Systems of Winter Milk Production based on all Autumn Calving Cows

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Effect of supplementing grass silage with grazed grass in the winter diet or feeding a mixed forage diet on milk production and reproduction of autumn calving cows.

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Summary

A supply of winter milk is needed by certain milk processors for the production of high value dairy products with a short shelf life to balance the high level of commodity based products which are mainly manufactured from seasonal milk produced from spring calving herds. Winter milk is generally produced by suppliers with split calving herds. A proportion of the cows (30-50%) calve in Autumn (September-December) to supply winter milk for which they receive a winter bonus for a contracted supply for the months of October to February. The remainder of the herd calve in Spring (Feb-April) and produce milk mainly off grass for which no bonus is paid. This system evens out the supply of milk throughout the year but complicates management, as it involves running two herds on the farm, with two calving seasons, two breeding seasons and two sets of replacement heifers to be reared. Also there is no break from milking. A system of winter milk production based on calving all of the cows in Autumn would be simpler, as it would involve only one herd, with a break from milking in late Summer and would appeal to many winter milk producers.

In this study the feasibility of operating an all Autumn calving herd was examined, in terms of management, calving, winter feeding, reproduction and summer grazing. The herd was located in the Ballyderown farm attached to the Moorepark Research Centre. Alternative winter feeding systems were put in place over a three year period to compare the feed requirements and milk

production of each system. A control system based on grass silage as the sole forage was compared with one where grass silage was supplemented with extended grazing of grass in late Autumn and early Spring or with a system based on a mixed forage diet based on grass silage, maize silage, brewers grains or a brewers grains/beet pulp mix. Grass silage and maize silage was produced within each system and the cows on each system were grazed separately within their own farmlets. The overall stocking rate for each system was 2.7 cows/ha using 350 kg N fertiliser/ha in addition to cattle slurry. Cows were dried off in mid-late July and were grazed tightly until calving down. The calving season extended from early September to early December. Most cows calved down outdoors at pasture or in a calving paddock without assistance. Cows were housed from early November to late March and were allocated to their respective diets in batches according to milk yield, lactation number and calving date. The cows given access to winter grass were given a daily allocation of grass (6-8 kg DM/cow) and grazed between morning and evening milking.

Main findings

- Compared with grass silage as the sole forage (Treatment 1 in Experiments 2 and 3), inclusion of grazed grass by day in early winter (Nov.-mid Dec.) partially replaced grass silage and increased milk yield by an average of 2.1 kg/day and improved milk protein concentration by 0.4 g/kg milk.
- Inclusion of early Spring grass in the diet (mid-Feb-late march) with grass silage increased milk yield by an average of 2.9 kg/day and increased milk protein concentration by 0.85g/kg. In Experiment 2 there was a carryover benefit from winter grazing, resulting in an overall increase in yield of 400 kg/cow or 20 kg fat + protein/cow, resulting in an overall response of 1.14 kg milk/kg grass DM eaten in winter.
- Feeding a mixed forage diet based on grass silage, maize silage, brewers grains and grazed grass/rape in early or late winter (Treatment 3 in Experiments 2 and 3) or grass silage and a brewers grains /beet pulp mix (Treatment 2 in Experiment1) resulted in a high level of intake and a consistent high milk yield over the winter. Compared with the grass silage diet, feed intake on the mixed forage diet was increased by an average of 4.4 kg DM/day, milk yield by an average of 3.8 kg/day and milk protein concentration by 0.9 g/kg. The difference in yield progressively increased over the winter from 2.5 to 5.4 kg/day, as milk yield declined on the grass silage based diet. In Experiments 2 and 3 the cows on the mixed forage diet produced more milk at pasture and produced an additional 619 and 952 kg milk/cow, respectively, over the lactation compared with the cows on the grass silage based diet. The overall response in milk production to the additional feed consumed was 1.12 kg milk/kg extra forage DM eaten in winter. In Experiment 1 feed intake on the mixed forage diet (Treatment 2)

was increased by 429 kg DM/cow over the winter compared with the control diet of grass silage and grazed grass (Treatment 1) and increased milk yield by 382 kg/cow, giving a response of 0.89 kg milk/kg extra DM eaten. In this experiment there was no carryover benefit in milk production when cows subsequently grazed at pasture.

- The overall reproductive performance of the herd when confined to a compact 13 week breeding season was poor, and 27-32 % of the cows were not in calf at the end of the breeding season. Factors involved were the short day length in winter, crowded housing conditions and slippery foot conditions on slats resulting in restricted oestrus activity among the housed cows and reduced oestrus detection when based on tail paint and observation. In addition conception rates to first service were moderate to low, resulting in a high incidence of repeat heats. Oestrus synchronisation of the herd using a CIDR programme in Experiment 3 to overcome the problem of accurate oestrus detection indoors did improve the submission rate early in the breeding season, but conception rates to the first and subsequent services remained low, resulting in only a small improvement in pregnancy rate and calving to conception interval. Increasing the level of feeding prior to or during the breeding season by providing grazed grass with grass silage or feeding a mixed forage diet had no beneficial effect on fertility. Cow fertility was actually poorer on the mixed forage diet in two of the three experiments.
- Good levels of milk production can be achieved with a system of all Autumn calving cows. A good response in milk production and in milk composition can be obtained by including winter grazed grass in the diet to supplement grass silage at little extra cost on free draining dairy farms. Where other feeds are available to provide a mixed forage diet, high levels of intake and milk production can be sustained over the winter and subsequently at grass without increasing the level of concentrate supplement. However, the low level of cow fertility achieved with an all Autumn herd would make the system unsustainable in the long term, unless a large proportion of replacement heifers are reared, which would add considerably to overhead costs. An alternative approach would be to retain a proportion of the younger non-pregnant cows, extend their lactation and rebreed them to calve down in the following Spring. However, this would involve having a small spring calving herd to manage alongside the main autumn calving herd which would complicate management and would provide no break in milking.

Introduction

In the Republic of Ireland the majority of dairy herds consist of Spring calving cows (calving from mid January to late April) and are involved in the production of seasonal milk for processing mainly into commodity type dairy products, such as butter, skim milk powder, casein, and hard cheeses. This seasonal system of milk production has evolved over many decades since the main commodity products can be produced relatively cheaply from milk produced mainly from grass during the main grass growing season (March-October), with some conserved forage, mainly grass silage, and a moderate level of concentrates being fed to supplement grass in late Autumn and early Spring. During the main winter months (November to January) these cows are producing very little milk in late lactation or are dried off for a period of 8 weeks. Consequently, their feeding requirements are considerably reduced during this period and can be met by feeding a diet based mainly or wholly on grass silage or other forage, with little or no concentrate supplementation.

While this system of milk production is adequate for the production of commodity based products with a long shelf life, which can be stored for sale and distribution during the winter months, it is not suited to the needs of some milk processors who require a supply of high quality milk on an all year round basis for the production of high value consumer dairy products with a short shelf life. These products include yoghurt, dairy deserts, soft cheeses, probiotic milk drinks and cream liqueur. These products require a supply of high quality milk in terms of chemical composition (fat, protein to lactose ratio), low somatic cell count, low total bacteria cell count and with good processability characteristics, which often cannot be supplied by Spring calving cows in late lactation or by freshly calved cows in early Spring. Milk for these products is produced under contract by certain milk suppliers who undertake to supply a minimum level of milk during the critical winter months (October to February) and for which a winter milk bonus is paid over the base price available for seasonal milk to cover the higher cost of producing milk during the winter. The extent of this bonus varies between milk processors and the proportion of milk supplied during the winter months.

To supply the required amount of winter milk, most winter milk producers calve a proportion of their herd, usually 30-50%, in Autumn (September- December), with the remainder (50-70%) calving in Spring (February –April). In this system a high proportion of the annual milk supply can be produced relatively cheaply from grazed grass, while the amount of milk produced in winter can be supplied by the autumn calving cows. However, this system involves running two herds of cows at different stages of lactation, with two calving seasons, two breeding seasons, rearing two sets of calves and replacement heifers, and with no break from milking. In many cases the calving and breeding seasons overlap for the two herds in winter/early spring, resulting in fatigue and a lack of focus. This leads to a long drawn-out calving and breeding season in the following year, often extending over a 5-6 month period, as the dairy farmer tries to retain good cows, which are difficult to get incalf, in the herd. This situation has often led to dissilusionment on the part of some winter milk producers. Some have opted out and moved to a system of seasonal Spring milk production, which they perceive to be easier to manage and yielding relatively good financial returns based on seasonal milk prices up to now compared with the winter/ summer system of milk production that they operated.

To counteract this trend a system of winter milk production based on a herd of all autumn calving cows was compared with a mixed season calving herd (50% Autumn, 50% Spring calving) and with a traditional all Spring calving herd over a two year period at the Solohead Field Station, Co.Tipperary. (G. Ryan et al., End of Project Report, No. 4169). The results of this study showed that a system of all autumn calving cows (A) could be established and resulted in a higher level of milk production per cow compared with either an Autumn/Spring calving system (AS) or an all Spring calving system (S), but required a higher input of concentrates with a grass silage based winter forage, (milk yield 6532, 6358 and 6142 kg/cow and concentrate input of 1237, 907 and 613 kg/cow, averaged over the two years, for systems A, AS and S, respectively). However, the reproductive performance of the Autumn calving cows in systems A and AS was poorer than the spring calving cows in systems AS and S, in terms of the proportion of cows served in the first 3 weeks of the breeding season (59 v 87%), due to poorer heat detection in housed cows in winter compared with cows at grass in summer, and in overall fertility (23 v 10% of cows not in calf).

To encourage winter milk producers to remain in or expand winter milk production, some of the milk processors involved in winter milk processing have altered their winter milk payment schemes to facilitate those who wished to move from their existing mix of Autumn/Spring calving to either a higher proportion of autumn calving or all autumn calving herds. The current study was undertaken at Ballyderown farm to provide further information on the management and feeding of an all autumn calving herd for those producers who wished to expand in winter milk production or move to an all Autumn calving enterprise.

Experimental

The broad objective of this study was to examine the feasibility of establishing and maintaining a compact calving all Autumn calving herd over a three year period and evaluate alternative systems of feeding and managing Autumn calving cows, based on different types of forage or feeds which may be available in different locations or situations.

The dairy herd at Ballyderown Research Farm consisted of a Spring calving herd which was used mainly for studies on aspects of milking machine research or milk quality research. This herd was partially replaced with an Autumn calving herd in 1998 by transferring Autumn calving cows from the Solohead Research Farm to Ballyderown and by purchasing Autumn calving heifers from a commercial autumn calving herd. The herd was changed over to an all Autumn calving herd by Autumn 1999.

Traditionally Autumn calved cows are housed in late October/ early November and are fed on a diet of grass silage as the main or sole forage supplemented with a moderate to high level of concentrates and remain indoor until fulltime turnout to grass in late March or early-mid April. However, in the main areas where winter milk is being produced, other feeds and feeding systems can be adopted. Grazed grass can constitute part of the diet on dry free-draining farms in the South and South-East in late Autumn and in early Spring, particularly on moderately stocked farms. Other forages, such as maize, can be grown on many dairy farms or purchased locally from tillage farms, and ensiled as an alternative forage to partially replace grass silage in many parts of the South, East and North –East. Wet by-product feeds, such as brewers grains or pressed sugarbeet pulp are also being increasingly used as part of the winter diet on dairy farms. These feeds can be purchased locally in the main areas involved in winter/liquid milk production, ensiled and fed to either partially replace grass silage or concentrates or as part of the total diet in a mixed ration to increase feed intake.

The objectives of the feeding regimes examined in this study were

1. to determine the benefit of providing grazed grass in the diet of Autumn calving cows to supplement grass silage in late Autumn (Nov-Dec) and early Spring (Feb-March) compared with cows housed all winter (Nov-March) and fed on grass silage as the main forage. This feeding system would be applicable on dry farms where late and early grazing is practical in areas of the South and East, in contrast to wet or cold areas in the Midlands and North-East where cows have to be housed fulltime for at least five months (Nov-March).
2. to determine the benefit of including alternative forages or feeds, such as maize silage or a by-product feed, such as brewers grains, to partially replace grass silage in a mixed forage diet. This feeding regime is applicable on many dairy farms in areas involved in winter milk production, but particularly where grass may not be available as an alternative winter feed.

Experiment 1

A comparison of a diet of grass silage and grazed grass with a mixed diet of grass silage and brewers grains/beet pulp for winter milk production.

During the changeover phase from an all Spring calving herd to an all Autumn calving herd, a limited number of Autumn calving cows (58), a high proportion (38) of which were in their first lactation, were available in the first season for a winter feeding experiment. In this experiment a low input winter feeding system was compared with a moderate input system for milk production. The two winter feeding treatments were conducted during the main winter months (early

Nov-early April) and subsequent milk production at grass was recorded until cows were dried off.

Treatment 1 (T1): A low input system based on grass silage and grazed grass by day in early Winter and in early Spring. The winter was divided into three periods, as follows;

P1. Early Winter (1/11-20/12/98). Cows were fed on grass by day and indoor on grass silage by night.

P2. Mid-late Winter. (21/12-6/3/99). Cows were indoor day and night and fed on grass silage.

P3. Early Spring. (7/3-4/4/99). Cows were fed on grass by day and on grass silage by night.

Treatment 2. (T2). A moderate input system based on grass silage and a by-product feed based on brewers grains and dried sugar beet pulp (Pulp and Brew; a 2:1 mix of brewers grains and beet pulp on a DM basis). The cows were housed fulltime and fed on this diet throughout the winter (P1-P3).

Cows on each treatment received the same concentrate supplement at a level of 7kg/cow/day fed in two equal feeds in the milking parlour. The grass silage and the silage and by-product mix was weighed out daily using a diet feeder, allowing approximately 5% refusals, to provide ad lib forage feeding. The cows were housed in two groups in a conventional cubicle shed with a slatted tank underneath the feeding area.

During the dry period (July-August) cows were grazed tightly at pasture and received a pre-calving supplementary mineral lick. The cows calved outdoors in a paddock near the yard from early September until early November. Later calving cows were housed, fed on grass silage alone and calved in a loose calving house. The early calving cows grazed fulltime at pasture and were supplemented with concentrates at 6 kg/cow/day, at milking, from calving to Mid-October. Due to inclement weather from mid-October to early November the cows grazed by day only and were housed by night and fed on grass silage. The level of concentrates fed was increased to 7 kg/cow/day. The cows were then placed on their experimental treatments. The cows were allocated to the treatments in three batches according to calving date, lactation number (lactation 1 or older) and milk yield. Initially 17 cows were allocated to each treatment (Batch 1) in early November. Later calving cows were assigned to the trial in mid-November (Batch 2, 4 cows/treatment) and in early December (Batch 3, 5 cows/treatment), resulting in 26 cows/treatment from then on. Two cows on Treatment 2 developed a severe mastitis infection and had to be removed from the experiment in early January and in mid March.

Three 1 ha paddocks were set aside in mid September for late autumn grazing by the cows on T2. A further two 1ha paddocks which had been grazed in late September and early October were also included for late grazing.

The cows were turned out to grass fulltime in early April and concentrates were reduced to 2 kg/cow/day over three weeks and ceased by late April. The cows were given a daily allowance of grass sufficient to leave a post-grazing height residue of 6-7 cm. All cows were dried off 8 weeks before next calving date or by late July.

Results of Experiment 1

Feed intake and milk production for the three winter periods and the total winter, subsequent milk production at pasture and for the total lactation are shown in Tables 1 and 2, respectively.

Period 1 (1/11-20/12). The cows on T1 had access to grazed grass by day and were indoor on grass silage by night, while the cows on T2 were indoor fulltime on the mixed forage diet of grass silage and brewers grains/ beet pulp mix. During the first four weeks the grass cover on the swards grazed by the cows on T1 was high, averaging 2010-2640 kg DM/ha above 4 cm cutting height. The cows were given a daily grass allowance of 7-8kg DM/cow. Grass intake, estimated by difference from pre and post grazing quadrant clips above 4 cm, averaged 4.4 kg DM/cow/day with a grass utilisation rate of 60%. During the last three weeks of this period the grass cover on the remaining paddocks was reduced (1310-1640 kg DM/ha). The grass allowance was maintained at 7 kg DM/cow/day but grass utilisation was much reduced (48%) due to soft ground conditions and grass intake was reduced, averaging 3.4 kg DM/cow/day. Overall intake of grass for this period averaged 3.9 kg DM/cow/day with a utilisation rate of 55%. Grass silage intake was similar for the two treatments but total forage and total DM intake was higher (+1.8 kg DM/day) on T2 compared with T1. Milk yield was higher for the cows on T2 (+ 1.4 kg/day) and protein concentration was also higher on T2 during this period.

Period 2 (21/12-28/2). The cows on T1 were indoor fulltime on grass silage. Silage intake increased to 9.6 kg DM/cow/day and was 1.8 kg DM/cow/day higher than on T2. However, inclusion of the brewers grains/pulp mix with the grass silage in T2 increased total forage and total DM intake by 3.3 kg DM/cow/day compared with T1. Milk production on T2 was 3.7 kg/day higher than on T1 and was maintained at a similar level as that achieved in Period 1, whereas milk production declined on T1 during Period 2. Milk fat and protein concentrations were also higher on T2 during this period.

Period 3 (1/3-2/4). The cows on T1 again had access to grazed spring grass by day and grass silage by night. Grass cover on the paddocks available for grazing was low (600-800 kg DM/ha) until mid March and increased to 900-1000 kg

DM/ha in late March. The cows were given a restricted grass allowance of 6 kg DM/cow/day for the first three weeks and a more lenient allowance of 8-9 kg DM/day for the last two weeks. Overall grass intake for the five-week period averaged 4.8 kg DM/cow/day with an average utilisation rate of 75%. Grass silage intake by the cows on T1 was much reduced and total forage and total DM intake was less than for T2 (-3.2kg DM/day). However, milk production was only marginally lower for T1 (-0.9 kg/day) compared with T2, while milk composition was similar for both treatments.

Over the total winter grass silage intake was similar for both treatments. Intake of additional feed in the form of grazed grass was 360 kg DM/cow on T1 compared with an intake of 812 kg DM/cow of the brewers gains/beet pulp mix, resulting in a higher total DM intake of 429 kg DM/cow on T2. This resulted in the additional production of 382 kg milk, 15.6 kg fat, 14.0 kg protein and a slightly higher milk protein concentration on T2 compared with T1 over the winter.

When the cows were subsequently grazed together at pasture until drying-off, milk production was slightly less on T2 compared with T1 and milk composition was similar. Over the total lactation milk yield was increased on T2 by 275 kg/cow, fat yield by 13.1 kg/cow and protein yield by 9.7 kg/cow compared with T1, while overall milk composition was similar on both treatments. The overall yields achieved were reasonable, bearing in mind that 18 cows on each treatment were in their first lactation.

The cows were in moderate to poor condition when placed on trial (Table 3). The cows on both treatments gained in condition over the winter, with those on the higher intake diet (T2) gaining more condition towards the end of the winter. When turned out to pasture in Spring/Summer the cows on both treatments continued to gain in condition and reached a similar good condition in mid-Summer.

Discussion on Experiment 1

Including a supplement of brewers grains and beet pulp with grass silage resulted in a very stable and high intake of total forage and total DM intake for the cows on T2 over the three periods (17.4-18.2 kg total DM/cow/day). As a result milk production also remained relatively stable, declining by only 1.2 kg/day from Period 1 to Period 3 and milk fat and protein concentration remained high. The benefit of including the brewers grains/ beet pulp mix in the diet was most obvious in Period 2, compared with the cows on grass silage as the sole forage on T1 during this period. Including the supplement reduced silage intake by 1.8 kg DM/cow/day but increased total DM intake by 3.3 kg DM/day, resulting in a low substitution rate of 0.35 kg silage DM/kg supplement DM consumed. Compared with T1, milk yield was increased by 3.7 kg/day, giving a response of 0.73 kg extra milk /kg supplement DM or 1.13 kg milk/kg extra total DM eaten. There was also an improvement in milk fat and protein concentration on T2, resulting in a higher yield of fat and protein (1.51 v 1.22 kg/day), producing a response of 57g fat + protein/kg supplement DM fed. The supplement also improved body condition of the cows over the winter compared with those on T1.

The contribution of grazed grass to the cows diet in late autumn and early spring in Treatment 1, in terms of a saving of grass silage and in milk production, can be estimated indirectly by comparing silage intake and milk production in Periods 1 and 3 with Period 2 when there was no grass in the cows diet. The scale of the differences in feed intake and milk production between the cows on Treatments1 and Treatment 2, (which remained on the same mixed forage diet for each of the periods) also give an indication of the contribution of grazed grass to the cows diet and milk production during late Autumn and early Spring. Compared with Period 2, silage intake/cow on T1 in Period 1 was 2.7 kg DM/day less (9.6 v 6.9 kg DM/day), while consuming 3.9 kg DM/day of grazed grass, resulting in an increase of 1.2 kg forage DM/day or a substitution rate of 0.7 kg silage DM/kg grass DM eaten. In terms of milk production, milk yield declined by an average of 2.7 kg/day when grass was omitted from the diet in Period 2 compared with Period 1, whereas milk yield declined only marginally (-0.4 kg/day) on T2 as lactation progressed when the cows remained on the same diet during Periods 1 and 2. The decline in milk yield (-2.3 kg/day) relative to the cows on T2 could be ascribed to the omission of Autumn grazed grass from the diet and therefore the response in milk yield to the provision of grass in Period 1 can be estimated to be 0.6 kg milk /kg grass DM eaten. Milk fat and protein concentration declined in Period 2 compared with Period 1 for T1 (-4.0 g fat, -0.8 g protein/kg milk). However, a similar but smaller decline in the composition of milk for the cows on T2 also occurred in Period 2 (-3.3g fat, -0.3g protein). The higher milk composition in Period 1 could be partly due to the inclusion of two batches of freshly calved cows in both treatments in that period. The net reduction in the yield of fat and protein for T1 compared to T2 in Period 2 (-0.17kg/day) could be attributed to the absence of grass in the diet of the cows on T1 in Period 2, indicating a response of 43g fat + protein/kg grass DM eaten in Period 1.

Table 1. Feed intake (kg DM/cow/day) per period during the winter in Experiment 1.

Feed intake (kg DM/cow/day) per period during the winter in Experiment 1

Winter Forage Treatment.	**T1. Grass Silage + grazed grass (P1&P3)**	**T2. Grass silage + Brewers grains / beet pulp mix**
	Kg DM/cow/day	**Kg DM/cow/day**

Period 1 (2/11-20/12/99)		
Grass silage	6.9	7.3
Brewers grains/beet pulp mix	-	5.3
Grazed grass	3.9	-
Total forage	10.9	12.6
Concentrates	5.3	5.3
Total diet	16.1	17.9
Period 2 (21/12/-28/2)		
Grass silage	9.6	7.8
Brewers grains/beet pulp mix	-	5.1
Total forage	9.6	12.9
Concentrates	5.3	5.3
Total diet	14.9	18.2
Period 3 (1/3-2/4)		
Grass silage	4.1	6.5
Brewers grains/beet pulp mix	-	5.6
Grazed grass	4.8	-
Total forage	8.8	12.1
Concentrates	5.3	5.3
Total diet	14.1	17.4
Total winter (22 weeks) (kg DM/cow)		
Grass silage	1155	1133
Brewers grains/beet pulp mix	-	812
Grazed grass	360	-
Total forage	1515	1945

Concentrates	812	812
Total diet.	2328	2757 (+429)

In Period 3 (early Spring) silage intake of the cows on T1 was much reduced compared with that consumed in Period 2 (-5.5 kg DM/day), when they consumed 4.8 kg grass DM/day, indicating a substitution rate of 1.15 kg silage DM/kg grass DM eaten. The reduction in silage intake was partly due to deterioration in the quality of the grass silage at the end of the pit. Milk production increased by 2.0 kg/day when the cows on T1 had access to spring grass, compared to Mid winter (Period2), while the yield of cows on T2 declined by 0.8 kg/day compared with Period 2. The net contribution of spring grass to the diet was thus estimated to increase milk yield by 2.8 kg/day or by 0.58 kg milk/kg grass DM eaten. There was also an improvement in milk composition during this period of 1.2 g fat and 2.1g protein/ kg milk for T1 in Period 3 compared with Period 2 The net increase of 0.8g fat and 1.1g protein/kg milk for T1 compared with T2, could be attributed to the effect of grass in the diet. The yield of fat and protein was increased by 0.22kg/day on T1 relative to T2 during this period, giving a response of 46g fat + protein/kg grass DM eaten. These responses in milk and milk solids to grass in the diet of cows on T1 were similar to those estimated for Period 1 and indicate that grass can contribute equally in early Winter and early Spring to milk production of Autumn calved cows fed on a grass silage based forage.

Table 2. Milk Production per Period, Total Winter and Total Lactation in Experiment 1.

Milk production per period, total winter and total lactation in experiment 1

Winter feeding treatment	T1. Grass Silage + Grazed grass (P1&P3)		T2. Grass silage + brewers grains/beet pulp mix	
Pre-Experiment (calving to 1/11/98)				
No. cows calved	21		21	
Milk (kg/cow)	793		716	
Fat (g/kg)	44.2		44.9	
Protein (g/kg)	34.4		35.1	

Period 1 (2/11-20/12) 7 wks				
Milk (kg/day)	21.1		22.5	
Fat (g/kg)	39.9		40.1	
Protein (g/kg)	31.5		32.2	
Period 2 (21/12-28/2) 10 wks				
Milk (kg/day)	18.4		22.1	
Fat (g/kg)	35.9		36.8	
Protein (g/kg)	30.7		31.9	
Period 3 (1/3-4/4) 5 wks				
Milk (kg/day)	20.4		21.3	
Fat (g/kg)	37.1		37.2	
Protein (g/kg)	32.8		32.9	
<u>Total winter</u> P1-P3 (1/11-4/4) 22 wks	kg/cow	g/kg	kg/cow	g/kg
Milk	3003		3385	
Fat	113.6	37.8	129.2	38.2
Protein	94.5	31.5	108.5	32.1
Period 4. At grass (5/4-1/8)	kg/cow	g/kg	kg/cow	g/kg
Milk	1870		1791	
Fat	76.1	40.8	73.4	40.5
Protein	63.9	34.2	60.8	34.0

Total lactation	kg/cow	g/kg	kg/cow	g/kg
Milk	5514		5789	
Fat	217.9	39.5	231.0	39.7
Protein	180.5	32.8	190.2	32.9

Table 3. Body Condition Score of cows on treatments during Experiment 1.

Body condition score of cows on treatments during experiment 1

	Trt.1 Grass silage + Grazed Grass		**Trt. 2 Grass silage+ brewers grains/beet pulp mix**	
Date	**BCS (no. cows)**	**Change in BCS**	**BCS**	**Change in BCS**
Start (5/11`or 7/12/98)	2.66 (26)		2.64 (25)	
21/12/98	2.64	-0.02	2.70	+0.06
7/1/99	2.75	+0.09	2.79	+0.15
2/3/99	2.82	+0.16	3.07	+0.43
9/4/99	3.09	+0.42	3.22	+0.58
10/5/99	3.10	+0.44	3.14 (23)	+0.50
23/6/99	3.43	+0.77	3.45 (21)	+0.81

Experiment 2

A comparison of grass silage, grass silage and grazed grass and a mixed forage diet for winter milk production.

In this experiment three winter feeding regimes were compared to evaluate the benefit of grazed grass in the cows diet in combination with grass silage for part of the winter and compared with grass silage as the sole forage or with a mixed forage diet based on grass silage, maize silage, and brewers grains and with grazed grass in the diet in early Spring. The three treatments were as follows:

Treatment 1. Cows were indoor fulltime and fed on grass silage throughout the winter (1st Nov-2nd April)

Treatment 2. Cows were given access to grazed grass by day in early winter and in early spring and silage by night and were housed fulltime in midwinter and fed on grass silage as the sole forage.

Treatment 3. Cows were fed on a mixed forage diet consisting of grass silage (25%), maize silage (50%) and brewers grains (25%), on a dry matter basis. Cows were indoor fulltime from early November until late February and were also given access to Spring grass by day in March.

The winter was divided into three periods based on when grass was available to the cows in Treatment 2.

Period 1 (1/11-5/12) - Cows on Treatment 2 had access to autumn saved pasture by day while the cows on the other treatments were indoor fulltime.

Period 2 (6/12-20/2) - Cows were housed fulltime on all treatments.

Period 3 (21/2-2/4) -Cows on Treatments 2 and 3 had access to early Spring pasture by day, were housed by night and were fed on their respective forages.

Feeding and management.

All of the herd at Ballyderown farm was changed over to an autumn calving herd. The herd was increased to 78 cows by including 25 recycled cows from the Spring calving herds at Moorepark and Curtin's farm, which had failed to go incalf for the previous Spring and were rebred to calve in Autumn. The herd also included 15 incalf heifers.

Cows calved from early September to mid November, with a mean calving date of 28th September, and most cows calved outdoors. Cows grazed fulltime at pasture and received 6 kg/cow/day of a concentrate supplement up to late September. During a period of very wet weather in late September/ early October, cows were housed by night and fed on grass silage. Concentrates were increased to 7.5 kg/cow/day, and up to 9 kg/day to a few thin high yielding cows. When weather conditions subsequently improved cows were again turned out to pasture by night but received grass silage after the evening milking, while the concentrate level was maintained at 7.5 kg/day. Cows were allocated to the three treatments in two batches, based on calving date, lactation number and milk yield. Batch 1, containing 21 cows/treatment, were assigned on 1st November, while batch 2, containing 5 cows/treatment, was assigned in late November. Each treatment contained 8 heifers (lactation 1) and 18 older cows (lactation 2-4). The cows were housed in single groups in a conventional cubicle shed with a slatted floor area along the feeding passage. The cows on T1 and T2 received 7.5 kg/day of a concentrate supplement (18% CP) in two equal feeds in the milking parlour. A similar level of concentrates was fed to the cows on T3, but 1kg of the concentrate was replaced with 1kg/day of a soyabean meal/mineral mix which was included with the mixed forage diet.

Cows on T1 and T2 were fed grass silage ad libitum. The mixed forage diet in T3 was mixed in a diet feeder wagon on a daily basis. During periods 1 and 3 the cows on T2 and those on T3 in period 3 were turned out to grass between morning and evening milkings (9.00-15.00h).

Early winter grazing for cows on Treatment 2 (P1): Four 1ha paddocks were set aside for winter grazing from late September to mid October. Grass yield was good in the two paddocks closed in September, when grazed in November (1390-1680 kg DM/ha over 4 cm) but was poor in the two paddocks closed in October (480-810 kg DM/ha). Grass was allocated on a daily basis at a level of 7kg DM/cow/day in weeks 1-2, declining to 6-7 kg DM/cow/day in weeks 3-4 and to 5.5 kg DM/cow/day in week 5. Daily intake of pasture, based on pre and post grazing quadrant cuts, was estimated to be 5.2 kg DM/cow in weeks1-2, declining to 4.4-4.7 kg DM/cow in weeks 3-4 and to 3.8 kg DM/cow in week 5. Overall utilisation of pasture was estimated to be 72% of that offered.

Early Spring grazing for cows on Treatment 2 (P3). Six 1ha paddocks which had previously been grazed in October were given a fertiliser dressing of 50 kg N/ha as urea in January to provide early grazing from late February to early April. The pre-grazing yield was in the range of 900-1090 kg DM/ha up to mid March, rising to 1550 kg DM/ha in late March. Cows were offered a daily grass allocation of 5-7 kg DM/cow up to mid March and 8-9 kg DM/cow in late March. Estimated daily herbage intake was low initially at 2.2 kg DM/cow in week 1, rising to 4.2-5.0 kg DM/cow in weeks 2-4 and 5.3-6.7 kg DM/cow in weeks 5-6. Overall grass utilisation was 67% of that offered.

Early Spring grazing for cows on Treatment 3 (P3). Four 1 ha paddocks of grass which had previously been grazed in October were fertilised with 50 kg N/ha in January for early Spring grazing. Two ha which had previously grown a crop of maize were surface seeded with Westernwolths or RVP Italian ryegrass after harvesting the maize in October. These were grazed in late March. The pre-grazing yields of grass in the permanent pasture were 840-1220 kg DM/ha up to mid March and yields in the reseeded Italian ryegrass swards were 1440-2110 kg DM/ha in late March. Cows were given a daily grass allocation of 5-7kg DM/cow up to mid March and 8-9 kg DM/cow in late March. Estimated daily herbage intake increased from 2.2kg DM/cow in week 1 to 4.7-5.3 kg DM/cow in weeks 2-4 and 6.8 kg DM/cow in weeks 5-6. Overall utilisation of grass was 71% of that offered.

Grassland management during the grazing season..

Each treatment was allocated 8.5 ha grassland to provide silage and grazing for the whole year. The overall stocking rate was high at 2.7 cows/ha using 350 kg N fertiliser/ha. Due to different requirements for grass silage for each treatment, different areas of pasture were closed for silage within each treatment. For Treatment 1 3ha was closed and cut for 1st cut silage (late May), and 2.5ha for 2nd cut silage (mid July). For Treatment 2, 2.5 ha was closed for 1st and 2nd cut silage. For treatment 3, 2ha was sown down to maize, 1ha of grass was closed for 1st cut silage and 0.5 ha for 2nd cut silage. Surplus grass was cut from each system as a 3rd cut silage in early September and conserved as baled silage. The aim was to make sufficient silage within each system for the winter, namely 1.5t grass silage DM/cow for T1, 1.25 t grass silage DM/cow for T2, and 0.5 t grass silage DM and 1.0 t maize silage DM/cow for T3. Sufficient silage was made within each system and surplus silage was fed to the replacement heifers.

Results of Experiment 2.

The winter feeding period was subdivided into three periods which coincided with the main events described earlier. In period 4 all cows were grazed fulltime at pasture until dried off in mid to late July. Data for feed intake, milk production, cow liveweights and body condition score for Experiment 2 are presented in Tables 4-6.

Pre-experiment (calving to 31/10/99). During this period cows were grazed at pasture mainly and freshly calved cows joined the herd. Cows produced an average of 994kg milk/cow during this period.

Period 1 (1/11-5/12/99). The cows on T2 had access to grazed grass by day and consumed an average of 4.7 kg grass DM/cow/day during this period (Table1). Intake of grass silage was reduced by 3.4kg DM/day, i.e. a substitution rate of 0.72 for grass silage, but total forage DM intake was increased by 1.3 kg DM/day compared with the cows fed fulltime on grass silage (T1). Cows on the mixed forage diet (T3) achieved the highest intake of forage and total DM.

Data for milk production during this period are shown for the first batch of cows (21 cows/treatment) only. Inclusion of grazed grass in the diet with grass silage increased milk production by 2.0 kg/day compared with the grass silage only based diet (T2 v T1) and had a small beneficial effect on milk protein concentration (Table 5). The cows on the mixed forage diet (T3) produced a similar level of milk production to those on T2, with somewhat higher milk fat and protein concentrations.

Period 2 (6/12/99-20/2/00). During this period cows on all treatments were housed fulltime and those on T2 were fed on grass silage as the sole forage, similar to T1. Forage intake was similar for T1 and T2 and was highest for T3. Milk production was similar for T1 and T2 and was about 3.0 kg/day higher for T3, with a higher milk protein concentration compared with T1 or T2.

Period 3 (21/2-2/4/00). The cows on T2 and T3 grazed on spring grass by day and consumed an average of 4.5 and 5.1 kg grass DM/cow/day, respectively. In T2 grazed grass largely replaced grass silage in the diet, resulting in similar intakes of forage and total DM to that consumed by the cows on T1. Forage and total DM intake was maintained at a higher level on the mixed forage diet (T3).

Milk yield was increased by 3.1 kg/day by including grass with grass silage and milk protein concentration was also improved (+0.5 g/kg milk) but milk fat concentration was reduced. The highest milk yield with the highest milk protein concentration was produced on the mixed forage diet (T3) supplemented with grazed grass. Milk production on this diet was maintained at a consistently high level of about 30 kg/day throughout the winter.

Table 4. Feed Intake per Period and for **the Total Winter. Experiment 2**

Feed intake per period and for the total winter. Experiment 2

Winter Forage Treatment.	**T1. Grass Silage**	**T2. Grass silage +grazed grass**	**T3. Mixed Forage diet**
Period 1 (1//11-5/12/99)		Kg DM/cow/day	
Grass silage or mixed forage	11.0	7.6	14.6
Grazed grass	-	4.7	-
Total forage	11.0	12.3	14.6
Concentrates	6.6	6.6	6.4
Total diet	17.6	18.9	21.0
Period 2 (6/12/99-20/2/00)			
Grass silage or mixed forage	10.5	11.0	14.4
Concentrates	6.6	6.6	6.5
Total diet	17.1	17.6	20.9
Period 3 (21/2-2/4/00)			
Grass silage or mixed forage	8.8	4.8	7.5
Grazed grass	-	4.5	5.1
Total forage	8.8	9.3	12.7
Concentrates	6.6	6.6	6.4
Total diet	15.4	15.9	19.1

Total winter (22 weeks)		Kg DM/cow	
Grass silage	1558	1317 (-241)	479
Grazed grass	-	354	216
Maize silage	-	-	959
Brewers grains	-	-	496
Total forage	1558	1671 (+113)	2150 (+592)
Concentrates	1016	1016	1000
Total diet.	2575	2687	3150

Period 4 (3/4-30/7/00). The cows were grazed fulltime at pasture until dried off in mid to late July. Concentrates were phased out over a three week period. Milk yields declined over time and there was a beneficial carryover effect in yield over the first 5-6 weeks on T2 and T3 compared with T1.

Total Winter (1//11-2/4). The cows on T2 consumed 354 kg grass DM/cow in periods 1 and 3 and reduced silage intake by 241 kg DM/cow compared with those on all grass silage in T1. (0.68 substitution rate). Forage intake was 592 kg DM/cow higher on the mixed forage diet (T3) compared with T1. The cows on all treatments consumed about 1000 kg DM concentrates over the winter. Milk production was increased over the winter by 161 kg/cow on T2 and by 451 kg/cow on T3 compared with T1. Fat and protein yield was increased by 8 and 36 kg/cow on T2 and T3, respectively, compared with T1. Fat concentration was generally similar for the three treatments, while protein concentration was highest for T3.

Table 5. Milk Production per Period, Total Winter and Total Lactation in Experiment 2.

Milk production per period, total winter and total lactation in experiment 2

Winter feeding treatment	**T1. Grass Silage**		**T2. Grass silage + grazed grass**		**T3. Mixed forage diet**	
Pre-Experiment (calving to 31/10/99)						
No. cows calved	23		24		24	
Milk (kg/cow)	995		1017		970	

Fat (g/kg)	43.6		45.5		42.6	
Protein (g/kg)	33.5		34.1		34.2	
Period 1 (1/11-5/12) 5wks						
Milk (kg/day)	27.4		29.4		29.6	
Fat (g/kg)	39.6		39.7		40.0	
Protein (g/kg)	31.2		31.7		32.1	
Period 2 (6/12-20/2) 11wks						
Milk (kg/day)	27.9		27.5		30.7	
Fat (g/kg)	40.0		39.5		40.2	
Protein (g/kg)	32.0		31.7		32.6	
Period 3 (21/2-2/4) 6 wks						
Milk (kg/day)	25.2		28.3		29.5	
Fat (g/kg)	39.9		37.9		39.4	
Protein (g/kg)	32.9		33.4		33.8	
Total winter P1-P3 (1/11-2/4) 22 wks	kg/cow	g/kg	kg/cow	g/kg	kg/cow	g/kg
Milk	4174		4335		4625	
Fat	167.2	40.1	169.6	39.2	185.2	40.1
Protein	133.4	32.1	139.2	32.2	151.4	32.8
Spring/Summer at grass (3/4-31/700) 17 wks.	kg/cow	g/kg	kg/cow	g/kg	kg/cow	g/kg
Milk	2185		2370		2339	
Fat	90.1	41.4	90.9	38.7	95.1	40.8

Protein	77.4	35.5	82.6	34.9	82.1	35.2
Total lactation						
Milk	7240		7644		7859	
Fat	295.8	41.0	302.5	39.7	318.8	40.6
Protein	240.0	33.2	253.3	33.2	263.5	33.6

Total Lactation. Two cows on T2 were removed from the herd in April due to TB infection. Milk production averaged 7240, 7644 and 7860 kg/cow for T1, T2 and T3, respectively. The overall lactation response to extra winter feed in the form of grazed grass was 404 kg/cow and to a mixed forage diet was 619kg/cow, or an increase in yield of fat and protein of 20 and 47 kg/cow, respectively, compared with a grass silage based diet.

Liveweight and body condition score.

Cows calved by late October averaged 554 kg liveweight, and those allocated to T3 were slightly lighter than those allocated to T1 or T2 (Table 6). Over the winter months cows on all treatments gained in weight, with those on T3 gaining more weight (37 kg) compared with those on T1 or T2 (24-28 kg). By the end of lactation cows had reached a similar liveweight on all treatments and had gained 43-53 kg from the start of indoor winter feeding.

Table 6. Mean Liveweight and Body Condition Score of cows on treatments in Experiment 2.

Mean liveweight and body condition score of cows on treatments in experiment 2

	Mean Liveweight (kg).			**Body Condition Score**		
Date.	**T1. (GS)**	**T2. (GSG)**	**T3. (MFD)**	**T1. (GS)**	**T2. (GSG)**	**T3. (MFD)**
Post calving				3.11	3.11	3.06
27/10/99	555	562	545	2.90	2.86	2.88
7/12/99	564	576	554	2.81	2.64	2.71
11/01/00	566	580	578	2.92	2.92	3.05
2/02/00	583	591	576	2.95	2.89	3.06
10/03/00	593	593	594	3.14	3.00	3.22
6/04/00	579	590	582	3.00	2.99	3.14

5/05/00	590	600	600	3.30	3.08	3.24
8/06/00	-	-	-	3.36	3.25	3.36
5/07/00	598	615	595	3.30	3.18	3.25
Winter gain (27/10-6/4)	+24	+28	+37	+0.10	+0.13	+0.26
Lactation gain	+43	+53	+50	+0.19	+0.07	+0.19

Cows were in moderate condition after calving (3.09 BCS) and at the start of winter feeding (2.88 BCS). Body condition continued to decline in early winter, particularly on T2 and T3, reflecting their higher milk production, but subsequently recovered in mid and late winter, resulting in a gain in condition over the winter months, particularly on T3, reflecting the higher intake on that treatment. Cows continued to gain condition when turned out to pasture, gaining 0.32-0.40 BCS from the start of winter to drying off. Overall, cows were in better condition at the end of lactation than at the start (+0.07-0.19 BCS), but recovery was least for cows on T2.

Discussion on Experiment 2

Inclusion of Autumn grazed grass in the cows diet with grass silage in T2 increased total forage and total DM intake by 1.3 kg DM/cow/day compared with cows on grass silage as the sole forage (T1) in Period 1. This resulted in a substantial reduction in silage intake (-3.4 kg/day) and a large substitution rate (0.72 kg silage DM/kg grass DMI). Milk yield was increased by 2.0 kg/day and fat + protein yield was increased by 0.15 kg/day by including Autumn grazed grass with grass silage. The response in production was 0.43 kg milk and 32g fat + protein/ kg grass DM eaten. In Period 2, when grazed grass was not available, milk production on T2 dropped by 1.9 kg/day compared with the milk yield in Period 1, whereas milk yield was maintained or slightly increased on T1 and T3 in Period 2 compared with Period 1.

In Period 3, grazed grass largely replaced grass silage (substitution rate of 0.9 kg grass silage DM/kg grass DM intake), with only a small effect on total forage intake. However, milk production was considerably increased by 3.1 kg/day and fat + protein yield by 0.18 kg/day by including early spring grass in the cows diet with grass silage. The response per kg grass DM eaten was 0.69 kg milk and 40g fat + protein. Over the whole winter milk yield was increased by 161 kg/cow, while consuming 354 kg grass DM, giving an overall response of 0.46 kg milk/kg grass DM eaten.

The mixed forage diet (T3) resulted in a high intake of feed throughout the winter and maintained milk production at a consistent high level of 30 kg/day, with the highest milk protein concentration. Over the three winter periods feed intake was higher on T3 by 3.4-3.8 kg DM/day compared with T1 and milk yield was maintained at a higher level, yielding an additional 2.2, 2,8 and 4.3 kg milk /day during periods 1-3, with additional yields of fat + protein of 0.21, 0.22 and 0.32 kg/ day, respectively. The milk response to the additional feed consumed on T3 progressively improved over the three periods and averaged 0.65, 0.74 and 1.16 kg milk /kg extra DM intake (62, 58 and 87 g fat + protein / kg extra DMI) for Periods 1-3, respectively.

Over the whole winter feed intake on the mixed forage diet (T3) was increased by 575 kg DM/cow, milk production was increased by 451 kg/cow and fat + protein yield by 36 kg/cow compared with the cows on the grass silage based diet (T1). The overall response in milk production during the winter to the additional feed consumed on the mixed forage diet was 0.78 kg milk /kg extra feed DM consumed (63g fat + protein / kg extra DMI). However, when account is taken of the additional milk produced by the cows on T3 over the full lactation, (+619 kg milk/cow or +46.5 kg fat + protein/cow compared with T1), the overall response was 1.08 kg milk /kg extra feed DM consumed (81 g fat + protein /kg extra DMI). This was a very good response from the extra high quality feed consumed by the cows on the mixed forage diet in winter.

Experiment 3

A comparison of grass silage as the sole forage with a diet of grass silage and grazed grass or maize in mid-winter or a mixed forage diet for winter milk production.

In this experiment three winter feeding treatments were again compared over the winter months (Nov-March). Some modifications were made to Treatments 2 and 3 compared with Experiment 2 to continue to assess the benefit of including grazed grass in the cows diet in early winter and in early spring and to evaluate the inclusion of maize silage with grass silage in midwinter.

All cows had been dried off in mid to late July and grazed tightly during the dry period. Surplus grass was closed for silage and cut in early September. Cows calved from early September to mid December. From early September to early October cows grazed at grass day and night and were supplemented with concentrates (18% CP) at 6 kg/cow/day in two feeds at milking time. From early October to early November cows received grass silage by night and grazed grass by day and the concentrate level was increased to 7.5 kg/cow/day. From early November until late March (6/11-31/3) the cows were allocated to the three treatments in three batches, blocked on the basis of calving date, lactation number and current milk yield. The winter was divided into three periods, depending on the availability of late winter or early spring grazing, e.g. P1, early winter (6/11-17/12); P2, mid winter (18/12-18/2/01); P3, early spring (19/2-31/3/01).

The three winter feeding treatments were as follows;

T1. Grass silage ad libitum. Cows were indoor fulltime all winter (P1-P3).

T2. Grass silage + grazed grass by day or maize silage in mid-winter.

P1. Grass silage + Autumn grass by day.

P2. Grass silage + maize silage (0.25: 0.75 DM basis). Cows indoor fulltime.

P3. Grass silage + early Spring grass by day.

T3. Mixed forage diet + grass/rape by day in early Winter and early Spring.

P1. Mixed forage diet + Autumn grass by day.

P2. Mixed forage diet. Cows indoor fulltime.

P3. Mixed forage diet + rape or Spring grass by day.

The mixed forage diet consisted of 0.25 grass silage, 0.50 maize silage and 0.25 brewers grains on a DM basis.

All treatments were supplemented with concentrates at a level of 7.5 kg/cow/day throughout the winter. A pelleted concentrate (18% CP) was fed in the milking parlour at each milking at a level of 7.5 kg/cow/day to cows on T1 throughout the winter and to cows on T2 during Periods 1 and 3. During Period 2 the cows on T2 received 5.0 kg/day of the concentrate in the parlour and 2.5 kg/day of a supplement containing soyabeanmeal and minerals mixed with the grass silage and maize silage diet to maintain the overall level of crude protein in the diet. The cows on T3 received 6.5 kg/day of the pelleted concentrate in the milking parlour and 1.0 kg/day of the soyabeanmeal/mineral supplement in the mixed forage diet throughout the winter.

One hectare of old pasture was ploughed and sown down to a mixture of rape and Italian ryegrass to provide feed for grazing in early spring to the cows on T3. Two ha of maize was sown under a plastic film covering as part of T3 to provide maize silage and was harvested and ensiled in early October. Additional maize silage was purchased from a local tillage farmer to provide maize silage in mid winter to the cows on T2. Three ha of older pastures (1 ha/treatment) were reseeded in September. The overall stocking rate on the three systems was 2.75 cows/ha, using a level of 350 kg N fertiliser/ha. Different areas were closed for grass silage within each system for 1st cut and 2nd cut silage, as was done in Experiment 2, to meet the requirements for grass silage as part of the winter diet in each system.

Results of Experiment 3

Out of Season Grazing.

Treatment 2.

P1: Early winter grazing (6/11-17/12/00).

Two 1ha paddocks rested since mid September were grazed by day during this period. The herbage mass was high in November (2400-2700 kg DM/ha) and somewhat lower in December (1680-2040 kg DM/ha).This allowed a herbage allocation of 7.5-8.0 kg DM/cow/day in November and 6.8-8.0 kg DM/cow/day in December. Herbage intake, estimated from pre and post grazing clips, averaged 4.9 kg DM/cow/day, and ranged from 5.6 kg DM/cow/day in early November to 4.1 kg DM/cow/day in mid December. Grass utilisation averaged 64% of the herbage offered.

P3. Early Spring grazing (18/2-31/3/01)

Six 1 ha paddocks were used for early Spring grazing. The herbage mass was much less than that available for early winter grazing, averaging 904 kg DM/ha (range 720-1100 kg DM/ha). Consequently the herbage allocation to cows was restricted to 5.5 kg DM/cow/day initially, but was increased to 6.5-7.0 kg DM/cow/day in March. Herbage intake averaged 3.7 kg DM/cow/day and ranged from 2.6 to 4.8 kg DM/cow/day for different weeks. Grass utilisation averaged 61% of that offered.

Treatment 3.

P1. Early winter (6/11-17/12/00)

Three 1 ha paddocks were available for grazing by day during this period. Herbage mass was in the range of 1900-2600 kg DM/ha in November and 1500-1680 kg DM/ha in early December. The cows were given a daily allocation of 8.0 kg DM/cow in early/mid November, declining to 6.6-7.0 kg DM/cow in late Nov/Dec. Herbage intake averaged 4.2 kg DM/cow/day, ranging from 3.6 to 5.2 kg DM/cow/day for different weeks. Grass utilisation averaged 55% of that offered.

P3. Early Spring (18/2-31/3/01)

The 1 ha rape/ Italian ryegrass, which consisted mainly of rape, was grazed first and lasted for 31 days, and was followed by 1.5 ha of perennial ryegrass. The yield of rape averaged 6600 kg DM/ha, while the grass in late March averaged 1120 kg DM/ha. Due to the high proportion of inedible stem in the rape the daily allowance was increased from 7.3 kg DM/cow initially to 10.0 kg DM/cow, while the grass allowance in late March was 7.0 kg DM/cow/day. Intake of rape averaged 4.0 kg DM/cow/day, while the intake of grass in late March averaged

3.8 kg DM/cow/day. Utilisation of rape averaged 45% of that offered, due to the large residue of inedible stem, while utilisation of grass was 54%.

In September-October, calved cows were given a daily allocation of pasture sufficient to leave a post-grazing height of 6-7 cm. Pre-grazing herbage yields were in the region of 1200-1500 kg DM/ha above 4 cm.

Feed Intake and Milk Production

The results for feed intake, milk production, and body condition score during the winter and for the total lactation are shown in tables 7-9, respectively.

From calving until cows were placed on the experimental treatments in early November, milk yield for the first batch of cows averaged 919 kg/cow with a composition of 48.6 g/kg of fat and 34.7 g/kg of protein.

Period 1. Early winter (6/11-17/12/00).

During this 6 week period cows were indoor fulltime on grass silage (T1) or had access to grazed grass by day and indoor by night on either grass silage (T2) or a mixed forage diet (T3). Forage intake averaged 11.2, 12.8 and15.8 kg DM/cow/day on T1-T3, respectively (Table 7). Grass intake averaged 4.9 and 4.2 kg DM/cow/day on T2 and T3. Total DM intake was increased on T2 by 1.6 kg DM/day by including grazed grass in the diet (substitution rate of 0.67 kg grass silage DM per kg of grass DM intake) and by 4.6 kg DM/day on the mixed forage diet and grazed grass (T3) compared with cows confined to grass silage as the sole forage (T1).

Data for milk production for this period shown in Table 8 is for the first two batches of cows (20 cows/treatment) only. Milk production during this period averaged 25.5 kg/day on the grass silage based diet (T1). Milk production by the cows with access to late Autumn grass on T2 and T3 was increased by 1.9 and 2.7 kg/day, respectively, and milk protein concentration was increased by 0.3 and 0.9 g/kg, respectively, compared with the cows indoor on grass silage fulltime.

Table 7. Feed Intake per Period and for the Total Winter. Experiment 3.

Feed intake per period and for the total winter – experiment 3

Winter Forage Treatment.	**T1. Grass Silage**	**T2. Grass silage + grass or maize silage**	**T3. Mixed Forage diet + grass/rape**
Period 1 (6//11-17/12/00)		Kg DM/cow/day	
Grass silage or mixed	11.2	7.9 (gs)	11.6

forage			
Grazed grass	-	4.9	4.2
Total forage	11.2	12.8	15.8
Concentrates	6.6	6.6	6.5
Total diet	17.8	19.4	22.4
Period 2 (18/12/00-18/2/01)			
Grass silage or mixed forage	9.4	15.3 (gs+ms)	15.5
Concentrates	6.5	6.4	6.5
Total diet	15.9	21.8	22.0
Period 3 (19/2-31/3/01)			
Grass silage or mixed forage	9.9	6.3 (gs)	11.8
Grazed grass/rape	-	3.7	3.9
Total forage	9.9	9.9	15.8
Concentrates	6.5	6.5	6.5
Total diet	16.4	16.4	22.2
Total winter (21 weeks)		Kg DM/cow	
Grass silage	1477	817 (-660)	466
Grazed grass/rape	-	360	343
Maize silage	-	741	992
Brewers grains	-	-	501
Total forage	1477	1918 (+441)	2302 (+825)
Concentrates	958	954	956
Total diet.	2434	2872	3258

Type of silage in Treatment 2: (gs)=grass silage only, (gs+ms) = grass silage + maize silage.

Period 2. Mid winter (18/12-18/2/01).

During this 9-week period cows were indoors fulltime on their respective diets. Cows on T2 were fed on a mixed diet of grass silage and a high proportion of maize silage during this period. Forage intake averaged 9.4, 15.3 and 15.5 kg DM/cow/day on T1-T3, respectively. Inclusion of a high proportion of maize silage or maize silage with brewers grains in place of grass silage considerably increased forage and total DM intake by 5.9-6.1 kg DM/cow/day.

Data for milk production is for all three batches of cows (24 cows/treatment). During this period milk production for the cows on the grass silage based diet (T1) declined to 22.8 kg/day. Inclusion of a high proportion of maize silage with grass silage in T2 increased milk yield by 1.9 kg day and improved milk fat concentration by 1.1 g/kg and milk protein concentration by 1.5 g/kg compared with the grass silage based diet (T1). Milk production of the cows on the mixed forage diet (T3) was maintained at a higher level (27.5 kg/day) compared with T1 or T2 and milk fat and protein concentration was also higher than for T1.

Table 8. Milk Production per Period, Total Winter and Total Lactation in Experiment 3.

Milk production per period, total winter and total lactation in experiment 3

Winter feeding treatment	T1. Grass Silage		T2. Grass silage + grazed grass		T3. Mixed forage diet	
Pre-Experiment (calving to 5/11/00) (20 cows/trt)						
Milk (kg/cow)	880		932		972	
Fat (g/kg)	49.6		48.1		47.9	
Protein (g/kg)	35.0		34.3		34.8	
Period 1 (6/11-17/12/00) 6 wks						
Milk (kg/day)	25.5		27.4		28.2	
Fat (g/kg)	46.4		46.4		44.8	
Protein (g/kg)	31.6		31.9		32.5	

Period 2 (18/12-18/2/01) 9 wks						
Milk (kg/day)	22.8		24.7		27.5	
Fat (g/kg)	40.4		41.5		42.2	
Protein (g/kg)	30.9		32.4		32.0	
Period 3 (19/2-31/3/01) 6 wks						
Milk (kg/day)	20.5		23.4		27.0	
Fat (g/kg)	41.0		40.6		41.7	
Protein (g/kg)	32.0		33.2		32.9	
<u>Total winter</u> P1-P3 (6/11-31/3) 21 wks	kg/cow	g/kg	kg/cow	g/kg	kg/cow	g/kg
Milk	3312		3625		3973	
Fat	139.3	42.4	155.2	42.8	170.3	43.0
Protein	102.9	31.4	117.7	32.5	128.0	32.5
Period 4 (1/4-29/7/01) At grass.	kg/cow	g/kg	kg/cow	g/kg	kg/cow	g/kg
Milk (kg/day)	2124		2265		2339	
Fat (g/kg)	85.4	40.8	90.2	39.8	94.6	40.7
Protein (g/kg)	74.9	35.4	80.0	35.4	80.9	34.7
Total lactation	kg/cow	g/kg	kg/cow	g/kg	kg/cow	g/kg
Milk	6169		6667		7121	
Fat	259.4	42.3	281.5	42.1	302.2	42.5
Protein	202.7	33.0	223.8	33.6	236.4	33.2

Period 3. Early Spring (19/2-31/3/01).

During this 6 week period the cows on T1 remained indoor fulltime on grass silage as the sole forage, while the cows on T2 were grazed on grass by day and were fed on grass silage as the sole forage by night. The cows on T3 were grazed on rape by day for 4 weeks, followed by Spring grass for 2 weeks in late March, and were fed on their mixed forage diet by night. Forage intake was similar for T2 and T1, indicating, complete substitution of grazed grass for grass silage, while forage and total intake was 5.9 kg DM/day higher on the mixed forage diet (T3).

Milk production on the grass silage based diet (T1) declined further and averaged 20.5 kg/day. Provision of grazed Spring grass with grass silage in T2 resulted in an increase in milk yield (+2.9 kg/day) and in milk protein concentration (+1.2 g/kg). The feeding of rape/spring grass with the mixed forage diet in T3 maintained milk production at a high level (27.0 kg/day), comparable to that achieved in mid-winter (P2), and resulted in a considerable increase in milk yield (+6.5 kg/day) and in milk fat and protein concentration compared with the silage based diet (T1).

Period 4. At pasture. (1/4-29/7/01).

The cows were subsequently grazed fulltime at pasture in late Spring and Summer, and the concentrates were phased out. The improvements in milk production achieved on T2 and T3 during the winter were carried over to some extent at pasture, resulting in an additional increase in milk yield of 141 and 215 kg/cow on T2 and T3, respectively, compared with T1. Milk composition at pasture was similar for the three treatments.

Total winter (6/11/00-31/3/01).

Compared with cows fed on grass silage as the sole forage (T1), total forage intake over the winter was considerably increased by giving cows access to grass in early winter and in early Spring and by feeding maize silage in mid winter to cows on T2 (+ 443kg DM/cow). This resulted in a considerable saving in grass silage (substitution rate of 0.6 kg of grass silage DM per kg of grass/rape and maize silage DM intake). Total forage intake for the cows on the mixed forage diet (T3) was also considerably increased (+825 kg DM/cow) compared with T1. Cows consumed an average of 956kg DM/cow of concentrates over the winter on each treatment.

Inclusion of grazed grass in the diet of cows on T2 in early winter and early spring and maize silage in mid-winter increased milk production by 313 kg/cow and fat + protein yield by 30.7 kg/cow compared with cows on the grass silage based diet throughout the winter (T1). Feeding the mixed forage diet supplemented with grazed grass and rape at the start and end of the winter (T3) resulted in a sustained high yield of milk with good composition throughout the winter. Compared with T1, milk production on T3 was increased by 661 kg/cow, fat and protein yield by 56.1 kg/cow, and fat and protein concentration was improved by 0.6 and 0.9 g/kg, respectively.

Total lactation.

By the end of July when cows were dried off, milk yields averaged 6169, 6667 and 7121 kg/cow for T1, T2 and T3, respectively. Milk production was 498 kg/cow higher for T2 and 952 kg higher for T3 compared with cows on T1. A small proportion of this increase was due to differences in yield before the earlier calved cows were placed on their winter dietary treatments and a further proportion was due to a carryover effect when the cows grazed fulltime at pasture. Yield of fat and protein was 43.2 and 76.5 kg/cow higher for T2 and T3 compared with T1. Overall milk fat content was similar for all treatments and was generally high (42.3 g/kg milk). Milk protein concentration was higher for the cows on T2 (33.6 g/kg) compared with those on T1 or T3 (33.0-33.2 g/kg).

Body condition score (BCS)

The cows were generally in good body condition at calving, averaging 4.00 BCS with a range of 3.00-4.50 BCS (Table 6). The fatter cows included some recycled young cows that failed to go in-calf in the previous breeding season. Cows lost a considerable amount of condition in early lactation up to mid November but improved thereafter and were close to 3.00 BCS for most of the winter. There was very little difference evident between the treatments at any stage. Cows lost about 0.8 BCS from prior to calving and the first recorded post-calving score. Thereafter cows continued to lose about 0.5 BCS until the nadir BCS score was reached at about 2.65. Cows subsequently regained condition (+0.4 to 0.5 BCS) and were in reasonably good condition, averaging 3.1 BCS, at the start of the breeding season (7/12/00). Over the winter months cows either maintained condition (T1) or gained a little condition (T2 and T3) and also gained in condition to a similar extent on all treatments at pasture.

When classified according to body condition prior to calving, the cows which were in the highest condition (BCS 4.25-4.50) lost most condition soon after calving (0.92 BCS) and subsequently to the nadir BCS point (0.65 BCS) compared with cows in moderate condition prior to calving (BCS 3.0-3.75), which lost 0.7 BCS after calving and a further 0.37 BCS to the nadir point. However, the cows in high BCS at calving had regained slightly more condition by the start of the breeding season (+0.51 v 0.31 BCS) and were in better condition during the breeding season than the cows calving down in moderate condition (BCS 3.14 v 2.80).

Table 9. Body Condition Score of cows on treatments in Experiment 3.

Body condition score of cows on treatments in experiment 3

Date or event.	T1. Grass silage	T2. Grass silage +grass /maize	T3. Mixed forage diet + grass/rape
Pre calving	3.89	4.08	4.05
Post calving	3.15	3.18	3.22
3/11/00 (calved cows only)	2.92	2.90	2.95
15/11/00 („ „ „)	2.73	2.81	2.73
7/12/00 (start of breeding)	3.07	3.13	3.01
5/01/01	2.86	2.95	2.88
15/02/01	2.94	2.95	2.97
30/03/01	2.92	3.02	3.00
15/05/01	3.03	3.08	3.11
Nadir BCS	2.66	2.67	2.61
Mean for breeding season	2.96	3.01	2.95
Body condition change			
Post calving to nadir	-0.49	-0.51	-0.60
Nadir to Start of breeding	+0.41	+0.47	+0.40
Winter (3/11-30/3)	0	+0.12	+0.05
Spring (30/3-15/5)	+.0.11	+0.06	+0.11

Discussion on Experiment 3

The value of grazed grass in the diet of cows to supplement grass silage as the sole forage indoors in early winter and in early Spring was again illustrated in this Experiment in terms of reducing silage intake, increasing milk yield and improving milk protein concentration. In early Winter (Period 1) cows on T2 consumed an average of 4.9 kg grass DM/day, reduced silage intake by 3.3 kg DM/day and increased milk yield by 1.9 kg/day, fat + protein yield by 0.17 kg/day compared with cows indoors on grass silage only (T1), resulting in a response of 0.39 kg milk and 35g fat + protein / kg grass DM eaten. In early

Spring (Period 3) grass consumption average 3.7 kg DM/day and largely replaced grass silage. A much greater response in milk production to grass in the diet was achieved in this period, i.e. 2.9 kg milk/day and 0.24 kg fat + protein/day compared with the cows on grass silage only (T1), giving a response of 0.78 kg milk and 65g fat + protein/kg grass DM eaten.

Including a high proportion of maize silage to replace grass silage in the diet of the cows on T2 in mid winter (Period 2) considerably increased forage intake by 5.9 kg DM/day and increased milk production compared with T1 by 1.9 kg milk/day or 0.21 kg fat + protein/day, giving a response of 0.32 kg milk and 36g fat + protein /kg extra forage DM consumed.

Feeding a mixed forage diet (T3) containing maize silage, brewers grains throughout the winter and grazed grass or rape in Periods 1 and 3 resulted in a consistently high intake of forage and a high level of milk production of good composition throughout the winter. Compared with the cows on grass silage as the sole forage (T1) forage intake on T3 was increased by 4.6, 6.1 and 5.9 kg DM/day in periods 1-3, respectively, milk yield by 2.7. 4.7 and 6.5 kg/day and fat + protein yield by 0.21, 0.42 and 0.52 kg/day in each of these periods. The response in extra milk per kg extra forage DM eaten by the cows on the mixed forage diet progressively increased over the winter, i.e. 0.69, 0.77 and 1.10 kg milk/ kg extra forage DM for Periods 1 to 3. The yield of fat + protein was correspondingly increased as milk fat and protein concentration was also improved, by 46, 69 and 88g/kg extra forage DM eaten during these periods.

The response in milk production to the extra forage consumed by the cows on T2 and T3 compared with T1 over the whole winter was similar at 0.71 and 0.80 kg milk/kg extra forage DM eaten (70 and 68g fat + protein / kg extra DMI). However, when account is taken of the extra milk produced on T2 and T3 over the total lactation to the extra forage consumed in winter, the responses were much larger and averaged 1.13 and 1.16 kg milk /kg extra forage DMI (98 and 93 g fat + protein/ kg extra forage DMI) for T2 and T3, respectively. These responses are generally better than milk responses obtained to additional concentrate supplementation of a grass silage based diet or grazed grass, which are generally less than 1kg milk/ kg extra concentrate DM, and would be cheaper and more economic to feed. Cow body condition and condition score change was similar for the three treatments at different stages of lactation, indicating that the additional feed was converted to milk rather than to body condition during the winter.

Reproduction

It is essential in an all Autumn calving system of milk production that a good level of reproduction be achieved in a compact breeding season, with a minimum of cows not going in-calf, if the system is to remain viable in the long-term. Due to restricted housing, with limited space for cows in oestrus to interact in small sexually active groups, slippery conditions on slats and passage ways which inhibit cows from mounting during oestrus, two different approaches to oestrus detection and cow fertility were undertaken in different seasons.

In Experiments 1 and 2 a normal system of oestrus detection was put in place. Cows were tail-painted and observed for oestrus during the day for three weeks prior to the start of the breeding season in early December. During the breeding season (early Dec.- early March) cows were observed for oestrus prior to morning and evening milking, at mid-day and at night, in addition to the use of tail paint. Cows that were not seen to exhibit oestrus were examined and treated appropriately. After 30 days service cows were examined for pregnancy, using ultrasonography, and non-pregnant cows were rebred.

In Experiment 3, due to the difficulty experienced in the previous years in observing cows on oestrus in a confined indoor situation, it was decided to synchronise all cows using a CIDR-based programme. Ten days prior to the start of the breeding season the reproductive tract of each cow calved for more than 35 days was examined using ultrasonography and any problem cows were treated appropriately. The remaining cows were synchronised using a CIDR programme (CIDR inserted for 8 days, 2mg oestradiol benzoate at CIDR insertion, 526ug prostaglandin at CIDR removal and 1mg oestradiol benzoate at 24 hours after CIDR removal). All cows were inseminated twice by the commercial AI technician at a fixed time (48 and72 hours) after CIDR removal with Holstein-Friesian and Hereford semen, respectively. Pregnancy detection was carried out using ultrasonography 30 days after each service and non-pregnant cows were treated as appropriate and rebred. A final pregnancy examination was carried out on all cows 45 days after the end of the breeding season. The reproductive results for each season are shown in Table 7 for the combined treatments.

Table 7. Reproductive performance of Autumn calved cows in three seasons.

Reproductive performance of autumn calved cows in three seasons

Fertility Index	**Expt. 1(1998/99)** **Normal heat detection** **(n=52)**	**Expt. 2 (1999/00)** **Normal heat detection** **(n=78)**	**Expt. 3 (2000/01)** **Synchronised oestrus** **(n=72)**
Oestrus detection rate (%)	89	77	74
Submission rate (21d), (%)	81	71	86
Non detected oestrus (%)	6	23	9

Normal (18-24d) repeats (%)	53	40	16
Short (<18d) repeats (%)	7	15	13
Long (>24d) repeats (%)	40	44	70
Pregnancy rate to first AI (%)	45	31	37
Pregnancy rate in 1st 6 weeks (%)	56	41	56
Pregnancy rate to all AI. (%)	73	68	73
Non pregnant rate (%)	27	32	27
AI per conception (served cows) (%)	2.2	3.1	2.5
Calving to service interval (d)	70	78	76
Calving to conception interval (d)	85	100	97
Length of breeding season (d)	73	86	88

Results on Reproduction

In Experiment 1, (1998/99) a system of normal oestrus detection with tail paint was used, with a smaller group of cows (52). Overall oestrus detection accuracy and submission rate during the first 21 days of the breeding season was good and the proportion of cows not detected in oestrus was low. Conception rate to the first service was reasonable but overall pregnancy rate to all services was disappointing, with 27 % of the cows not in calf. The indices for number of services per cow, calving to service interval and calving to conception interval were on target. The fertility of the cows on the higher level of feeding (T2) was poorer than for the cows on T1, in terms of pregnancy rate to first service (36 v 54%), overall pregnancy rate (68 v 77%), services/conception (2.5 v 1.9) and calving to conception interval (88 v 83 days). However, the number of cows in this study (52) was limited.

In Experiment 2 (1999/2000) a system of normal heat detection, and tail paint was again used, but with a larger herd size (78 cows). The herd had been increased by including 25 recycled cows which had failed to go in-calf in the previous season when bred as part of other Spring calving herds at Moorepark, but subsequently conceived when rebred to calve in Autumn, in addition to including 15 incalf heifers. Both oestrus detection rate and the submission rate in the first 21 days of the breeding season were lower than in the previous year and a high proportion of cows (23 %) were not detected in oestrus during the breeding season. A relatively high proportion of cows exhibited a long repeat interval (>24 d). The pregnancy rate to first service and for the first 6 weeks of the breeding season was low, resulting in a high number of services per conception and a delayed calving to conception interval. The overall pregnancy rate to all services was poor (68%). A similar trend in fertility was evident within treatments as in the previous year. The cows on the highest level of feeding on Treatment 3 had a lower submission rate (58%), a lower pregnancy rate to the first service (27%) and to all services (62%), resulting in a high number of services per conception (3.2) and a higher proportion of cows not in-calf (38 v 27-31%) compared with Treatments 1 and 2.

In Experiment 3 (2000/01) oestrus was synchronised in all cows using a CIDR programme, to overcome the problem of poor oestrus exhibition and detection in the confined indoor situation. As a result the submission rate in the first three weeks was much higher (86 %) than in the previous season but the pregnancy rate to first service (37 %) was low. There was a relatively high incidence of late embryonic mortality (8.5%), which contributed to a high incidence of late repeats (70%). The synchronisation programme improved pregnancy rate in the first 6 weeks compared with the previous year (56 v 41%). However, the overall pregnancy rate at the end of the breeding season (73%) was less than desirable to sustain the herd with a moderate replacement rate. The number of services per conception was reduced and the intervals from calving to first service and calving to conception were reduced by 2-3 days compared with the previous season. There were no large differences evident in Experiment 3 between treatments for any fertility parameter. The incidence of late embryonic mortality in both cows and heifers suggested a herd problem, possibly of infectious origin. A blood metabolic profile carried out on all cows during the breeding season failed to detect any abnormalities.

General Discussion

Effect of grazed grass in the diet with grass silage.

Inclusion of grazed grass in the diet to supplement grass silage in early winter and in early spring had a large effect on silage intake and on milk production in each of the experiments. The benefit of grazed grass in the diet of cows on treatment 1 in Experiment 1 was estimated indirectly by comparing silage intake and milk production in Periods 1 and 3 with Period 2 (mid-winter) when grass was not part of the diet and allowing for changes in milk production over the winter, as was evident for cows fed on a constant diet (Treatment 2) throughout the winter. In early winter (Period 1) grass intake averaged 4.5 kg DM/cow/day over the three experiments (range 3.9-4.9 kg DM/day), while grass silage intake was reduced by an average of 3.1 kg DM/day, resulting in an average substitution rate of 0.7 kg silage DM/kg grass DM eaten. Milk yield was increased by an average of 2.1 kg /day (range 1.9-2.3 kg day) and fat + protein yield by 0.16 kg/day (range 0.15-0.17 kg/day) as a result of including Autumn grass in the diet. The average milk production response per kg grass DM eaten for the three experiments was 0.47 kg milk (range 0.39-0.59) and 37g fat + protein /kg grass DMI (range 32-45g).

In early Spring (Period 3) grazed grass also made a significant contribution to the cows diet. Grass intake averaged 4.3 kg DM/day over the three experiments (range 3.7-4.8 kg DM/day), while silage intake was reduced by 3.8 kg DM/day in Experiments 2 and 3, with a substitution rate of 0.9 kg silage DM/kg grass DM eaten. Provision of Spring grass made a bigger contribution to milk production than late Autumn grass. Milk yield was increased by an average of 2.9 kg/day (range 2.8-3.1 kg/day) and yield of fat + protein by an average of 0.21 kg/day (range 0.18-0.24 kg/day). The average response per kg grass DM eaten was 0.69 kg milk (range 0.59-0.78kg) and 50 g fat + protein (40-65g). The better response from Spring grass is likely to be due to higher quality grass, from swards with a lower grass cover, with little or no senescent material which is present in autumn saved grass.

Milk protein concentration was also improved by including grazed grass in the diet with grass silage. The increase averaged 0.4 g/kg milk in early winter (Period 1) in experiments 2 and 3, and by an estimate of 0.8 g/kg on Treatment1 in Experiment 1 compared with Period 2 when cows were fed on silage alone. Milk protein concentration was increased to a greater extent when early spring grass was included in the diet with grass silage in Period 3, by an average of 0.85 g/kg in Experiments 2 and 3, and by an estimate of 2.1 g/kg in Experiment 1 compared with Period 2.

The benefit in milk production to providing grass in the winter diet in late autumn and early Spring was evident not only in winter but in the subsequent period when cows grazed fulltime at pasture, as is shown in Experiment 2. In that study milk yield for the total lactation was increased by 404 kg/cow and fat + protein yield by 20kg/cow compared with the cows fed grass silage as the sole forage in winter, giving an overall response of 1.14kgmilk or 56g fat + protein per kg grass DM grazed in winter. Thus, on farms with dry soils where extended grazing is feasible, provision of winter grazing for an extended period will reduce silage requirements and increase milk production and milk protein concentration.

Effect of a mixed forage diet versus grass silage.

The benefit of partially replacing grass silage with other forages or feeds, such as brewers grains/ beet pulp mix in Experiment 1 or maize silage and brewers grains, with grazed grass /rape in some periods in Experiments 2 and 3, was evident in terms of increased forage and total DM intake and higher milk yields with improved protein concentration throughout the winter. The higher intakes on the mixed forage diets resulted in a very consistent yield of milk throughout the winter, whereas milk yield declined on the grass silage diet from early to late winter. In addition, there was a carryover benefit in milk production in two of the experiments (Experiments 2 and 3) when the cows grazed on Spring and Summer pasture, resulting in additional milk production at no extra cost from the mixed forage diets. The benefit to feeding the mixed forage diet increased as the winter advanced compared to the diets and periods when grass silage was fed as the sole forage. Compared with the diets and periods when grass silage was fed as the sole forage (Treatment 1 in Experiments 2 and 3 and Period 2 of Treatment1 in Experiment 1) total DM intake of the mixed forage diets was increased by an average of 4.0, 4.4 and 4.8 kg DM/day for Periods 1-3, respectively. Milk yield was increased by an average of 2.5, 3.4 and 5.4 kg/day, while yield of fat and protein was increased by an average of 0.21,0,31 and 0.42 kg/day for these respective periods. Milk protein concentration was consistently increased on the mixed forage diets compared with grass silage based diets (T1) in all experiments by an average of 0.8, 1.0 and 0.9 g/kg in Periods 1-3, respectively, (with the exception of Period 3 in Experiment 1).

The response in milk yield to the extra feed consumed averaged 0.62, 0.78 and 1.14 kg milk/kg extra DM eaten in Periods1-3, while fat + protein yield increased by an average of 54, 72 and 89 g /kg extra DMI in Periods 1-3, respectively. These responses were very consistent across the experiments for each period. Over the total winter, for Experiments 2 and 3, the extra feed consumed on the mixed forage diet (T3) average 700kg DM/cow (range 575-824 kg DM/cow) compared with T1. Milk production was increased by an average of 556 kg/cow (451-661 kg/cow) and yield of fat + protein by 46.1 kg/cow (36-56 kg/cow) compared with the grass silage based diet. The average response in milk production to the extra feed consumed over the winter was 0.79 kg milk and 66g fat + protein/ kg extra DM eaten, and was very consistent for both experiments. In Experiment 1 the extra feed consumed over the winter on the mixed diet (T2) compared with T1, (which included grazed grass with grass silage in Periods 1 and 3) was somewhat less at 429 kg DM/cow, resulting in an additional yield of 382 kg milk/cow and 30 kg fat + protein/cow. The overall response in milk production to the extra feed was very similar to that obtained over the winter for Experiments 2 and 3, i.e. 0.89 kg milk and 69 g fat + protein/kg extra DM consumed.

The additional milk produced off pasture in Spring/Summer for the cows on the mixed forage diet in experiments 2 and 3 compared with the cows on the grass silage based diet resulted in an additional increase in total yield /cow (619-952 kg milk/cow and 46-76 kg fat + protein/cow in experiments 1 and

2,respectively). This resulted in a much improved and similar response in total milk production of 1.12 kg milk and 87g fat + protein/kg extra DM consumed on the mixed forage diets for both experiments. This response is generally better than responses obtained to increased concentrate supplementation of a grass silage based diet, which are generally less than 1kg milk/kg extra concentrate DM.

In the mixed forage diets it is not possible to itemise what the separate benefits of the individual components of the diet were. However, some indication can be obtained on the value of maize silage compared with a mixture of maize silage and brewers grains in period 2 of Experiment 3, by comparing milk production on Treatment 2 with Treatment 3 for that period. In that period the cows on T2 were fed a mixture of 25% grass silage and 75% maize silage on a DM basis, while the cows on T3 remained on a diet of 25% grass silage, 50% maize silage and 25% brewers grains. Compared with cows on 100% grass silage (T1), feed intake on T2 was increased by 5.9 kg DM/day and by 6.1 kg DM/day on T3 (Table 7). However, milk yield was increased by only 1.9 kg/day on T2 compared with an increase of 4.7 kg milk /day on T3 for a similar increase in forage intake. This would suggest that the additional milk produced on T3 compared with T2 (2.8 kg/day) was due to the inclusion of brewers grains (3.8 kg DM/day) in the diet. The response in milk production to inclusion of brewers grains in place of maize silage was estimated to be 0.74 kg milk /kg brewers grains DM fed compared with a response of 0.16 kg milk/ kg maize silage DM fed in T2. However, part of the additional milk obtained in period 2 with the mixed diet (T3) could be due to a carryover effect from feeding the same diet in Period 1. In Period 2 of Experiment 1 a level of 5.1 kg/day of a brewers grains/ beet pulp mix was fed with grass silage (T2) and compared with grass silage as the sole forage (T1). The extra milk produced in that period (2.7 kg/day) was due to the effect of including the brewers grains/beet pulp mix, giving a response of 0.53 kg milk /kg DM of brewers grains/ beet pulp mix fed.

These results show a consistently good benefit in terms of increased feed intake, improved milk yield and fat and protein yield as well as protein concentration to including alternative feeds such as maize silage and brewers grains or a brewers grains /beet pulp mix to partially replace grass silage in the diet of Autumn calved dairy cows. Only a small improvement in body condition was evident to the feeding of a mixed forage diet, indicating the most of the additional intake of feed was used to sustain a higher milk yield.

Reproduction of Autumn calved cows.

Oestrus detection efficiency and overall conception rates to AI are generally low in Autumn calving herds. In this study the problem was compounded due to confined housing conditions, with cows divided into two or three groups each year, and the need to maintain a compact calving season of 13 weeks. While oestrus detection and submission rate in the first 21 days of the breeding season, based on tail painting and observation, was good in Experiment 1, it was much lower in Experiment 2, with a high incidence of non detected oestrus (23 %). This was probably due to the short duration of oestrus with some cows, more crowded housing conditions with three groups of animals with a poorer opportunity for cows to interact in a confined housing situation and disinclination of cows to mount other cows on oestrus when standing on slippery slats. In addition, conception rate to first service and for the first six weeks was low, leading to a low overall pregnancy rate (68 %) and an extended calving to conception interval of 100 days. The poor fertility in that season might be partly attributed to the high number of recycled cows in the herd, which had failed to go incalf in the previous breeding season, some of which may have had inherent poor fertility. Synchronisation of all cows in the following season (Experiment 3) to overcome the problems associated with oestrus detection did improve submission rate in the first 21 days to 86 % and reduced the incidence of non detected oestrus. However, conception rate to first service remained low at 37 %. While pregnancy rate in the first six weeks (56 %) was improved compared with the previous year, a high proportion of cows (27 %) were not in-calf at the end of the breeding season compared with Spring calving herds (~ 14 %). Approximately two thirds of the cows that did not become pregnant by the end of the breeding season were either late calvers, cows with reproductive problems or cows with late embryonic mortality. A high proportion of the cows (70 %) in that experiment exhibited a long repeat interval (>24 days), resulting in poor heat detection in the subsequent oestrus cycle and a relatively high incidence of late embryonic mortality (8.5%), based on scanning. The high incidence of late embryonic mortality suggested that there was a herd problem, possibly of infectious origin. A blood metabolic profile carried out on all cows failed to detect any abnormalities. Synchronisation of oestrus did help to reduce both the average, and more importantly, the spread in calving to service interval and the calving to conception interval, which is important to avoid slippage in the calving season in a compact calving herd.

The high level of feeding on the mixed forage diets (T2 in Experiment 1 and T3 in Experiments 2 and 3) did not result in improved fertility compared with the grass silage based diets. Indeed, fertility tended to be lower in two of the experiments (Experiment 1 and 2) on the mixed forage diets compared with diets based on grass silage with or without late autumn grazed grass. This would suggest that the extra energy consumed by the cows on the mixed forage diets was diverted to milk production rather than to improving body condition and fertility. Consequently, the problem of low fertility in Autumn calved cows was not nutritional in origin.

The overall results for reproduction in an Autumn calving herd are disappointing and indicate that a high replacement rate of heifers are needed to maintain the herd when confined to a short breeding season. This would considerably increase the overhead costs of an all Autumn calving system. An alternative approach, which would reduce the number of replacement animals required, would be to retain a proportion of the non-pregnant Autumn calved cows, e.g. young, high yielding cows. These could be milked on for a further 4-5 months and rebred to calve down in the following Spring. Extending the lactation of these cows would partly compensate by reducing the size of the lactating herd needed to stay within quota, but would involve maintaining two herds rather than one.

Conclusions

1. The objective of this study was to produce milk with an all-autumn calving herd at a reasonable cost during the winter period. Two approaches were taken to achieve this objective. One approach was to include grazed grass in the diet with grass silage in early winter and in early spring and thereby reduce feed costs. The second approach was to partially replace grass silage with alternative feeds of high intake potential, such as maize silage, brewers grains or a brewers grains / beet pulp mix, so as to maximise feed intake and milk production, while maintaining the level of concentrates fed at a moderate level.
2. Including Autumn saved grass in the diet with grass silage in early Winter partially replaced grass silage, increased milk yield by an average of 2.1 kg/day, fat + protein yield by 0.16 kg/day and protein concentration by 0.4 g/kg milk. Inclusion of early Spring grass in the diet with grass silage largely replaced grass silage and increased milk yield by an average of 2.9 kg/day, fat + protein yield by 0.21 kg/day and increased milk protein concentration by an average of 0.85 g/kg milk. There was a carryover benefit in Experiment 2 to including grazed grass in the winter diet. Milk yield for the total lactation was increased by 404 kg/cow and fat + protein yield by 20 kg/cow, producing an overall response of 1.14 kg milk or 56g fat + protein/ kg grass DM eaten in winter.
3. Feeding a mixed forage diet containing maize silage, brewers grains and grazed grass/rape or a brewers grains /beet pulp mix to partially replace grass silage consistently increased total DM intake, by an average of 4.4 kg DM/day compared with a grass silage based diet. Milk yield was increased by an average of 3.8 kg/day, progressively increasing from 2.5 to 5.4 kg /day from early Winter to early Spring (Periods 1-3). Yield of fat + protein increased by an average of 0.31 kg/day (0.21-0.42 kg/day from P1to P3) and milk protein concentration increased by an average of 0.9 g/kg milk on the mixed forage diets compared with a grass silage based diet.
4. Over the total winter (P1-P3) the additional feed consumed by the cows on the mixed forage diet (T3) compared with the grass silage based diet (T1) in

Experiments 2 and 3 was 575 and 824 kg DM/cow and resulted in an increase in milk production of 451 and 661 kg/cow, while yield of fat and protein was increased by 36.0 and 56.1 kg/cow, respectively. The response in milk production to the extra feed was similar for both experiments and averaged 0.79 kg milk and 66g fat + protein/ kg extra DM consumed. A smaller increase in total feed intake and milk production was achieved on the mixed diet (T2) in Experiment 1 compared with the grass silage/ grazed grass diet (T1), i.e. + 429 kg DM/cow, 382 kg milk/cow and 30 kg fat + protein/cow, giving a similar response of 0.89 kg milk and 69 g fat + protein / kg extra DM eaten. Due to additional milk produced off grass, the total lactation milk yields for the cows on the mixed forage diets in Experiments 2 and 3 were increased by 619 and 952 kg/cow and fat + protein yield by 46.5 and 76.5 kg/cow, respectively. The overall milk production response to the additional feed consumed was similar for both experiments and averaged 1.12 kg milk and 87g fat + protein per kg additional feed consumed in winter. Consequently a very good overall response in milk production was achieved from a high quality forage based diet.

5. Reproductive performance of an all Autumn calving herd when confined to a compact calving season (13 weeks) was disappointing. In a normal system of oestrus detection, based on tail painting and frequent observation employed in Experiments 1 and 2, the proportion of non pregnant cows at the end of the breeding season was 27-32 %. This was partly due to confined housing and slippery underfoot conditions on slats, which restricted interaction between sexually active cows compared with outdoor conditions. A high incidence of non detected oestrus occurred in Experiment 2. Conception rates to first service were moderate to poor, resulting in a high incidence of repeat oestrus. Synchronisation of oestrus in the herd in Experiment 3, using a CIDR programme, reduced the incidence of non-detected oestrus, but conception rates to first service remained low, resulting in a small improvement in fertility and calving to conception interval compared with the previous season. However, more cows conceived in the first six weeks of the breeding season and this would help to maintain a compact calving and breeding pattern in the following season. Increasing the level of feeding in early-midwinter by means of providing grazed grass or feeding a mixed forage diet had no beneficial effect on cow fertility.
6. On moderately stocked free draining dairy farms involved in winter milk production where grass silage is the main source of winter feed, grazed grass can be included in the diet in late Autumn and early Spring and will partially replace grass silage and increase milk production and milk protein concentration at a relatively low cost. In areas where alternative forage can be produced, e.g. maize silage, or by product feeds e.g brewers grains or pressed beet pulp can be purchased locally, these feeds can be used in combination with grass silage and grazed grass to maximise feed intake and sustain a high

level of milk production throughout the winter and subsequently at pasture at a moderate cost.

7. Reproductive performance with an all Autumn calving herd confined to a compact calving season is a limiting constraint to the widespread adoption of this system of milk production. The system requires a high proportion of replacement heifers to sustain the herd, which adds considerably to the overhead costs of the system. An alternative approach would be to retain some of the younger, high yielding non-pregnant cows, extend their lactation and breed them to calve in the following Spring. This would reduce the number of replacement heifers required but would involve running a small Spring calving herd along with the main Autumn calving herd.

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