	210	Nitrogen (N)	**	5.4
400	205	208	282	237	233	M x N	***	10.9
Mean	198	212	228	228				

The OMD of pre-grazing pasture was significantly influenced by pre-grazing pasture mass, although not consistently with increasing pre-grazing pasture mass (Table 5). The 100 kg N ha^{-1} treatment had significantly higher OMD of pre-grazing pasture than the two higher N fertilizer treatments (Table 5).
The OMD of post-grazing pasture was significantly affected by an interaction between treatments, where it tended to decline with increasing pre-grazing pasture mass and with increasing N application levels, albeit not very consistently (Table 5). Declining OMD of the post-grazing pasture with increasing N application levels was most pronounced at the higher pre-grazing pasture masses and not evident at the lowest pre-grazing pasture mass treatment.

The estimated OMD of grazed pasture was significantly affected by pre-grazing pasture mass but not by N fertilizer application levels or by an interaction with N application levels (Table 5). The 1000 kg DM ha^{-1} target pre-grazing pasture mass treatment had significantly higher OMD of the grazed pasture than the 4000 kg DM ha^{-1} treatment.
The crude protein concentration in pre-grazing pasture was affected by a significant interaction between treatments where the crude protein concentration showed a reasonably consistent tendency to decline with increasing pre-grazing pasture mass and a reasonably consistent tendency to increase with increasing N fertilizer application levels (Table 6).

The crude protein concentration in post-grazing pasture declined significantly with increasing pre-grazing pasture mass and significantly increased with increasing N fertilizer application levels (Table 6). The crude protein concentration in post-grazing pasture was not significantly affected by an interaction between the main treatments.
The estimated crude protein concentration in grazed pasture was significantly affected by an interaction between treatments; again there was a clear tendency for crude protein concentrations to decline with increasing pre-grazing pasture mass and to increase with increasing N application levels (Table 6)

Total annual N offtake grazing pasture (kg N ha^{-1} year^{-1}) was significantly affected by an interaction between treatments where there was a clear tendency for N offtake to increase both with increasing pre-grazing pasture mass and with increasing N fertilizer application levels (Table 7).

mass on the crude protein concentration in pasture pre- and post-grazing and on estimated crude protein concentration in grazed pasture (means of repeated harvests throughout the year)

Table 5 The effect of nitrogen fertilizer and pre-grazing pasture mass on the organic matter digestibility (OMD) of pasture pre- and post-grazing and on estimated OMD of grazed pasture (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
		Pre-grazing OMD (g kg^{-1})						
100	774	764	775	766	770	Mass (M)	***	1.5
250	762	763	769	760	764	Nitrogen (N)	**	1.3
400	768	758	770	759	764	M x N	NS	2.6
Mean	**768**	**762**	**771**	**762**				
		Post-grazing OMD (g kg^{-1})						
100	710	696	721	689	704	Mass (M)	***	4.1
250	715	713	679	672	695	Nitrogen (N)	**	3.6
400	710	703	665	664	685	M x N	**	7.1
Mean	**712**	**704**	**689**	**675**				
		Estimated OMD of Intake (g kg^{-1})						
100	833	792	792	785	801	Mass (M)	***	3.6
250	812	792	807	786	799	Nitrogen (N)	NS	3.2
400	831	791	818	783	806	M x N	NS	6.3
Mean	**825**	**792**	**806**	**785**				

Table 6. The effect of nitrogen fertilizer and pre-grazing pasture mass on the crude protein concentration in pasture pre- and post-grazing and on estimated crude protein concentration in grazed pasture (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
		Pre-grazing Crude Protein (g kg-1)						
100	268	256	237	233	248	Mass (M)	***	2.8
250	298	290	279	239	277	Nitrogen (N)	***	2.5
400	310	298	302	279	297	M x N	**	4.9
Mean	292	281	273	251				
		Post-grazing Crude Protein (g kg^{-1})						
100	236	216	203	193	212	Mass (M)	***	6.3
250	252	244	231	205	233	Nitrogen (N)	***	5.4
400	270	258	231	229	247	M x N	NS	10.9
Mean	253	239	222	209				
		Estimated Crude Protein in Intake (g kg^{-1})						
100	297	277	249	246	267	Mass (M)	***	4.8
250	352	320	302	250	306	Nitrogen (N)	***	4.2
400	385	331	349	296	340	M x N	**	8.4
Mean	345	309	300	264				

Table 7. The effect of nitrogen fertilizer and pre-grazing pasture mass on nitrogen off take in the pasture grazed over the grazing season.

	Target pre-grazing pasture mass (kg N ha^{-1} $year^{-1}$)							
kg N ha^{-1}	1000	2000	3000	4000	Mean		Sig.	SEM
		Nitrogen Offtake (kg N ha^{-1})						
100	470	569	552	603	549	Mass (M)	***	12.4
250	576	629	684	657	637	Nitrogen (N)	***	10.8
400	610	612	733	765	680	M x N	*	21.6
Mean	552	604	656	675				

Discussion and Conclusions

The discussion of, and conclusions from, this experiment are presented with those of experiment 2, later in this report (section 4).

3. Experiment 2: The effects of pasture mass and nitrogen fertilizer on pasture intake by grazing cattle

3.1. Introduction

The background and objective of the present experiment are quite similar to the previous experiment. However, in the present experiment greater emphasis was placed on examining the influences of N fertilizer applications. This experiment was a two by four factorial experiment with two target pre-grazing pasture masses (2000 and 4000 kg DM ha^{-1}) and four N application levels (0, 83, 166 and 250 kg N ha^{-1}). This experiment was arranged in a randomized complete block design and replicated four times.

3.2. Materials and Methods

Plot size, as in the previous experiment, was 15 m x 12 m and treatments were conducted in a similar manner to the previous experiment.

3.3 Results

Generally speaking the intake of DM, OM and DOM increased both with increasing fertilizer N application levels and with increasing pre-grazing pasture mass (Table 8). There was no significant interaction between the main treatment effects in the case of DOM intake, although intake of DOM increased significantly with both increasing N fertilizer application levels and with increasing pre-grazing pasture mass.

The mean pre-grazing pasture masses at each grazing throughout the grazing season for each treatment is presented in Table 9. Mean pre-grazing pasture masses were reasonably close to target masses and reasonably consistent across N application level treatments.

Post-grazing pasture mass increased significantly with increasing target pre-grazing pasture mass (Table 9). Post-grazing pasture mass was also significantly affected by N fertilizer treatments; there was a tendency for mean post-grazing pasture masses to increase with increasing N fertilizer application levels (Table 9).
Mean DM intake of pasture was significantly higher at the higher pre-grazing pasture mass treatment (Table 9). Mean DM intake was not significantly affected by N fertilizer application levels or by an interaction between the main treatment effects (Table 9). Mean percentage utilization of pasture was significantly higher at the higher pre-grazing pasture treatment (Table 9). Mean percentage utilization was significantly affected by N fertilizer treatments; the 0 kg N ha^{-1} treatment had relatively low percentage uti-

Table 8. The effect of nitrogen fertilizer and pre-grazing pasture mass on the annual intake of grazed grass in terms of dry matter (DM), organic matter (OM) and digestible organic matter (DOM)

	Target pre-grazing pasture mass (kg DM ha^{-1})					
kg N ha^{-1}	2000	4000	Mean		Sig.	SEM
		Annual Intake (kg DM ha^{-1})				
0	9403	12028	10716			
83	9734	12129	10932	Mass (M)	***	158
166	11454	12303	11879	Nitrogen (N)	***	224
250	11605	13755	12680	M x N	*	317
Mean	10549	12554				
		(kg OM ha^{-1})				
0	8963	11658	10310			
83	9250	11548	10399	Mass (M)	***	147
166	10892	11801	11347	Nitrogen (N)	***	207
250	11232	13073	12153	M x N	*	293
Mean	10084	12020				
		(kg DOM ha^{-1})				
0	7418	9559	8489			
83	7682	9366	8524	Mass (M)	***	112
166	8887	9706	9297	Nitrogen (N)	***	158
250	9335	10735	10035	M x N	*	224
Mean	8331	9841				

Table 9. Actual mean pre-grazing pasture mass, post-grazing pasture mass, dry matter intake at each grazing and percentage utilization of pasture as influenced by nitrogen fertiliser application and target pre-grazing pasture mass (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})					
kg N ha^{-1}	2000	4000	Mean		Sig.	SEM
Target pre-grazing pasture mass (kg DM ha^{-1})						
0	2137	3983	3060			
83	2038	3833	2936	Mass (M)	***	30
166	2106	3912	3009	Nitrogen (N)	NS	43
250	2146	3790	2968	M x N	NS	60
Mean	**2107**	**3879**				
Post-grazing pasture mass (kg DM ha^{-1})						
0	991	1149	1070			
83	886	950	918	Mass (M)	**	18
166	961	1015	988	Nitrogen (N)	**	25
250	1003	1104	1053	M x N	NS	35
Mean	**960**	**1054**				
Intake (kg DM ha^{-1})						
0	1146	2834	1990			
83	1152	2883	2018	Mass (M)	***	29
166	1145	2896	2021	Nitrogen (N)	NS	41
250	1143	2686	1914	M x N	NS	58
Mean	**1146**	**2825**				
Utilization (%)						
0	53.7	71.2	62.4			
83	56.5	75.2	65.9	Mass (M)	***	0.5
166	54.4	74.1	64.2	Nitrogen (N)	**	0.7
250	53.2	70.9	62.1	M x N	NS	1.0
Mean	**54.5**	**72.8**				

Table 10. The effect of nitrogen fertilizer and pre-grazing pasture mass on the number of grazings per year and the length of interval between grazings (means of repeated harvests throughout the year)

kg N ha^{-1}	Target pre-grazing pasture mass (kg DM ha^{-1}) 2000	4000	Sig.
	Number of grazings (year^{-1})		
0	9	5	
83	10	5	
166	11	5	
250	11	6	
	Mean inter-grazing interval ± SE (days)		
0	25.0 ± 2.6	45.5 ± 4.4	
83	25.2 ± 2.6	43.8 ± 5.9	***
166	22.7 ± 3.6	43.5 ± 7.1	
250	21.1 ± 2.2	39.4 ± 3.4	
Mean	23.5	43.1	

Table 11. The effect of nitrogen fertilizer and pre-grazing pasture mass on the ash concentration of pasture pre- and post-grazing (means of repeated harvests throughout the year)

kg N ha^{-1}	Target pre-grazing pasture mass (kg DM ha^{-1}) 2000	4000	Mean		Sig.	SEM
	Pre-grazing Ash (g kg^{-1})					
0	128	111	119			
83	132	131	131	Mass (M)	**	1.9
166	134	121	128	Nitrogen (N)	**	2.7
250	135	132	133	M x N	NS	3.8
Mean	132	124				
	Post-grazing Ash (g kg^{-1})					
0	220	247	233			
83	245	268	256	Mass (M)	**	6.2
166	242	288	265	Nitrogen (N)	NS	8.8
250	243	278	260	M x N	NS	12.4
Mean	237	270				

Table 12. The effect of nitrogen fertilizer and pre-grazing pasture mass on the organic matter digestibility (OMD) of pasture pre- and post-grazing and on estimated OMD of grazed pasture (means of repeated har vests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})					
kg N ha^{-1}	2000	4000	Mean		Sig.	SEM
	Pre-grazing OMD (g kg^{-1})					
0	785	779	782			
83	789	774	782	Mass (M)	NS	2.2
166	778	788	783	Nitrogen (N)	NS	3.1
250	781	785	783	M x N	*	4.4
Mean	783	781				
	Post-grazing OMD (g kg^{-1})					
0	721	679	700			
83	713	674	693	Mass (M)	***	3.1
166	716	669	692	Nitrogen (N)	NS	4.4
250	709	655	682	M x N	NS	6.2
Mean	714	699				
	Estimated OMD of Intake (g kg^{-1})					
0	842	811	826			
83	840	799	820	Mass (M)	***	3.2
166	819	817	818	Nitrogen (N)	NS	4.5
250	832	824	828	M x N	*	6.4
Mean	833	813				

lization of pasture, significantly lower than the 83 kg N ha^{-1} treatment and above this N fertilizer application level, mean percentage utilization tended to decline with increasing N fertilizer application levels (Table 9).

The number of grazings during the grazing season and mean inter-grazing interval are presented in Table 10. The higher pre-grazing pasture mass had longer mean inter-grazing intervals than the lower pre-grazing pasture cover. Nitrogen fertilizer application level had no significant effect on inter-grazing interval.

The ash concentration in pre-grazing pasture was significantly lower at the higher pre-grazing pasture mass treatments (Table 11). The N fertilizer application treatments also had a significant effect on ash ß in the pre-grazing pasture; there was a tendency for ash concentrations to increase with increasing N fertilizer treatments (Table 11). The ash concentration in the post-grazing pasture was significantly higher at the higher pre-grazing pasture mass treatments (Table 11). However, ash concentrations in the post-grazing pasture were not significantly affected by the N fertilizer treatments or by an interaction between the main treatments (Table 11).

Table 13. The effect of nitrogen fertilizer and pre-grazing pasture mass on the crude protein concentration in pasture pre- and post-grazing and on estimated crude protein concentration in grazed pasture (means of repeated harvests throughout the year)

	Target pre-grazing pasture mass (kg DM ha^{-1})					
kg N ha^{-1}	2000	4000	Mean		Sig.	SEM
		Pre-grazing Crude Protein (g kg^{-1})				
0	181	160	171			
83	204	191	197	Mass (M)	***	1.9
166	221	209	215	Nitrogen (N)	***	2.7
250	250	224	237	M x N	NS	3.8
Mean	214	196				
		Post-grazing Crude Protein (g kg^{-1})				
0	151	134	142			
83	157	145	151	Mass (M)	***	1.6
166	182	153	168	Nitrogen (N)	***	2.3
250	202	178	190	M x N	NS	3.3
Mean	173	153				
		Estimated Crude Protein in Intake (g kg^{-1})				
0	210	171	191			
83	247	207	227	Mass (M)	***	3.6
166	255	229	242	Nitrogen (N)	***	5.1
250	298	244	271	M x N	NS	7.2
Mean	253	213				

The OMD of pre-grazing pasture was affected by a significant interaction between pre-grazing pasture mass and N applications. The

OMD of pre-grazing pasture tended to be higher at the lower N treatments at the lower pre-grazing pasture mass treatment and at the higher N treatments at the higher pre-grazing pasture mass treatment and vice versa (Table 12).

The OMD of post-grazing pasture was significantly lower at the higher pre-grazing pasture mass treatment (Table12). The OMD of post-grazing pasture was not significantly effected by N fertilizer application or by an interaction between treatments (Table 12).

The estimated OMD of grazed pasture was affected by a significant interaction between treatments; estimated OMD of grazed pasture tended to be higher in the lower pre-grazing pasture mass treatment at the lower N application levels but not at the higher N application levels (Table 12).

The crude protein concentrations in pre-grazing pasture, post-grazing pasture and estimated crude protein concentration in grazed pasture were significantly lower in the higher pre-grazing pasture mass treatment (Table 13). Furthermore the crude protein concentrations in pre-grazing pasture, post-grazing pasture and estimated crude protein concentration in grazed pasture increased significantly with increasing N fertilizer application levels (Table 13).

Nitrogen offtake in grazed pasture was not significantly affected by pre-grazing pasture mass treatment, however, N offtake increased significantly with increasing N fertilizer application levels (Table 14).

Table 14. The effect of nitrogen fertilizer and pre-grazing pasture mass on nitrogen offtake in the pasture over the grazing season.

	Target pre-grazing pasture mass (kg DM ha^{-1})					
kg N ha^{-1}	2000	4000	Mean		Sig.	SEM
	Nitrogen Offtake (kg N ha^{-1})					
0	319	337	328			
83	381	409	395	Mass (M)	NS	8.0
166	463	457	460	Nitrogen (N)	***	11.3
250	543	544	544	M x N	NS	16.0
Mean	426	437				

4. Discussion of experiments 1 and 2: The effects of pasture mass and nitrogen fertilizer on pasture intake by grazing cattle

4.1. Pre-grazing pasture mass

The results of the previous two experiments indicate that increasing pre-grazing pasture mass will increase annual intake and utilization of DM, OM and DOM. In general, there was no detectable difference in the OMD of swards presented to grazing cattle within the range of pre-grazing pasture masses between 2000 kg DM ha^{-1} and 4000 kg DM ha^{-1} in both experiments. Furthermore, it is likely that differences in OMD of grazed pasture recorded in these experiments are likely to have been influenced by the degree of grazing pressure that was recorded (i.e. percentage utilization) on both of these treatments in these experiments. The nutritive value of the sward declines with increasing depth in the sward profile, moving from the upper sward surface down through the profile. (This is evident from the differences in the OMD of pre-grazing compared to post-grazing pasture masses in these two experiments). Therefore increasing percentage utilization is likely to be concomitant with reductions in the nutritive vale of the sward ingested. In the present two experiments, there tended to be substantially higher percentage utilization of pasture on the higher pre-grazing pasture mass treatments, at each grazing. This, in part, may account for the lower OMD of grazed pasture recorded on the higher pre-grazing pasture mass treatments.

There was a clear tendency to have lower crude protein concentration in pre-grazing pasture presented to the grazing cattle with increasing pre-grazing pasture mass. However, the minimum crude protein concentration in pasture DM required for optimum animal production of approximately 150 g crude protein kg^{-1} pasture DM (Thompson and Poppi, 1990) was achieved in all treatments in both experiments. It therefore seems likely that increasing pre-grazing pasture mass (inter-defoliation interval) within the range examined in the present two experiments (1000 to 4000 kg DM ha^{-1}) is not likely to have a detrimental impact on sward quality to the extent that it would impact negatively on animal performance. This aspect will be examined in more detail in the following experiment.

Pre-grazing pasture mass at each grazing substantially increased percentage utilization. In both experiments percentage utilization was between 45% and 80% of pre-grazing pasture mass, in line with that observed by Peel and Green (1984). In the experiment carried out in 1997, there was a tendency for percentage utilization to decrease with increasing N fertilizer inputs at the 1000, 2000 and 3000 kg DM ha^{-1} but not at the 4000 kg DM ha^{-1} pre-grazing pasture mass treatments. Reductions in percentage utilization associated with increasing fertilizer N inputs generally coincided with increasing post-grazing mass and increased frequency of grazing during the year. It would appear that lower percentage utilization could be attributed, in part, to rejection of the sward as a consequence of fouling - as recorded by Deenen and Middelkoop (1992). There is some evidence in both experiments to suggest this. There was a tendency for the ash concentration to be higher in pre-grazing pasture in the treatments that were more frequently grazed. Higher ash concentrations would be indicative of fouling of the sward during previous grazings, either by soil transferred on the hooves of the grazing cattle or by faecal deposition. (Hence, sward productivity is presented primarily in terms of OM or DOM production, which do not include the ash component).

4.2. Nitrogen fertilizer application levels

In experiment 1, N application levels had small and inconsistent effects on the annual intake of DM, OM and DOM within the range of 100 to 400 kg N ha^{-1}. However, in experiment 2 increasing N application levels increased the annual intake of DM, OM and DOM. In experiment 2 there was a clear advantage in applying N fertilizer up to 250 kg N ha^{-1} $year^{-1}$.The differences in these results between the two experiments can be attributed to differences in the grass growing conditions between the two years.

Nitrogen application had little impact on the estimated OMD of grazed pasture in the present two experiments. Generally, reducing fertilizer N inputs to grassland results in a decrease in crude protein content with a simultaneous increase in water-soluble carbohydrate content with minor effects on crude fibre concentrations cell wall contents and OMD, on feed intake and on animal performance (Vellinga *et al*., 1995; Delaby *et al*., 1996; Valk and Kappers, 1996; Delaby *et al*., 1998; Peyraud and Astigarraga, 1998;Valk and Van Vuuren, 1998).The moderate effects on animal performance can be attributed to the fact that any decrease in crude protein content is compensated for by an increase in water-soluble carbohydrates, which are completely digestible and provide a readily available source of energy for rumen protein synthesis (Peyraud and Astigarraga, 1998).

In both years there was a clear response in the crude protein concentration in pasture DM on offer up to the maximum fertilizer N application rates in both experiments (400 kg N ha^{-1} $year^{-1}$ in 1997 and 250 kg N ha^{-1} $year^{-1}$ in 1998). Delagarde *et al.* (1999) showed that low crude protein in pasture limited intake by a strong deficiency in rumen-degradable protein. However, in the latter experiment crude protein concentrations ranged between 137 and 108 g kg^{-1} DM, which was lower than that encountered in the present two experiments. The minimum crude protein concentration in pasture DM required for optimum animal production is approximately 150 g crude protein kg^{-1} pasture DM (Thompson and Poppi, 1990). This minimum concentration was achieved in all treatments in both experiments. On the other hand, relatively high crude protein concentration in pasture DM (greater than 250 g crude protein kg^{-1} pasture DM) may not offer any advantage in terms of animal production. However, concentrations above this level may consequently result in increased excretion of N in urine, which carries with it the possible implications for potential leaching losses to ground water quality and loss of N to the atmosphere (Jarvis *et al.*, 1989; Delaby *et al.,* 1995; Krober *et al.,* 1999). Furthermore, Peyraud and Astigarraga (1998) pointed out that lowering the levels of N fertilization to grassland would appear to be an efficient means of reducing N losses in grazing ruminants.

In 1998 a mean of 328 kg N ha^{-1} $year^{-1}$ was removed in grazed pasture from the treatments where no N fertilizer was applied (Table 14).This indicates that the site used in both of these experiments had a very high potential to release mineralized soil organic matter N for uptake by the pasture crop. In an experiment carried out in the late 1960's on 26 sites around Ireland, Ryan (1976) recorded a mean uptake of 219 kg N per ha from native soil and clover sources in the absence of applied fertilizer N under cutting (no N recycling). In the present two experiments, the high potential to release mineralized soil organic matter N accounts for the relatively low response to applied fertilizer N. Sheehy (1989) pointed out that, after many years, grazed grass swards might achieve N saturation at a level of inputs that would be considered low in agricultural terms. Simpson and Freney (1967) studied the fate of tagged ammonium and nitrate in pasture soils, and found that recovery in the soil-plant system was between 90 and 100%, except when nitrate was added to soil with high organic matter content. In the latter instance, recovery was only 69% similar to that recorded in the present two experiments. This is concordant with the fact that the soils of Grange tend to have relatively high organic matter contents (14%) for a mineral soil. (Generally mineral soils in Ireland have organic matter contents of around 6%).

4.3. Conclusions

Pre-grazing pasture mass

* Increasing pre-grazing pasture mass at each grazing increased the quantity of grazed pasture DOM ha^{-1} year^{-1} in both experi ments.
* Increasing pre-grazing pasture mass at each grazing increased the percentage utilization of pasture DM on offer above 4 cm in both experiments.
* In general there were no clear differences in the OMD of the pasture on offer above 4 cm in both experiments.
* Increasing pre-grazing pasture mass resulted in decreasing crude protein concentration in the pasture on offer above 4 cm in both experiments.
* Increasing pasture mass increased N offtake in grazed pasture in the experiment conducted in 1997 but not in the experiment conducted in 1998.

Nitrogen fertilization

* Increasing N fertilization increased the quantity of grazed pasture DOM ha^{-1} year^{-1} in both experiments, although this trend was clearer in the experiment conducted in 1998 than in the experimented conducted in 1997.
* Increasing N fertilization had no clear effect on the OMD of pas ture on offer above 4 cm in both experiments.
* Increasing N fertilization increased the crude protein concentration in the pasture on offer above 4 cm in both experiments.
* Increasing N fertilization increased N offtake in grazed pasture in both experiments.

5. Experiment 3: The effect of pre-grazing pasture mass on the performance of beef cattle

5.1. Introduction

Grazing swards with a pre-grazing pasture mass of over 2500 kg DM ha-1 (above 4 cm) is not generally recommended. The results of the previous two experiments indicate that there may be advantages associated with grazing swards with a higher pre-grazing pasture mass in terms of increasing intake and utilization of DM, OM and DOM. Furthermore a higher pre-grazing pasture mass may not be detrimental to the nutritive value of swards presented to grazing cattle. The objective of the present experiment was to examine the performance of beef cattle grazing swards of the recommended pre-grazing pasture mass of c. 2000 kg DM ha^{-1} (1500 - 2500 kg DM ha^{-1}) compared to that of beef cattle grazing swards of a higher pre-grazing pasture mass of c. 3500 kg DM ha^{-1} (2500- 4500 kg DM ha^{-1}).

5.2. Materials and Methods

There were two treatments in this experiment: target pre-grazing pasture mass of (1) c. 2000 kg DM ha^{-1} (control) and (2) c. 3500 kg DM ha^{-1} (high). There were two replications in this experiment. Twenty-one ha was divided into 84 paddocks of 0.25 ha in spring 1998. Forty-two of these were assigned to each replication. Twenty-one of each of these 42 paddocks were then randomly assigned to each of the two treatments within each replication. Sixty-eight continental-crossbred cattle with a mean live-weight of 479 kg were weighted off silage on two consecutive days in March 1998. These were paired on the basis of source, weight, breed and age. One of each pair was randomly assigned to either treatment (s.e. = 0.72).
Cattle were turned out to grass on 18 March and grazed through to 2 November. Pasture cover (above 4 cm using the rising plate meter) and pre- and post-grazing pasture mass (cut to 4 cm using a lawn-

mower) were measured weekly. In order to maintain target pasture masses on both treatments, surplus grass was removed as necessary, recorded and ensiled. Paddocks were grazed down to a height of c. 4 cm in the spring increasing to c. 8 cm in the autumn before cattle were moved to the next paddock.The high treatment paddocks were strip-grazed, grass was allocated on a daily basis. On the control treatment cattle generally spent 2 days on each paddock. Cattle were weighed at monthly intervals. 180 kg N ha^{-1} applied during the grazing season.

5.3. Results

There were no significant differences in cattle live-weights and carcass weights between grazing treatments at the end of the experiment or in live weight gain between grazing treatments during the experiment (Table 15). Furthermore there were no significant differences in kill out percentage (~ 54%), confirmation (~ R) or fat score (~5) between grazing treatments (treatment means not shown). While mean pre-grazing pasture masses in terms of DM, OM and DOM during the experiment were significantly different between grazing treatments, there were no significant differences in post-grazing pasture masses between treatments (Table 15). Intake of DM, OM and DOM was significantly higher on the higher pre-grazing pasture mass treatment at each grazing. Percentage utilization of DM was significantly higher on the higher pre-grazing pasture mass treatment at each grazing. There were no significant difference in OMD of pre-grazing pasture between treatments or in the OMD of post-grazing pasture between treatments during the experiment. There was no significant difference in the surplus grass (t DM ha^{-1}) removed off both treatments.

Table 15: The effect of target pre-grazing pasture mass on cattle live- and car cass-weights, mean pre- and post-grazing pasture masses in terms of dry matter (DM), organic matter (OM) and digestible organic matter (DOM), percentage utilization of dry matter, pre- and post-grazing ash, organic matter digestibility (OMD), intake of dry matter, organic matter and digestible organic matter, rotation length (pasture measurements are means of repeated harvests throughout the year) and grass surpluses harvested as silage (mean quantity harvested per hectare per year)

	Target pre-grazing pasture mass (kg DM ha^{-1})			
	2000	3500	Sig.	SEM
Final Live weight (kg) (n = 16)[1]	717	713	NS	4.6
Live weight gain at grass (kg) (n = 16)[1]	238	234	NS	4.4
Cold carcass weight (kg) (n = 17)[1]	388	385	NS	2.9
Pre-grazing DM Mass (kg DM ha^{-1})	2037	3192	***	70
Post-grazing DM Mass (kg DM ha^{-1})	906	850	NS	26
Percentage Utilization	56.0%	72.6%	***	1.2%
Pre-grazing Ash (g kg^{-1})	120	101	***	4
Post-grazing Ash (g kg^{-1})	198	183	NS	11
Pre-grazing OM Mass (kg DM ha^{-1})	1793	2873	***	64
Post-grazing OM Mass (kg DM ha^{-1})	743	701	NS	24
Pre-grazing OMD (g kg^{-1})	767	765	NS	3
Post-grazing OMD (g kg^{-1})	699	696	NS	4
Pre-grazing DOM Mass (kg DM ha^{-1})	1371	2189	***	49
Post-grazing DOM Mass (kg DM ha^{-1})	520	486	NS	18
DM Intake (kg DM ha^{-1})	1131	2342	***	67
OM Intake (kg OM ha^{-1})	1049	2172	***	66
DOM Intake (kg DOM ha^{-1})	851	1703	***	51
Total Surpluses (kg DM ha^{-1})	3310	3544	NS	151
Mean rotation length (days)	28.5	46.3		

[1]One animal per treatment was slaughtered in late September

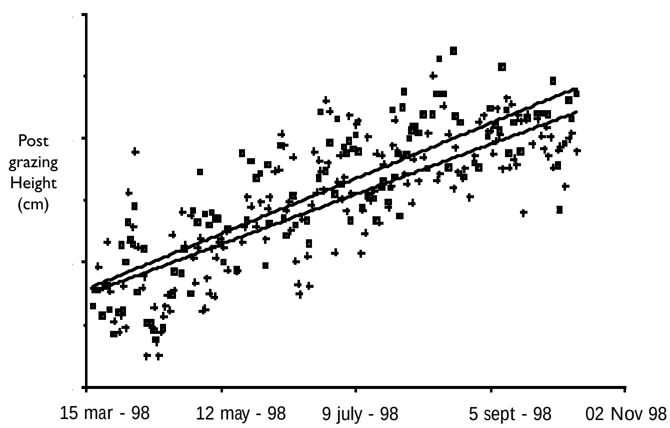
5.4. Discussion

High levels of performance by the grazing cattle were recorded over a relatively long grazing season in this experiment; c. 236 kg live-weight gain over a 225 day grazing season. The absence of any detectable difference in animal performance between treatments in this experiment is supported by the nutritive values for pasture recorded in the present and the previous two experiments and with the results of Binnie *et al.* (1997). The absence of any detectable difference in the quantities of grass removed as surpluses is perhaps surprising in the context of the results of the previous two experiments where the higher pre-grazing pasture mass resulted in substantially higher intakes of pasture. It was not possible to accurately measure annual production of pasture on both treatments throughout the grazing season in the present experiment. However, the absence of any detectable difference in surpluses removed may have been due to the fact that only 180 kg N ha^{-1} was applied to both treatments which may have limited the production potential of the higher pre-grazing pasture mass treatment. The results of the previous two experiments indicate that applications of 250 kg N ha^{-1} or more may have been relatively more beneficial to the higher pasture mass treatment. This aspect may need to be examined in greater detail in the future. Furthermore, in the previous two experiments pasture was grazed as soon as target pasture masses were achieved because the cattle could be brought in to graze the pasture as required. In the present experiment pasture could not be grazed as required but under a system where swards were grazed in rotation. During the late summer and autumn this resulted in swards carrying high pasture masses at a time when conditions (i.e. declining solar radiation and ambient temperatures) were not suitable for carrying such high masses. It is likely that there was a certain amount of senescence at the base of these swards resulting in a loss of DM production (Binnie and Mayne, 1996; Neilan *et al*., 1996). However, the alternative would have been to remove some of these paddocks (carrying high pasture masses) as surpluses but this would have diminished the extent of difference between treatments contrary to the objective of the experiment.

5.5. Conclusions

* High levels of animal performance were recorded in this experiment: mean of 236 kg live-weight gain per animal over a 225 day grazing season.
* No detectable difference in the performance of cattle grazing substantially different pasture masses was recorded in this experiment.
* There were no detectable differences in the quantities of grass surpluses removed from treatments in this experiment.
* The higher pre-grazing pasture mass treatment resulted in higher percentage utilization at each grazing during this experiment.
* There was no difference in the OMD concentration in the DM of pasture on offer above 4 cm between treatments in this experiment.

Figure 1. Post-grazing height during the experiment. Control (+) = target available pre-grazing herbage mass of 2000 kg DM/ha. High (·) = target available pre-grazing herbage mass of 3500 kg DM/ha.



6. Experiment 4: Effects of perennial ryegrass cultivar mixture on grazed grass supply in spring and on first-cut silage

6.1. Introduction

Although grazed grass is the cheapest feed source on Irish farms, the provision of adequate winter forage (generally as ensiled grass) is an essential requirement for efficient year-round livestock production (O'Riordan *et al.,* 1996). Harvesting grass close to its mean heading date is an important aspect of making high-digestibility silage. Typically, in Ireland, reseeded swards tend to be composed of intermediate-heading perennial ryegrass cultivars, and the aim is to ensile highly digestible grass in mid- to late-May. There are now a number of very-late-heading perennial ryegrass cultivars on the market. These have heading dates as late as mid-June. It is possible that the quality of silage made using these cultivars would not decrease as rapidly if harvest is delayed into June compared to intermediate-heading cultivars. Delaying the harvest until mid-June could potentially allow more grass to accumulate for silage after a late spring grazing. Silage harvesting is usually priced by contractors on an area basis. Higher yields of grass per unit area will then reduce the relative cost of each tonne of silage produced. Therefore it is important to have high yields of high quality grass for harvest on the silage area. Compared to grazed grass, the associated costs of winter-feed production and storage make silage a relatively expensive winter-feed. To reduce animal production costs, a short indoor feeding period is association with a long grazing season has to be an option of choice (O'Riordan *et al*., 1996). As little pasture DM accumulates during the December to early March Period, turnout of livestock to pasture in spring has to be delayed until grass growth begins and sufficient has accumulated to partly or fully support the grazing livestock (Roche *et al*., 1996). A lack of available pasture may be further complicated by poor grazing conditions especially on wet soils. Late-heading cultivars are generally associated with the production of relatively low grass yields in the early spring compared to the best intermediate-heading cultivars. Thus, they might not be suitable for early grazing.The objective of the present experiment was to examine the potential to optimize the yields of grass for spring grazing and the yield and quality of first-cut silage by using a new strategy of late-heading ryegrass cultivars and delaying silage harvest until mid-June.

6.2. Materials and Methods

This was a 4 factor experiment with 2 (grass cultivar type) x 3 (spring grazing options) x 4 (silage harvest date) x 2 (year, 1998 and 1999) factorial arrangement of treatments within a randomized complete block design, with four replications. There were two perennial ryegrass mixture treatments; intermediate-heading vs. very-late-heading cultivars. The intermediate-heading cultivars used were Respect, Spelga and Napoleon (mean heading dates between 21 - 24 May; spring growth index ~ 131). The very-late-heading cultivars were Tivoli and Condesa (mean heading dates between 9 - 10 June; spring growth index ~ 101). Plots were sown in June 1997 at 32 kg seed ha^{-1}. Plot size was 30 m2 (3 x 10 m).

There were three spring grazing treatments: (1) no grazing; (2) grazed once in the spring; (3) grazed twice in the spring.The first grazing was taken when a pre-grazing pasture mass of between 1100 and 1200 kg DM ha^{-1} had accumulated across relevant treatments. On this basis the first grazing took place on 3 March 1998 and 29 March 1999 (mean date of 16 March across years).The second grazing was taken when swards had subsequently accumulated approximately 2000 kg DM ha^{-1} across relevant treatments and the second grazing took place on 14 April 1998 and 30 April 1999 (mean date of 21 April across years). Plots were grazed by 300 kg LW cattle for approximately 5 hours during the first grazing and for 24 hours at the second grazing in both years. Pre- and post-grazing harvests were taken to a height of 4 cm using a lawn mower.The mass of grazed pasture grass DM was calculated as the difference between pre- and post-grazing masses. Fertilizer N was applied to all treatments at rates of 60 kg N ha-1 in mid-February and 60 kg N ha^{-1} after the first grazing.

There were four silage harvest dates (mean dates across years were 20 May, 30 May, 9 June and 19 June) for first cut silage. Plots were harvested on 19 May, 28 May, 9 June and 16 June in 1998 and on 20 May, 31 May, 9 June and 21 June in 1999. Plots were harvested to a height of 5 cm using a Haldrup. Grass DM yields ha-1 for silage were calculated. Pre- and post-grazing pasture was analyzed for ash concentration and OMD in the pasture DM for both grazing bouts in both years. Grass harvested for silage was analyzed for ash and crude protein concentration and DMD in the grass DM in 1999 only.

6.3. Results

Perennial ryegrass cultivar mixture had no significant effect on pre-grazing masses of dry matter (DM) or organic matter (OM) on offer to cattle during the first and second grazing in the spring (Tables 16 and 17). In general, there were no differences in the intake of OM between the cultivars, except during the first grazing in 1998 where there was a significantly ($P < 0.05$) higher intake of the late heading cultivars. Similarly, there were no differences in the utilization of OM between the cultivars during the second grazing, however, during the first grazing, there was a significantly ($P < 0.05$) higher utilization of

The late heading cultivars in both years. The pre-grazing ash concentration in pasture DM was significantly ($P < 0.05$) lower in the late heading cultivars during the first grazing in both years, however, there was no significant difference between cultivars during the second grazing. There was a significant ($P < 0.001$) interaction between cultivar mixture and year on the OMD of pasture on offer during the first grazing with higher OMD on offer in the late heading cultivars in 1998 but not in 1999. However, the OMD of pasture on offer was not significantly different between cultivar mixtures in both years during the second grazing. Furthermore, the OMD of pasture grazed was not significantly affected by cultivar mixture during both first and second grazing during either year.

Table 16: The effect of perennial ryegrass cultivar mixture on pre-grazing pasture mass (kg DM ha_{-1}) and organic matter mass (kg OM ha^{-1}), ash (g kg^{-1} DM) and OMD (g kg^{-1} DM) concentrations in the pre-grazing pasture, intake of OM (kg ha^{-1}), OMD of grazed pasture (g kg^{-1} DM) and the percentage utilization of pasture OM during the first grazing

		Perennial ryegrass cultivar mixture (heading date)								
		Intermediate		Late				Year	Cultivar	
Year:	1998	1999	Mean	1998	1999	Mean		(Y)	(C)	Y x C
		Grazed once and twice: First Grazing								
Pre-grazing DM	1087	1168	1128	1180	1101	1141	Sig.	NS	NS	NS
							SEM:	39	32	45
Pre-grazing Ash	125	96	110	118	94	106	Sig.	***	*	NS
							SEM:	1.8	1.4	2.0
Pre-grazing OMD	764	818	791	793	818	805	Sig.	***	***	***
							SEM:	2.9	2.6	3.7
Pre-grazing OM	952	1056	1004	1047	997	1019	Sig.	NS	NS	NS
							SEM:	34	28	40
OM Intake	593	636	614	794	625	709	Sig.	NS	*	*
							SEM:	32	33	46
OMD of Intake	782	851	817	804	840	822	Sig.	***	NS	NS
							SEM:	6.6	6.3	8.9
OM Util. (%)	63	60	61	76	62	69	Sig.	*	*	NS
							SEM:	2.3	2.7	3.8

Table 17: The effect of perennial ryegrass cultivar mixture on pre-grazing pasture mass (kg DM ha^{-1}) and organic matter mass (kg OM ha^{-1}), ash (g kg^{-1} DM) and OMD (g kg^{-1} DM) concentrations in the pre-grazing pasture, intake of OM (kg ha^{-1}), OMD of grazed pasture (g kg^{-1} DM) and the percentage utilization of pasture OM during the second grazing. The effect of perennial ryegrass cultivar mixture on the cumulative intake of OM (kg ha^{-1}), where first and second grazings are combined are also presented

		Perennial ryegrass cultivar mixture (heading date)								
		Intermediate		Late				Year	Cultivar	
Year:	1998	1999	Mean	1998	1999	Mean		(Y)	(C)	Y x C
		Grazed twice: Second Grazing								
Pre-grazing DM	2003	2231	2117	1906	1992	1948	Sig.	NS	NS	NS
							SEM:	86	69	97
Pre-grazing Ash	105	90	97	108	94	101	Sig.	**	NS	NS
							SEM:	3.1	2.5	3.5
Pre-grazing OMD	794	841	817	802	842	822	Sig.	***	NS	NS
							SEM:	2.5	2.1	2.9
Pre-grazing OM	1790	2026	1908	1695	1804	1750	Sig.	NS	NS	NS
							SEM:	75	61	86
OM Intake	1300	1557	1428	1384	1323	1354	Sig.	NS	NS	NS
							SEM:	77	68	96
OMD of Intake	811	857	834	820	858	839	Sig.	***	NS	NS
							SEM:	4.3	4.0	5.6
OM Util. (%)	58	64	61	66	63	65	Sig.	NS	NS	*
							SEM:	2.0	1.5	2.1
		Grazed twice: first and second grazing combined								
OM Intake	1692	1960	1826	1953	1887	1920	Sig.	NS	NS	NS
							SEM:	100	112	159

Where mass of intake from the first and second grazings were combined, there was no difference between perennial ryegrass treatments (Table 18).

Yields of grass for silage were affected by a significant (P < 0.01) interaction between perennial ryegrass cultivar mixture, spring grazing treatment, silage harvest date and year. Spring grazing reduced yields of grass for silage. Swards that were not grazed in the spring had higher yields of grass for silage than swards that were grazed once and these swards had higher yields than swards that were grazed twice. Silage yields tended to increase substantially with delayed harvest date. Generally speaking the late-heading cultivar mixture tended to have lower yields of grass for silage than the intermediate-heading cultivar mixture but this depended on spring grazing treatment, silage harvest date and year. Also, in general, yields of grass for silage were higher in 1998 than in 1999.

The later heading cultivars had significantly (P < 0.001) higher ash concentration in the grass DM harvested for silage than the intermediate heading cultivars (Table 19). The ash concentration in the grass DM harvested for silage tended to increase significantly (P < 0.05) with the intensity of spring grazing. Ash concentrations were higher where swards were grazed twice rather than once, which was higher than where swards were not grazed at all in the spring. The ash concentration in the grass DM harvested for silage tended to decrease significantly (P < 0.001) with later silage harvest date. This decrease was most pronounced at the later harvest dates.
The trends observed in mass of OM harvested for silage (Table 19) were similar to those observed in the mass of DM harvested for silage.

The DMD of grass harvested for silage was significantly affected by interactions between cultivar and spring grazing (P < 0.05) and

Table 18: **The effect of perennial ryegrass cultivar mixture, spring grazing and silage harvest date on the mass of grass DM harvested for silage** (kg DM ha-1)

Spring Grazing:	Perennial ryegrass cultivar mixture (heading date): Intermediate Twice	Once	Not	Mean	Late Twice	Once	Not	Mean
Silage harvest								
1998								
20 May	1901	5177	6083	4387	1347	4335	5603	3762
30 May	3029	7628	8144	6267	2897	5840	7520	5419
9 June	4157	8753	9339	7417	3766	6730	10651	7049
19 June	6183	9662	9439	8428	4999	8963	9779	7914
Mean	3818	7805	8252	6625	3252	6467	8388	6036
1999								
20 May	1508	4440	6280	4076	1182	3492	4539	3071
30 May	2107	6226	7759	5363	2389	4028	6503	4307
9 June	3703	7391	8671	6588	2805	5798	7830	5478
19 June	3986	7887	9949	7274	4423	7451	9569	7147
Mean	2826	6486	8165	5825	2700	5192	7110	5001
Mean of years								
20 May	1705	4808	6181	4231	1265	3913	5070	3416
30 May	2568	6927	7951	5815	2643	4934	7011	4863
9 June	3929	8072	9005	7002	3286	6264	9240	6263
19 June	5084	8774	9694	7851	4711	8207	9674	7531
Mean	3322	7145	8208	6225	2976	5830	7749	5518
					Sig.	SEM		
Cultivar x spring grazing x silage harvest date					**	239		
Cultivar x spring grazing x silage harvest date x year					**	338		

Table 19: The effect of perennial ryegrass cultivar mixture, spring grazing and silage harvest date on the ash concentration in grass DM and the mass of grass OM harvested for silage in 1999

	Perennial ryegrass cultivar mixture (heading date)							
Spring	Intermediate				Late			
Grazing:	Twice	Once	Not	Mean	Twice	Once	Not	Mean
Silage harvest	Ash 1999 (g kg^{-1} DM)							
20 May	86	86	83	85	90	96	88	91
30 May	93	85	79	86	97	90	92	93
9 June	82	72	70	75	84	83	82	83
19 June	70	70	67	69	76	75	75	75
Mean	83	78	75	79	87	86	84	86
			Sig.	SEM				
	Cultivar (C)		***	1.0				
	Spring grazing (G)		*	1.2				
	Silage Harvest (S)		***	1.4				
			OM 1999 (kg OM ha-1)					
20 May	1376	4058	5759	3731	1075	3156	4136	2789
30 May	1911	5694	7146	4917	2154	3664	5903	3907
9 June	3396	6861	8060	6106	2570	5316	7181	5022
19 June	3705	7337	9279	6774	4089	6893	8849	6610
Mean	2597	5987	7561	5382	2472	4757	6517	4582
			Sig.	SEM			Sig.	SEM
	Cultivar (C)		***	82		C x G	***	142
	Spring grazing (G)		***	100		C x S	*	164
	Silage Harvest (S)		***	116		G x S	*	201

Table 20: The effect of perennial ryegrass cultivar mixture, spring grazing and silage harvest date on the ash concentration in grass DM and the mass of grass OM harvested for silage in 1999

	Perennial ryegrass cultivar mixture (heading date)							
Spring	Intermediate				Late			
Grazing:	Twice	Once	Not	Mean	Twice	Once	Not	Mean
Silage harvest				DMD 1999 (g kg^{-1} DM)				
20 May	822	791	769	794	841	816	787	815
30 May	804	747	738	763	827	794	768	796
9 June	777	731	703	737	836	796	756	796
19 June	749	678	676	701	787	747	712	749
Mean	788	737	721	749	823	788	756	789
			Sig.	SEM			Sig.	SEM
	Cultivar (C)		***	2.0		C x G	*	3.5
	Spring grazing (G)		***	2.5		C x S	***	4.1
	Silage Harvest (S)		***	2.9				
			Crude Protein 1999 (g kg^{-1} DM)					
20 May	151	120	127	133	154	132	135	140
30 May	142	122	119	128	142	119	128	130
9 June	117	91	95	101	111	104	104	106
19 June	93	87	90	90	99	91	93	94
Mean	126	105	108	113	126	112	115	118
			Sig.	SEM				
	Cultivar (C)		*	1.4				
	Spring grazing (G)		***	1.8				
	Silage Harvest (S)		***	2.0				

between cultivar and silage harvest date (P < 0.001) (Table 22). In general, the late heading cultivars had higher DMD than the intermediates. In both sets of cultivars, the DMD of grass increased with increased grazing intensity in the spring: grazed twice > grazed once > not grazed. Also in both sets of cultivars, the DMD declined witater silage harvest date.

In general, the late heading cultivars had significantly (P < 0.05) higher crude protein concentration in the grass DM than the intermediates (Table 20). Swards that were grazed twice in the spring had significantly (P < 0.001) higher crude protein concentration in the pasture DM than the other two spring grazing treatments in both

Table 21: The effect of perennial ryegrass cultivar mixture, spring grazing and silage harvest date on, (1) the mass of grass harvested either as grazed pasture or as grass for silage, and (2) the mass of forage harvested either as grazed pasture or as grass for silage where consumption of silage is assumed to be 70% of grass harvested for silage, during the experiment

	Perennial ryegrass cultivar mixture (heading date)							
	Intermediate				Late			
Spring grazing:	Twice	Once	Not	Mean	Twice	Once	Not	Mean
Silage harvest	Mass of grass harvested (kg DM ha^{-1})							
20 May	3839	5409	6181	5143	3481	4654	5070	4402
30 May	4702	7528	7951	6727	4859	5675	7011	584
9 June	6063	8673	9005	7914	5502	7005	9240	7249
19 June	7218	9375	9694	8762	6927	8948	9674	8516
Mean	5456	7746	8208	7137	5192	6571	7749	6504
	Mass of forage; silage consumption = 70% of grass harvested (kg DM ha^{-1})							
20 May	3328	3967	4327	3874	3102	3480	3549	3377
30 May	3932	5450	5566	4982	4066	4195	4908	4390
9 June	4884	6251	6304	5813	4516	5126	6468	5370
19 June	5693	6743	6786	6407	5514	6486	6772	6257
Mean	4459	5603	5745	5269	4299	4822	5424	4848

sets of cultivars. Furthermore, the crude protein concentration in the pasture DM declined significantly ($P < 0.001$) with later silage harvest dates.

In Table 21 masses of grass harvested either as grazed pasture or as grass for silage during the experiment combined for both years are presented without statistical analysis. It is clear, however, that, although masses of grazed grass are included, spring grazing substantially reduced masses of grass harvested during the experiment for both perennial ryegrass cultivars and for each of the silage harvest dates.

It can be assumed for comparison purposes that cattle will consume 70% of grass harvested for silage. The capacity of each of the treatments to supply forage on this basis is also presented in Table 21.

Table 21: The effect of perennial ryegrass cultivar mixture, spring grazing and silage harvest date on, (1) the mass of grass harvested either as grazed pasture or as grass for silage, and (2) the mass of forage harvested either as grazed pasture or as grass for silage where consumption of silage is assumed to be 70% of grass harvested for silage, during the experiment

6.4. Discussion

6.4.1. Spring grazing

No difference in the capacity of swards, composed of either intermediate- or late-heading cultivars, to supply grass for spring grazing was detected in this experiment. This is divergent from the fact that the intermediate-heading cultivars had a mean spring growth index ~ 131 and the late-heading cultivars had a mean spring growth index ~101. Brereton and McGilloway (1999) compared the pasture DM production early-heading, intermediate-heading and late-heading cultivars during three seasons and for three periods: September to November, November to March and March to April. Early-cultivars out-yielded late-cultivars in two years out of three. However, they found that the differences between the intermediate-heading cultivars and the late-heading cultivars were not generally large or significant. Therefore, the results of the present experiment are in agree ment with the results of the experiment of Brereton and McGilloway (1999) in that there were no differences in early-spring pasture DM production between intermediate- and late-heading cultivars.

In the Department of Agriculture recommendations, spring growth index is determined on swards with uninterrupted growth up until the 11 April each year. In the present experiment swards were first grazed on a mean date of 16 March and no difference in pre-grazing mass was detected in both years. However, this first grazing represents an interruption in growth. Swards were again grazed on a mean date of 21 April and again no difference in pre-grazing mass was detected in both years. Although, these results seem to contradict the Department of Agriculture recommendations, it is likely that this is due to the method of measurement. When grass yields for silage are examined, it is clear that the intermediate-heading cultivars have higher yields at the earlier silage harvest dates across spring grazing treatments and that these differences become less pronounced as silage harvest date was deferred. This clearly indicates that the intermediate-heading cultivars have higher growth rates in the late spring and early summer i.e. during late-April and May compared with late-heading cultivars. This brings into question the definition of spring growth. In a practical farming situation, where grazing livestock are turned out to grass between late-February and mid-March, higher grass growth rates would be advantageous prior and subsequent to this period (i.e early February to early April). This period probably should be more correctly referred to as the early spring. It would appear, from the results of this experiment, that the index used to define spring growth by the Department of Agriculture does not apply to growth rates in the early spring. Therefore, in terms of the objectives of this experiment, cultivar mixture had no impact on supply of grass for grazing in the early spring.

Although, there were no differences in pasture on offer, either in terms of DM or OM on offer, during the first and second grazings in both years between cultivar mixtures, there was a tendency for the late-heading cultivars to have higher OMD in 1998 but not in 1999. In Ireland, Gately (1984) demonstrated that the digestibility of the late-heading ryegrass was significantly greater than the early-heading ryegrass under two stocking rates and especially at the lower stocking rate. Similarly, in England (Minson *et al*., 1960) reported that the early-heading perennial ryegrass was lower in digestibility during the spring, than the late-heading cultivar. In the present experiment, higher digestibility of the late-heading cultivars may have contributed, in part, to the higher percentage utilization of the late-heading cultivars in 1998 and would also account, in part, for the absence of a difference in percentage utilization in 1999. Nevertheless, overall differences in OMD of pasture on offer and percentage utilization between cultivar mixtures were small, and there were no differences in the OMD of grazed grass, and higher OM intake of grazed grass was recorded in the late-heading cultivars only during the first grazing in 1998.

6.4.2. Grass for silage production

Contrary to that recorded during the spring grazing measurements, the late-heading cultivars tended to have higher ash concentrations in the DM than the intermediate-heading cultivars when harvested for silage in 1999. This difference was consistent across treatments. Nevertheless grass OM yields for silage were consistent with grass DM yields for silage: the ash concentration in grass for silage did not substantially alter the relative differences in grass yields for silage (measured as either OM or DM yields) between treatments.

During this experiment the sward of intermediate cultivars that was not grazed in the spring yielded approximately 6.2 t of grass DM ha^{-1} for silage production harvested on 20 May. This sward had a DMD of 769 g kg^{-1} in 1999. When harvest date was delayed until the 30 May, this sward yielded approximately 8 t of grass DM ha^{-1} for silage production with DMD declining to 738 g kg^{-1} in 1999.

The sward of late cultivars that was not grazed in the spring yielded approximately 7 t DM ha^{-1} on 30 May with a DMD of 768 g kg^{-1}.

Delaying harvested date until 9 June, increased yields to approximately 9.2 t DM ha^{-1} with a DMD of 756 g kg^{-1}. Therefore, delaying silage harvest date by 10 days on late cultivars will give similar, if not higher, DM yields and be of a similar DMD compared with intermediate heading cultivars harvested in late May.

When silage harvest date was deferred to the 30 May, the sward of

intermediate cultivars that was grazed once in the spring yielded approximately 6.9 t DM ha^{-1} at a DMD of 747 g kg^{-1}. Although, DM yield was increased, DMD was lower compared to the intermediate sward harvested on 20 May. Delaying silage harvest date by 10 days on the intermediate-heading swards resulted in a substantial reduction in DMD even when the sward was grazed once in the spring.

However, on the late-heading swards that were grazed once in the spring, delaying silage harvest date until 9 June resulted in yields of approximately 6.2 t DM ha^{-1} with a DMD of 796 g kg^{-1}. Furthermore, delaying silage harvest date until the 19 June resulted in yields of approximately 8.2 t DM ha^{-1} with a DMD of 747 g kg^{-1}. These are similar DM yields with similar DMD's to intermediate swards that were not grazed in the spring and harvested for silage between the 20 and 30 May. Therefore, late-heading swards can be grazed once in the spring and will produce grass yields for silage of similar DMD as intermediate swards not grazed in the spring and harvested between 20 and 30 May, once silage harvest date is delayed by approximately 20 days.

Grazing twice in the spring had a very large negative effect on yields of grass harvested for silage. Deferring silage harvest date to 19 June resulted in yields of approximately 5 t DM ha^{-1} at a DMD of 749 g kg^{-1} on the intermediate-heading swards. This is a relatively low yield of low DMD compared with target yields of between 6 and 7 t DM ha^{-1} at DMD's between 800 and 750 g kg^{-1} in the grass DM. When silage harvest was deferred to 20 June the late-heading swards that had been grazed twice in the spring, grass yields for silage of approximately 4.7 t ha^{-1} were recorded at a DMD of 787 g kg^{-1}. This is relatively high quality but yields were very low. Furthermore, further delaying silage harvest date on the late-heading swards that had been grazed twice in the spring is likely to increase yield, however, this is likely to be associated with a decline in DMD to relatively low levels.

6.4.3. Cumulative effects

When yields of total grass removed either as grazed grass or as grass for silage are examined, it can be seen that a single grazing in the spring reduced cumulative grass yields a little, but the second grazing resulted in substantial reductions in grass yields. In this comparison, cumulative yields include the grazed grass that was consumed. The pre-grazing yields of OM were utilized with an efficiency of approximately 64%. The yields of grass for silage would not be fully utilized: only about 70% of grass harvested for silage would be actually consumed by cattle, as suggested by previous work at Grange. This is based on 3% being lost in the field, 3% lost due to respiration during harvesting and filling, 4% lost via fermentation, 3% via effluent, 8% lost due to respiration during storage and feeding out, 2% wastage during feeding and 7% rejected by the animal. Gordon (1988) recorded losses of 10.4% during harvesting grass for silage and 13.5% during the ensiling process. This amounts to losses of 23.9% during harvesting and ensiling (a further 6 or 7% can be attributed to losses associated to feeding out ~ 30% losses). In the present experiment, when treatments are compared on the basis of 30% losses between harvesting and feeding, it can be seen that grazing once had only a minimal impact on cumulative yields, whereas, grazing twice again reduced yields.

If the swards composed of intermediate cultivars, not grazed in the spring and harvested on the 20 May, are used for comparison, it can be seen that these swards had the capacity to supply approximately 4.3 t of forage that would have been consumed. The quality of the material that would be consumed can only be speculated upon, but the grass harvested had a DMD of 769 g kg^{-1}. The swards composed of late heading cultivars, grazed twice and harvested on the 19 June, had the capacity to supply 5.5 t of forage that would be consumed. Approximately 40% of this material was grazed grass with OMD's somewhere between 800 and 860 g kg^{-1}. The other 60% would have been as silage, and the grass that was harvested for this silage had a DMD of 787 g kg^{-1}. It is clear that better animal performance would have been achieved if the cattle were allowed to graze the late-heading swards twice and fed on the silage that was subsequently harvested on 19 June rather than fed on silage harvested from ungrazed intermediate swards on 20 May.

However, while the biological advantage may lie with grazed late-heading swards, the economics involved in the comparison are more complicated. The costs of silage consumed on the ungrazed intermediate sward harvested on the 20 May would be in the region of £96 t^{-1} DM compared to £117 t^{-1} DM consumed on the late sward, grazed twice and harvested on 19 June (O'Kiely, 1994). Grazed grass can be valued at £37.5 t^{-1} DM consumed (O'Kiely, 1994). On this basis, total costs of silage and grass consumed would be £469 ha^{-1} on the late swards grazed twice and harvested on 19 June, compared with costs of silage consumed of £415 ha^{-1} on the intermediate swards that weren't grazed in the spring and harvested on 20 May.

There are discrepancies in this comparison, in that, the intermediate swards are harvested on 20 May and the late swards are harvested on 19 June. It could be assumed that the regrowth on intermediate swards would have supplied a pre-grazing yield of around 2 t DM ha^{-1} by 19 June. It could be further assumed that this 2 t DM ha^{-1} would be utilized with an efficiency of 75% giving 1.5 t DM ha^{-1} consumed. If this is valued at £37.5 t-1 DM similar to above, this brings the total costs of the intermediate swards, between the early spring and 19 June to £472 ha^{-1}. Therefore, it could be said that there would be no real difference between the costs involved in either system of production.

Therefore, the final issue deciding whether it is better to use intermediate swards, not grazed in the spring and harvested on the 20 May, or to use late swards, grazed twice in the spring and harvested on the 19 June depends on how well either approach fits into the overall system of production. This will depend on individual farms. However, in general, it is much more likely that there will be a risk of grass being in short supply in the early spring on farms than during June under good management on farms where early turnout to grass is feasible. If this situation should arise, grazing late heading cultivars for a second time during the spring and delaying silage harvest date would relieve this shortage. Although this will reduce first-cut silage yields, the overall impact in terms of costs may be negligible and, importantly, overall animal performance is likely to be better.

6.5. Conclusions

* No difference in the capacity of swards, composed of either inter mediate- or late-heading cultivars, to supply grass for grazing in the early spring was detected in this experiment.
* In general, differences in sward quality and in the quality of pasture consumed in the early spring were small, between swards composed of intermediate- or late-heading cultivars.
* On swards that were not grazed in the spring, delaying first cut silage harvest date by 10 days on swards composed of late-heading cultivars resulted in similar, if not higher, grass DM yields of similar DMD compared with swards composed of intermediate-heading cultivars harvested in late-May.
* On swards composed of intermediate-heading cultivars that were grazed once in the spring, delaying silage harvest date by 10 days, resulted in higher grass DM yields but of substantially lower DMD than swards composed of intermediate-heading cultivars not grazed in the spring and harvested on the 20 May.
* On swards composed of late-heading cultivars that were grazed once in the spring, delaying silage harvest date by 20 days resulted in similar grass DM yields of similar DMD as swards composed of intermediate cultivars, not grazed in the spring and harvested for silage between the 20 and 30 May.
* Grazing silage ground twice in the spring substantially reduced grass DM yields for silage even where first cut silage harvest date was deferred to the 19 June.
* Grazing silage swards composed of late-heading cultivars twice in

the spring and harvested for silage on 19 June will result in higher first-cut silage making costs compared to swards com posed of intermediate-heading cultivars, ungrazed in the spring and harvested for silage on 20 May.

* Nevertheless, grazing silage swards composed of late-heading culti vars twice in the spring supplies substantial quantities of high-quality grass during a period when there is risk of grass shortage on the farm. When this is taken into account, the overall costs involved in grazing silage swards composed of late-heading cultivars twice in the spring and harvested for silage on 19 June are unlikely to be substantially different from swards composed of intermediate swards, not grazed in the spring, harvested for silage on 20 May and grazed subse quently in late June. Furthermore, grazing the late-heading cultivars in the spring is also likely to improve overall animal performance.

* From an overall systems point of view, there are very clear advan tages associated with having late-heading cultivars (heading date close to mid-June) on a farm where early turnout to grass is seen as a priority.

7. General Discussion, Implications and Conclusions

Grazing swards with a higher than recommended pre-grazing pasture mass did not impact upon the production of beef cattle in experiment 3. This result is supported by the pre-grazing OMD of swards in experiments 1, 2 and 3 (Tables 5, 12 and 16). Generally differences in OMD of swards with pre-grazing pasture masses between 2000 and 4000 kg DM ha^{-1} were small and non-significant. Furthermore, it is apparent that the estimated OMD of pasture consumed was influenced by the degree of grazing pressure imposed (percentage utilization). As the pasture canopy expands the relative distribution of parts of the grass plant changes. Obviously, as individual grass tillers increase in size, each tiller will have longer leaf-blades and longer sheaths. There is evidence to suggest that grass tillers maintain a leaf-blade length to sheath length ratio of approximately 3.1:1 (Davies, 1977; Wilman and Pearse, 1984). The digestibility of leaf-blade is generally higher than that of sheath material (Wilman and Altimimi, 1982; Wilman, Gao and Altimimi, 1996). Therefore, while the relative distribution of digestible material is similar in swards with different pre-grazing pasture masses, the actual distribution of the digestible material will differ. In other words, swards with high pre-grazing pasture masses will generally have longer sheaths. While the ratio of leaf-blade to sheath remains the same, it is likely that less digestible sheath material will be encountered higher above ground level in the profile of swards with higher pre-grazing pasture masses. The implications of this would appear to be that swards with a higher pre-grazing pasture mass should not be grazed to the same post-grazing height as swards with a pre-grazing pasture mass of less than or equal to 2000 kg DM ha-1. In experiments 1 and 2, this occurred during the course of the experiments; the cattle were not inclined to graze below the stubble (sheath) barrier and hence post-grazing pasture mass generally increased with the pre-grazing pasture mass on offer. Nevertheless, in experiment 3, where cattle grazed to similar post-grazing pasture masses and heights (Fig. 1), the OMD of pre-grazing pasture and the OMD of post-grazing pasture did not differ significantly between treatments. It appears that the cattle in both treatments were able to select pasture of sufficiently high nutritive value to achieve very high levels of animal performance.

This indicates that it is possible to get high levels of performance from beef cattle grazing swards with high pre-grazing pasture masses once appropriate grazing management practices are employed. Nevertheless, grazing swards with high pre-grazing pasture masses cannot be generally recommended as good grassland management. However, on beef farms, particularly in the late spring and during the summer, grass surpluses can sometimes arise as a result of sustained above average grass growth rates. Under such circumstances, removal of these surpluses of baled silage is currently recommended. However, this is generally considered to be a relatively expensive process. As pointed out in Experiment 4 higher yields of grass per hectare have a large influence on lowering silage production costs. Therefore, on beef farms, where every opportunity to cut costs as a means of maximizing profitability must be pursued, not removing surpluses as baled silage and grazing higher pre-grazing pasture masses may be the more profitable option. Grazing high pre-grazing masses, which will be associated with high pasture covers, reduces the area required for grazing. Moreover, once acceptable pasture covers are maintained (by carrying a higher cover on a truncated grazing area) the grass on the remaining grazing area can be allowed to accumulate and be taken out as part of the main silage harvests. (The area involved may only be a very small proportion of the grazing area and would be closed for silage in a manner that aims at high DM yield per unit area).

Surpluses of pasture, when they occur, are relatively easy to deal with - the objective being to deal with them as cheaply as possible while maintaining grass quality for the remainder of the grazing season. Deficits in pasture supply are generally more troublesome and can necessitate feeding relatively higher cost alternatives. Deficits in pasture supply can occur at any time of the grazing season, but are most likely to occur during the second grazing rotation and during the period immediately after first cut silage. In the latter situation, a high pasture cover on the grazing area helps to buffer against potential deficit and, as outlined above, need not result in lowered performance of beef cattle once appropriate management practices are employed. In the former situation, where deficits arise during the second grazing rotation, grazing the silage area for a second time and deferring the silage date is considered to be a cheap option on some farms. The results of experiment 4 would support this assertion. In experiment 4 the fertilizer N application pattern and rates were identical across treatments (60 kg N ha^{-1} in mid-February and 60 kg N ha^{-1} after the first grazing). It is likely that this approach was not the optimum for any treatment and perhaps least of all for maximizing silage yields on the swards that were grazed twice in the spring. This is a valid criticism of this experiment but the alternative would have resulted in the inclusion of N fertilizer application pattern as a factor or the possibility of confounding the results by using different application patterns in the different treatments. Inclusion of fertilizer N applications as a factor would have increased the size of, and the number of factors in, an already large and complex multi-factorial experiment. Nevertheless, this is an area that merits further investigation. Its is likely that fertilizer N application practices, resulting in higher yields of grass for first cut silage, can be designed for swards that have been grazed twice in the spring. For example, 30 kg N ha-1 in mid-February, 60 kg N ha^{-1} after the first grazing and 60 kg N ha-1 after the second grazing. In farming practice, where the silage ground is grazed for a second time only as a matter of necessity, 60 kg N ha-1 can be applied after the first grazing (mid-March). If grass growth rates and pasture supply on the grazing area are sufficient to meet demand and the silage ground need not be grazed for a second time, the second 60 kg N ha^{-1} can be applied in mid- to late-April. This is generally the time of year when the farmer can be reasonably sure that grass growth rates will be sufficient to ensure that pasture supply is likely to meet demand during the subsequent period up until first cut silage regrowths are available for grazing.

Although it would seem paradoxical, late-heading cultivars probably offer the best prospect for ensuring supply of grass for grazing in a 'late spring' (with sub-normal grass growth rates). This is mainly because they have higher nutritive value in late-May and early-June than intermediate cultivars when harvested for silage. They can be harvested for silage later at the same digestibility as intermediate cultivars, and hence, they can be grazed later into the growing season before closing for silage. For this reason, there are very clear advantages associated with having late-heading cultivars (heading date close to mid-June) on a farm where early turnout to grass is seen as a priority.

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