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May
2003

A COMPARISON OF FOUR GRASSLAND-BASED SYSTEMS OF MILK PRODUCTION FOR WINTER CALVING HIGH GENETIC MERIT DAIRY COWS

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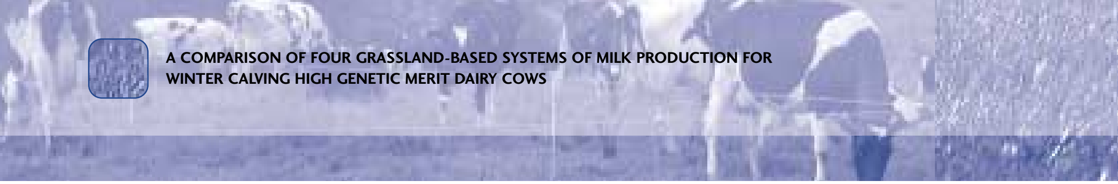
The Milk Development Council
Irish Fertilizer Industries Ltd



OVERALL SUMMARY OF PROJECT

Four different grassland-based systems of milk production were examined over a three-year period, with each system designed to allow high levels of nutrient intakes to be obtained with high genetic merit dairy cows. The systems examined involved a range of concentrate feed levels (1.0 to 2.6 t/lactation), either high or medium feed value grass silage, and either lax or tight grazing systems. Although total milk outputs were similar with each of the four systems (mean 7,900 litres/cow), milk protein contents were higher with systems involving high concentrate inputs during the winter. In addition, system had only minor effects on the degree of tissue loss/gain during the lactation, and on the fertility of the cows involved. However, the land requirements associated with each of the systems were very different, with stocking rates ranging from 2.3 to 3.3 cows/ha. Consequently, gross margin per ha increased with increasing stocking rate, while gross margin per cow and gross margin per litre of milk produced were both relatively unaffected by system. Thus the profitability of each of the systems will, to a large extent, be influenced by the fixed costs which arise on the individual farm.

INTRODUCTION

As a result of the rapid increase in genetic merit within the Northern Ireland dairy herd during the last 20 years, milk yields/cow have increased considerably. While high genetic merit animals have the ability to eat more, the main reason for their higher milk yields is related to how they utilise their feed nutrients. For example, in early lactation high merit dairy cows will produce more milk 'off their back', and as a result, lose more body condition compared to animals of lower genetic merit. Similarly, in later lactation high merit animals will continue to use a large proportion of their feed nutrients for milk production, rather than to replace body condition, while animals of lower genetic merit will use more of their feed nutrients to replace body condition, rather than for milk production. Excessive loss of body condition, combined with long periods in low body condition, may result in health, fertility and animal welfare problems. **Thus a key management objective with high genetic merit animals must be to increase feed nutrient intakes.** As systems based on grazed grass and grass silage are likely to remain dominant in Northern Ireland for the foreseeable future, higher nutrient intakes must be obtained within these grassland-based systems.

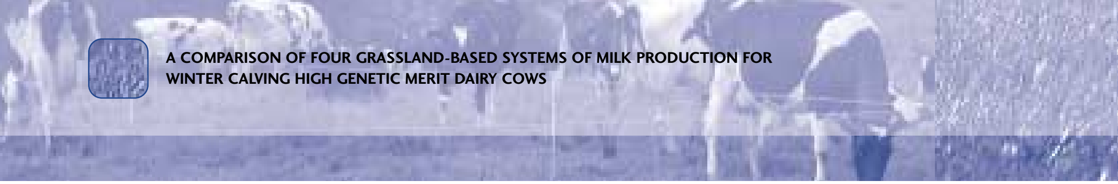
To address this issue, four different grassland-based systems of milk production were examined in a three-year study at Hillsborough. Each of the four systems were designed to allow high levels of nutrient intakes to be obtained. The systems examined incorporated the following broad approaches to increasing nutrient intakes:

- During the winter, by either improving the feed value of the silage offered or by increasing concentrate feed level.
- During the summer, by either offering a high allowance of high quality pasture without supplementation, or by tighter grazing regimes combined with concentrate supplementation.

In addition to examining the effects of system on animal performance, the study was designed to allow the economics of milk production with each of the systems to be examined.

PROCEDURE

- The study was conducted at the Agricultural Research Institute of Northern Ireland (Hillsborough), and involved an examination of four grassland-based systems.
- These systems were examined over a period of three lactations, with 80 high genetic merit Holstein Friesian animals (mean PIN_{2000}, £38) on the study each year.
- Animals involved in the study were Autumn calving (mean calving date, 16 November), and were a mixture of cows and heifers (mean lactation number, 1.9).



SYSTEMS

- Key elements of each of the four systems are summarised below:

	System 1	System 2	System 3	System 4
Winter period	High feed value grass silage +6 kg concentrate/day		Medium feed value grass silage +12.5 kg concentrate day	
Spring period	Early turnout	Later turnout	Early turnout	Later turnout
Summer period	Lax grazing, plus 0.5 kg concentate/day	Tighter grazing, plus concentrate to yield	Lax grazing, plus 0.5 kg concentrate/day	Tighter grazing, plus concentrate to yield

- **Winter period:** Animals on Systems 1 and 2 were managed identically during the winter period. The high feed value grass silages were produced from rapidly wilted herbage, within a four-cut system. The first cut was harvested between 10-15 May, with the remaining harvests taken at approximately 32-33 day intervals. The concentrates offered (6.0 kg/day) had a crude protein content of 25% (fresh basis) and were offered through an out-of-parlour feed station. Similarly, animals on Systems 3 and 4 were also managed identically during the winter. The medium feed value grass silages were produced within a two-cut system, from herbage wilted for between 0-3 hours only. First and second cuts were harvested during the first week of June and the first week of August respectively. The concentrates offered (12.5 kg/day) had a crude protein content of 18.5% (fresh basis), and, because of the high feed level used, were mixed with the silage in the form of a complete diet.
- **Spring period:** From 15 March onwards, animals on Systems 1 and 3 were given access to spring grass, initially for only a couple of hours/day (extended grazing). Animals on Systems 2 and 4 had a later turnout date (8 April). All animals were at grass full time by 27 April. Dates given in this section are average dates for the three years of the study.
- **Summer period:** During the Summer, animals on Systems 1 and 3 were managed within a flexible grazing system (fence lines moved daily) and offered large daily herbage allowances. Grass quality was maintained through regular grass topping. Concentrates were restricted to 0.5 kg/day, with this concentrate acting as a magnesium carrier. With Systems 2 and 4, animals were grazed within a paddock grazing system (tighter grazing) with concentrates offered 'to yield'. The mean concentrate input was 4.0 kg/day, with this concentrate having a crude protein content of 17% (fresh basis).

REVIEW OF FINDINGS

Mean herbage yields

- The annual yields of herbage harvested within the two- and four-cut silage systems were 12.8 and 11.9 t DM/ha respectively, a difference of 7.5%.

Silages produced

- The mean chemical composition (DM basis) of the silages produced over the three years of the study are presented below:

	High feed value silage	Medium feed value silage
Dry matter (%)	31.3	20.2
Crude protein (%)	16.3	11.8
pH	4.0	4.2
Ammonia N (% total N)	9	11
D value (%)	74	65
ME (MJ/kg DM)	12.2	10.7

- The high DM content and high nutrient value of the high feed value silages reflect the frequent harvesting intervals and the rapid wilting techniques used. The much lower DM content and lower nutritive value of the 'medium feed value' silages reflect the direct-cut, two-harvest system used.

ANIMAL PERFORMANCE

Winter period: (calving to 14 March)

- The responses to winter management systems are presented below:

	Systems 1 and 2 High feed value silage + 6.0 kg concentrate/day	**Systems 3 and 4** Medium feed value silage + 12.5 kg concentrate/day
Dry matter intakes		
Grass silage (kg/day)	11.5	6.7
Concentrate (kg/day)	5.2	10.9
Total (kg/day)	16.7	17.6
Milk production		
Milk Yield (kg/day)	29.8	29.7
Fat (%)	4.1	4.1
Protein (%)	3.1	3.3

- Total DM intake was slightly lower with Systems 1 and 2, compared to Systems 3 and 4.
- Daily milk yield was unaffected by Winter system.
- Milk protein levels were higher with animals offered medium feed value silage plus high levels of concentrates.
- In a small scale subsidiary study, feeding the higher level of concentrates (12.5 kg/day, as in Systems 3 and 4) with the high feed value silage (as in Systems 1 and 2) increased milk yield by only 0.9 kg/day.
- In a second small scale subsidiary study, the effects of reducing the crude protein content of the concentrate offered with Systems 1 and 2, from 25% to either 20% or 15%, was examined. Milk output and gross margin (per litre and per cow) were both maximised at the highest concentrate crude protein level, namely 25%. This finding supports the use of the 25% crude protein concentrate within the main study.

Spring period: (15 March - 27 April)

- The responses to spring management systems are presented below:

	System 1 Early turnout	**System 2** Later turnout	**System 3** Early turnout	**System 4** Later turnout
Dry matter intake				
Grass silage (kg/day)	7.5	10.0	4.7	5.7
Concentrate (kg/day)	5.2	5.2	9.8	10.1
Milk production				
Milk yield (kg/day)	29.4	29.0	28.9	28.3
Fat (%)	3.7	3.8	3.9	4.0
Protein (%)	3.3	3.3	3.5	3.5

- Giving animals access to pasture for short periods in early Spring (Systems 1 and 3) reduced silage DM intake by an average of 1.7 kg/cow/day.
- There was very little evidence of any milk yield benefit from the use of extended grazing in early spring. It is likely that animals offered high quality diets during the winter, such as those offered in this study, are less likely to show positive responses to early turnout, compared to those offered poorer quality diets.
- Extended grazing can be very weather dependent. For example, the dates of commencement of extended grazing ranged from 25 February in Year 1, to 11 April in Year 3, a difference of 45 days.

Summer period: (28 April to 26 October)

- The responses to summer management systems are presented below:

	System 1 Lax grazing, plus 0.5 kg conc./day	**System 2** Tighter grazing, plus conc. to yield	**System 3** Lax grazing, plus 0.5 kg conc./day	**System 4** Tighter grazing, plus conc. to yield
Mean grass allocation (kg/cow/day, above 4 cm)	22.4	16.8	22.4	16.8
Dry matter intake				
Grazed grass (kg/day)	18.9	14.7	18.9	14.7
Concentrate (kg/day)	0.6	3.6	0.6	3.6
Milk Production				
Milk Yield (kg/day)	19.3	21.0	18.9	20.9
Fat (%)	4.2	4.0	4.3	4.2
Protein (%)	3.6	3.6	3.6	3.6

- Post-grazing sward heights were 6.3 cm with Systems 1 and 3, and 5.8 cm with Systems 2 and 4. Regular grass topping was used to maintain sward quality with Systems 1 and 3.
- Higher milk yields were obtained with systems based on tighter grazing plus concentrates offered to yield (Systems 2 and 4), compared to systems based on lax grazing plus minimum concentrate inputs (Systems 1 and 3). This trend (which occurred throughout the 3 years of the study) highlights that it is more difficult to achieve consistently high milk yields with systems involving high allowances of high quality pasture, compared to systems based on lower grass allowances, plus concentrates offered to yield.
- The winter management regime did not influence the performance of the cows during the summer.
- During the summer, 4.0 kg of a 17% crude protein concentrate was offered with Systems 2 and 4. The results of a small scale subsidiary study indicated that there was no milk yield benefit or economic advantage to be gained from either increasing (23% crude protein) or decreasing (11% crude protein) the crude protein content of the grazing concentrates offered. In addition, while doubling the level of concentrate offered within this subsidiary study resulted in an 11% increase in milk output, margins over feed costs were considerably reduced at higher levels of concentrate feeding.

Full lactation:

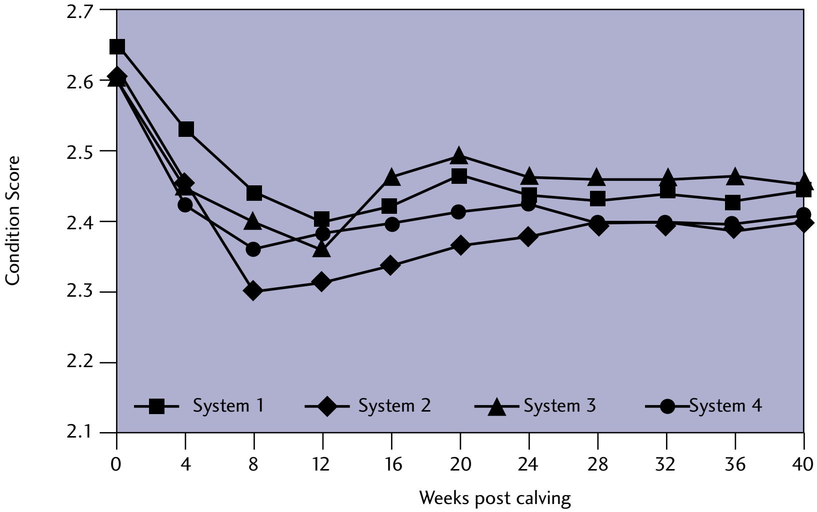
- A summary of the full lactation data (mean for 3 years) is presented below:

	System 1	System 2	System 3	System 4
Dry matter intake				
Concentrate (kg)	928	1388	1851	2277
Grass silage (kg)	1895	1984	1106	1160
Grazed grass (kg)	3119	2379	3156	2406
Total (kg)	5941	5752	6114	5843
Milk Production				
Total Milk Yield (kg)	7868	8083	7721	8007
Fat (%)	4.1	4.0	4.1	4.1
Protein (%)	3.3	3.3	3.5	3.5
Milk from forage (kg)	5498	4538	2993	2191

- Across the full lactation, concentrate intakes (fresh basis) increased from 1.0 t/cow with System 1, to 2.6 t/cow with System 4.
- Intakes of grass silage were approximately 70% higher with Systems 1 and 2, compared to Systems 3 and 4.
- Intakes of grazed grass were approximately 30% higher with Systems 1 and 3, compared to Systems 2 and 4.
- Despite the very different feeding and management regimes adopted in the study, total lactation milk outputs were relatively unaffected by system. This result clearly indicates that it is possible to achieve very similar milk outputs from very different combinations of feed inputs within grassland-based systems.
- The 5498 kg of milk produced from forage with System 1 highlights the potential of high quality home produced forages to sustain high levels of milk outputs.

BODY TISSUE RESERVES

- The changes in condition score of animals on each of the four systems followed a similar trend, and are presented below:



- Condition score losses averaged approximately 0.3 of a score across the first 10 weeks of lactation, with small gains thereafter. Condition score loss with System 2 was slightly greater than for any other system.
- By week 40 post calving, the mean condition score of cows on all four systems was between 2.4 - 2.5. Cows tended to have returned to their ‘calving condition score’, by the time they calved down in the next lactation. This suggests that in the long term the body condition of cows were not more severely depleted on any one system, compared to any other system.

FERTILITY

- During each year of the study, the breeding season commenced in early December, and finished mid June. Key fertility data are presented below:

	System 1	System 2	System 3	System 4
Conception to 1st service (%)	38	36	41	32
Conception to 1st + 2nd service (%)	64	55	62	66
Number of services/pregnancy	2.5	2.6	2.4	2.3
Calving interval (days)	400	389	379	386
% of cows not in calf during breeding season	9	12	9	3

- While there were some variations in fertility between systems, these differences were not large enough to be considered as 'statistically significant', and as such, it is unlikely that these were 'real treatment effects'.
- Although conception rates were low (mean of 37% to 1st service, across all systems), they were in line with the 39% conception to first service recorded across 19 Northern Ireland dairy farms in a recent study.

LAND REQUIREMENTS

- Overall stocking rates (grazing plus silage) are presented below:

	System 1	System 2	System 3	System 4
Stocking rate (cows/ha)	2.3	2.6	2.9	3.3
Stocking rate (cows/acre)	0.9	1.1	1.2	1.3

- 44% more land was required for System 1 compared to System 4. Alternatively, 44% more animals could be kept on a given area of land by a farmer operating System 4, compared to a farmer operating System 1.
- The availability of land is likely to be a key factor influencing the adoption of a particular system. In addition, the proximity of grazing land to the milking parlour, together with suitability of land for harvesting silage, are additional factors which may influence the choice of system.

LABOUR AND MANAGEMENT INPUTS

- The systems examined involved very different labour requirements and management inputs. Components of the systems that are associated with either ‘high’ or ‘reduced’ labour/management requirements, are listed below.

	High labour/management input components	Reduced labour/ management input components
Silage production	Four-harvest silage system Use of rapid wilting techniques	Two harvest silage system Direct cut techniques
Winter feeding (including extended grazing)	Complete diet feeding systems Extended grazing in Spring	Simple in-parlour or out-of-parlour feeding system Normal turnout dates
Summer management	Assessing herbage allowances, and moving fence lines daily Grass topping	Fixed paddock system Tight grazing systems plus concentrates

- When examined within this context, System 1 involved the highest levels of labour and management inputs, and System 4 the lowest.
- With the availability of farm labour decreasing, simple systems involving reduced labour and reduced management inputs will become increasingly important.

ENVIRONMENTAL IMPLICATIONS

- The environmental impact of milk production systems, especially in relation to nitrogen and phosphorus, are becoming increasingly important.
- Manure nitrogen outputs associated with each system (including outputs from young stock) have been calculated below:

	System 1	System 2	System 3	System 4
Manure nitrogen produced/ha (kg)†	213	232	251	273

† Assumes a manure nitrogen output for cows, heifers and young stock of 106, 58 and 9.5 kg respectively (DEFRA, 2002). Replacement rate assumed as 30% across all systems.

- Within nitrate vulnerable zones (NVZ) the permitted quantity of manure/slurry which can be spread on the land is restricted. System 4 would fail to meet the requirements of most NVZs currently designated in the UK, namely a limit of 250 kg nitrogen/ha in the form of manure/slurry.
- Systems involving higher concentrate feed levels are more likely to be associated with increased risk of phosphorus pollution.

ECONOMICS OF THE FOUR SYSTEMS

- A key aim of this study was to use the animal production data to conduct simple economic appraisals.
- The following values have been used in the economic appraisal:

	Component	Value†
Output	Milk price	18pence/litre
	Cull cow	£280/cow
	Replacement cost	£126/cow/year
	Calf value	£50/cow/year
Variable costs	High feed value silage	£46/t DM
	Medium feed value silage	£34/t DM
	25% crude protein winter concentrate	£175/t fresh
	18.5% crude protein winter concentrate	£133/t fresh
	Grazing concentrate	£157/t fresh
	Dry cow concentrate	£126/t fresh
	Grazing cost/cow (tight grazing)	£48/cow/year
	Grazing cost/cow (lax grazing)	£64/cow/year
	Sundry costs	£70/cow/year

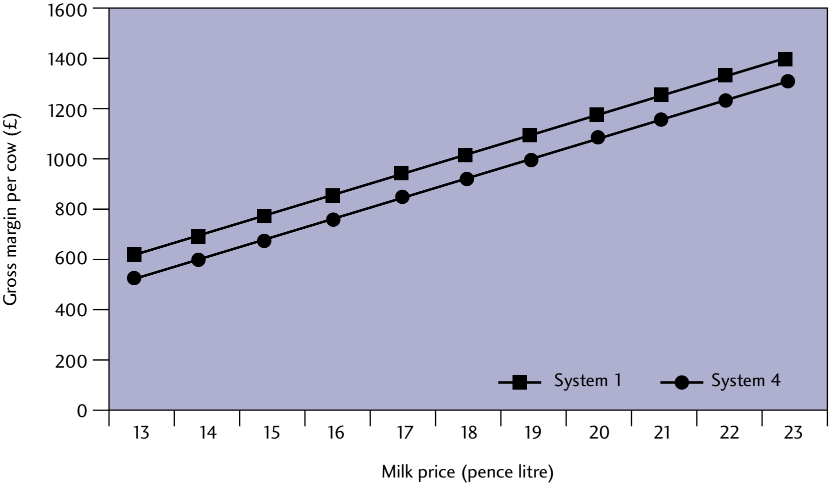
† Milk prices adjusted for current composition bonuses. Concentrates, fertiliser and contractors costed at 2002 prices. Land charges and depreciation charges not included in silage and grazing costs.

- Using these values and the animal production data presented earlier, gross margins have been calculated.

	System 1	System 2	System 3	System 4
Gross margin/ha (£)	2359	2543	2821	3174
Gross margin/cow (£)	1026	978	973	962
Gross margin/1000 litres (£)	125	117	122	117

- Gross margin per ha increased from £2359 with System 1, to £3174 with System 4. This reflects the much lower land requirements associated with System 4.
- System had little effect on either gross margin per cow or gross margin per 1000 litres of milk produced.

- Gross margins per cow have been calculated below for a range of milk prices (13 - 23 pence/litre), for the two most extreme systems, namely System 1 and System 4:



- As expected, gross margin/cow decreases as milk price falls. However, across the range of milk prices examined, gross margin fell at an equal rate with each of the two systems. This suggests that neither system had an advantage over the other system in either low or high milk price scenarios. This is due to the fact that both systems were based on high levels of nutrient inputs and high levels of milk outputs.
- However, these gross margin results do not take account of the opportunity cost associated with land, the depreciation of buildings and grazing infrastructure, nor any fixed costs on the farm, including labour.
- As gross margin per cow and per 1000 litres of milk produced were relatively similar for all four systems, the profitability of any of these system will be mainly determined by the fixed costs for the individual farm. It is well known that fixed costs vary considerably from farm to farm. For example, two farms could adopt the same production system and produce the same level of milk output (eg 7800 kg) using the same inputs of feed, silage quality and grazing systems. However, because of very different fixed costs, the profit per litre of milk produced could be very different on each of the two farms.

DISCLAIMER

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