The Effect of Various Pasture-based Systems of Milk Production on Animal Performance in the Northeast Region of Ireland

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1. Introduction.

The potential of Irish soils to grow grass throughout the year and success in utilizing grass are key factors affecting output and profitability of dairy production systems (Shalloo et al., 2004). In the Northeast region of Ireland, the potential grazing season is shortened due to impeded land drainage, topography, high rainfall and northerly aspect. The main focus of the Ballyhaise research programme is to develop more sustainable production systems suitable to the limitations of the region with a specific focus on grass growth and utilization. Progress in these technologies will improve the competitiveness of dairying in the Northeast region.

We are also now faced with a new economic environment with market forecasts predicting a steady decline in dairy product prices for Irish dairy farmers while input prices continue to increase. It has been shown from previous studies that dairy farmers need to expand and/or increase the efficiency of their dairy operation to maintain their real farm incomes over the coming years (Breen and Hennessey, 2003). It is likely that land purchase price will continue to be high in future years. Firstly, dairy farmers can continue at their current level of production and efficiency, and suffer a decline in farm profit as milk price falls. It is likely that greater amounts of milk quota will become available in the coming years; therefore many dairy farmers will have the option to increase production. Expansion opportunities will be limited by the key constraints such as labour supply and cost, capital cost, milk quota availability and price and availability of land around the milking parlour. Labour efficient work practices will have to be adopted on farms to allow one operator to manage a greater number of cows.

The objective of this experiment was to examine the effect of two divergent pasture-based systems of milk production on animal performance over a two-year period and to subsequently describe the optimum system for dairy farmers in the Northeast region both now and into the future.

2. Introduction to Animals and Feed Systems

The Ballyhaise dairy herd (n=49, 2003; n=69, 2004) of Holstein-Friesian dairy cows used in the current study have derived mainly from the use of sires that are genetically superior for high milk production (such as SSB, ELC, ASI, HSN, TUS and FAL). The herd are approximately 80% Holstein-Friesian and have an overall Economic Breeding Index value of €28, and were therefore very similar in overall genetic potential to the national dairy population at the time during which this project was carried out. A breakdown of the overall genetic potential of the herd is shown in Table 1 below. This data clearly shows that this herd has been selected on a variety of production traits with little overall emphasis given to the maintenance of the animals genetic potential for fertility traits.

Table 1. The Economic Breeding Index (EBI) values for the three strains of Holstein-Friesian cows studied.

	Ballyhaise Herd
Overall EBI (€)	28
Sub-Indices	
Milk (€)	27.5
Fertility (€)	2.5
Calving (€)	0.4
Beef (€)	-1.0
Predicted Differences	

Milk (kg)	154
Fat (kg)	5.6
Protein (kg)	6.8
Fat (%)	0.00
Protein (%)	0.03
Calving Interval (days)	+0.06
Survival (%)	+0.38

All values were obtained from the February 2004 evaluation (ICBF, 2004).

Over the last two years the Ballyhaise dairy herd were allocated to one of two feed systems (FS); high milk output per cow from pasture (HG) and high concentrate feeding system at pasture (HM). The purpose of the HG (control) system was to maximise milk production from a predominantly grazed grass diet, with cows receiving no concentrate during the main part of the grazing season. In contrast, the HM system was designed to observe the effect of additional concentrate supplementation throughout lactation on animal performance relative to the control system. Concentrate supplementation averaged 632 and 1,457 kg per cow for feeding system HG and HC, respectively.

In the HG system cows were supplemented with approximately 650 kg of concentrate, while in the HM system, cows received 1,450 kg of concentrate, with the greatest proportion being fed in early and late lactation. The cows were turned out to grass by day in early March and by day and night in late March and were managed for the duration of the grazing season on a rotational grazing regime. In the HG system, the whole farm was grazed in the first grazing rotation, finishing in mid April, while in the HC system approximately 60% was grazed in the first grazing rotation. Grass cover was monitored weekly and surpluses and deficits were corrected as necessary. Nitrogen was applied after each rotation with 240 kg/ha being applied annually. Approximately 50% to 60% of the farm was harvested for first cut silage, with 30% of the farm harvested for second cut silage. The harvest date for first and second cut silages are May 25th and July 15th, respectively. Grass cover was increased from mid August and by late September the covers peaked at approx 1,100 kg DM/ha. The breeding commenced on April 20th and finished on July 29th and the calving season stretched from late January to mid-May.

3. The Effect of Various Pasture-based Systems of Milk Production on Animal Performance in the Northeast Region of Ireland.

Materials and Methods

Individual animal milk yields were recorded daily and milk fat, protein and lactose concentrations were determined using a Milkoscan 203 (Foss Electric DK-3400, Hillerod, Denmark), from successive evening and morning samples collected once weekly. Data were analysed using a repeated measures model (Proc MIXED) using the statistical procedures of SAS (SAS, 2002). In the final model, cow was included as a random effect while year, parity and feed system were included as fixed effects. Calving date was also included as a co-variate in the analysis.

Results

The effect of feed system and year on animal performance over the two years of the experiment is shown in Table 2.

Table 2. Effect of feed system and year on 305 day milk production.

	Feed System		Year		†Significance levels		
	HG	HM	2003	2004	s.e.	FS	Y
Total Production (kg/cow)							
Milk	5782	6524	6086	6220	201.3	***	NS
SCM	5594	6277	5931	5940	186.1	***	NS
Milk solids	438	490	460	467	14.4	***	NS
Fat	245	276	260	261	9.1	***	NS
Protein	192	213	200	205	9.5	***	NS
Lactose	271	304	290	285	9.2	***	NS

Daily Production(kg/cow/day)							
Average yield	20.4	22.7	21.3	21.7	0.67	***	NS
Peak yield	35.5	35.3	36.0	34.8	1.09	NS	NS
Milk Composition (g/kg)							
Fat	42.4	42.3	42.5	42.2	0.82	NS	NS
Protein	33.1	33.0	32.7	33.5	0.39	NS	***
Lactose	46.8	46.9	47.3	46.4	0.29	NS	***

†Significance: ***= $P < 0.001$, NS = Non-significant. FS = feed system effect, Y = year effect.

No significant feed system by year interaction was observed for any of the variables measured. FS had a significant effect on all milk production traits with the exception of peak milk yield. The cows in the HM system produced the highest yields of milk, SCM (Solids Corrected Milk), milk solids (fat plus protein yield), fat, protein and lactose over the study period. The average response to concentrate supplementation at pasture over the study period was 0.92 kg milk per kg of additional concentrate fed to the HM group. Animal performance was not affected by year, however a significant increase in milk protein and lactose composition was achieved in 2004.

4. An economic appraisal of various alternative production systems in the Ballyhaise farming environment.

The objectives of this section are to examine the effect of 4 key constraints to expansion in dairy farms i.e. availability and cost of labour, capital costs, milk quota availability and price and land availability for the grazing dairy herd. Particular emphasis in this analysis will be on defining a system of milk production that will maximize profit in an expanding environment. Of the four constraints listed land availability will be dealt with in most detail in this paper. Data from an ongoing two-year study being carried out at Ballyhaise comparing two groups of cows under two different feed systems was used for modeling data at the Ballyhaise site.

Ballyhaise site

In the Ballyhaise High Grass System (BHG) cows are supplemented with approximately 650 kg of concentrate, while in the Ballyhaise High Concentrate System (BHC) cows receive 1,450 kg of concentrate, with the greatest proportion being fed in early and late lactation. The cows are turned out to grass by day in early March and by day and night in late March. Cows are managed on a rotational grazing regime. In the BHG system the whole farm is grazed in the first grazing rotation, finishing in mid April, while in the BHC system approximately 60% is grazed in the first grazing rotation. Grass cover is monitored weekly and surpluses and deficits are corrected as necessary. Nitrogen is applied after each rotation with 240 kg/ha being applied annually. Approximately 50% to 60% of the farm is harvested for first cut silage, with 30% of the farm harvested for second cut silage. The harvest date for first and second cut silages are May 25th and July 15th, respectively. Grass cover is increased from mid August and by late September the covers peak at approx 1,100 kg DM/ha. The breeding and calving season are similar to Moorepark.

Maize silage feeding systems

There may be potential to increase milk production by using alternative high quality forage instead of concentrates. Experiments in Moorepark and elsewhere have demonstrated the potential of maize silage to increase intake and milk production, or alternatively to reduce the requirement for concentrates supplementation. Therefore, in a scenario of expanding milk production, purchased maize silage is considered as an alternative to purchased concentrate in terms of its effect on farm profitability. The costs associated with maize silage were based on a yield of 5 tonnes DM/ha, with plastic used at the Ballyhaise site (Kavanagh, 2003). In the analysis a response of 0.35 kg of milk per kg of Maize silage DM was assumed based on experiments at Moorepark. Based on this assumption a high Maize silage system was evaluated for the Ballyhaise (BHM) site.

Biological Data

Table 3 shows the milk production, liveweight, replacement rate and overall feed budget for the Ballyhaise site. The response to increasing the level of concentrate supplementation at the Ballyhaise site it was 0.7 kg of milk per kilogram of extra concentrate (i.e. going from the BHG to the BHC system). Sixty-one percent of the diet of the HGS and 50% in the HCS were composed of grazed grass.

Table 3. Milk production, liveweight, replacement rate, feed budget and the proportions of each feed in the diet for Moorepark and Ballyhaise feeding systems.

	BHG	BHC
Milk Production		
Milk (kg/cow)	6,389	6,894
Fat (g/kg)	42.3	45.5
Protein (g/kg)	33.0	32.8
Lactose (g/kg)	45.3	45.6
Average live-weight (kg)	539	549
Feed Budget (kg DM/cow)		
Grass DM intake	3,372	3,020
Silage DM intake	1,554	1,678
Concentrate DM intake	604	1291
Proportions of total DM intake		
Grass	0.61	0.50
Silage	0.28	0.28
Concentrate	0.11	0.22

Economic scenarios investigated

Four milk production scenarios were investigated:

1. EU milk quota applied at farm level where the consequence of higher milk (fat adjusted) production necessitated a reduction in cow numbers (S1). Therefore the purchase of milk quota is not possible.
2. EU milk quota applied at industry level (quota purchasing possible) with fixed cow numbers (S2). Therefore additional milk quota could be purchased but milk output could only be increased through increasing milk yield per cow with additional feeds.
3. EU milk quota applied at industry level (quota purchasing possible) with a fixed land base (S3). Therefore additional milk quota can be purchased and cows can be expanded up to a point where land becomes limiting.
4. EU milk quota applied at industry level (quota purchasing possible) with land available for expansion (S4). Therefore additional land can be rented, additional milk quota purchased and cow numbers increased.

Quota was purchased at a cost of €0.70/gallon, which was financed over 5 years with the interest and capital considered an expense. Table 4 shows the key assumptions used in the farm model for the four scenarios. The overall farm size in the model was 29.5 ha, with deficits and surpluses treated as an opportunity cost of €262/ha. The model farm was assumed to have a milk quota of 323,327l (71,120 gallon). All costs and prices were based on projections from FAPRI in the post-decoupling era (Binfield et al., 2003). Concentrate cost was assumed to be €205/t. The differences in concentrate costs were based on regional data from Monitor Farms. No cost was associated with the first 1.1 labour units, while any extra labour was considered as an expense and charged at €12.37 per hour. Farm net profit included total receipts less all other costs. It was assumed that there were 50 cow places available on the farm and when cow numbers increased over 50 conventional housing was constructed at a cost of €1,590 per cow. Additional cows were financed over a 5-year period with the interest portion of the loan considered an expense.

Table 4: Assumptions used in the model farm.

	Ballyhaise
Farm size (ha)	29.5
Quota (kg)	323,327
Reference fat (g/kg)	36
Gross milk price (c/kg)	22.3
Price protein to fat	2.00
Replacement Heifer price (€)	1,397
Reference cull cow price (€)	270
Reference male calf price (€)	102
Labour cost per unit (€/month)	1,905
Concentrate costs (€/tonne)	205
Opportunity cost of land (€/ha)	262
No. of Cow places on the farm	50
Concentrate Cost (€/tonne)	205
Maize Silage Cost (€/tDM)	120

At the Ballyhaise site the BHG in S1 scenario was used as the control system i.e. each other system compared to this system. Therefore it was possible to investigate the economic consequences of opting for a higher concentrate or high maize supplementation system in a variety of scenarios.

Economic Analysis

The Moorepark Dairy Systems Model (Shalloo *et al.,* 2004), which is a stochastic budgetary simulation model, was used to simulate the model farms by integrating biological data from each site. Table 3 shows the key herd output parameters from the model for the Moorepark site for each of the four scenarios for each of the three feeding systems.

Table 5 shows the key herd output parameters from the model for the Ballyhaise site for each of the same four scenarios (S1, S2, S3, S4) for each of the three feeding systems (BHG, BHC, BHM). Where milk quota was fixed (S1) the farm profit from the BHG system was €4,709 and €1,521 more than the BHC and the BHM systems, respectively. The margin per cow was highest with BHG while margin per cow and margin per litre were lowest with the BHC system.

Where milk quota purchasing was possible and cow numbers were fixed (S2) the BHG system returned €3,602 and €1,095 higher farm profit than the BHC and the BHM systems, respectively, when the additional labour was charged. If the additional labour was not charged then there was a loss of €548 and a gain of €69 in the BHC and BHM systems, respectively. In the BHC and the BHM systems 42,061 and 14,996kg (8,985 and 3,203gallons) of additional milk quota were purchased respectively.

Where milk quota purchasing was possible and land was limiting (S3) the BHG system was €3,103 and €599 more profitable than the BHC and BHM systems respectively, when additional labour was charged. If the extra labour was not charged then there was an advantage of €1,412 and €4,817 to BHC and BHM systems respectively. In the BHC and the BHM systems 62,055 and 69,659kg (13,256 and 14,881gallons) of additional milk quota were purchased over the BHG system.

Where milk quota purchasing was possible and land was available for expansion (S4) (a similar amount of quota was purchased as in S3) the BHG system returned €646 more farm profit than the BHG system in the S1 scenario or €6,071 where extra labour is not charged.

Table 5: Key herd output parameters at the Ballyhaise site in a fixed quota scenario (S1), in a scenario with fixed cow numbers and quota leasing (S2), in a of limited land area with quota leasing (S3) and in a scenario where land is available (S4) for a high grass (BHG), high concentrate (BHC) and high maize silage (BHM) system.

	S1			S2		S3		S4
	BHG	BHC	BHM	BHC	BHM	BHC	BHM	BHG
Milk Price	24.1	24.7	24.1	24.7	24.1	24.7	24.1	24.1
Total hectares used	19.4	15.7	15.8	18.2	16.6	19.4	19.4	24.1
Quota lease (kg)	-	-	-	42,061	14,996	62,055	69,659	69,601
# Cows calving	45.7	39.5	43.4	45.7	45.7	48.5	54	56.8
Livestock units (LU)	42.9	37.0	40.7	42.9	42.9	45.6	50.7	53.3
Stocking rate (LU/ha)	2.22	2.35	2.59	2.35	2.59	2.35	2.59	2.22
Milk produce	292,020	272,274	291,225	315,058	306,486	335,395	362,114	362,912

d (kg)								
Milk sales (kg)	286,700	267,677	286,170	309,738	301,166	329,732	355,828	356,301
Fat sales (kg)	12,126	12,196	12,129	14,112	12,765	15,023	15,082	15,069
Protein sales (kg)	9,500	8,797	9,491	10,180	9,989	10,837	11,802	11,806
Milk returns (€)	69,010	66,168	68,990	76,565	72,604	81,508	85,782	85,764
Livestock sales (€)	12,568	10,860	11,942	12,567	12,568	13,378	14,849	15,619
Feed costs per kg milk	4.78	6.55	5.34	6.55	5.78	6.55	5.78	4.78
Total costs (€)	56,223	56,383	57,098	67,379	60,904	72,341	75,875	75,340
Margin per cow (€)	555	523	549	476	531	459	458	459
Margin per kg	8.69	7.58	8.19	6.91	7.91	6.66	6.83	7.17

milk (cents)								
Single Farm Payment (€)	-	-	-	-	-	-	-	-
Labour Costs (€)	-	-	-	3,054	1,164	4,515	5,416	5412
Farm Profit (€)	**25,355**	**20,646**	**23,834**	**21,753**	**24,260**	**22,252**	**24,756**	**26,044**

Table 6 shows the effect of variation in concentrate costs and the effect of the concentrate price c/kg to the milk price c/kg ratio on farm profitability for the Ballyhaise site. Table 6 shows that the BHC system is less profitable than the BHG system even at a concentrate cost of less than €145/tonne in the S1, S2 and S3 scenarios respectively. In a fixed quota scenario dairy farmers could afford to pay €1,535/ha to maintain a low input system rather than going to a high input system and still break even. When land area for grazing is available with quota purchasing (S4), the BHG is more profitable until concentrate cost is reduced to €115/tonne when compared to the BHC system in S3.

Table 6. The effect of variation in concentrate costs on the profitability of the high and low input systems for Ballyhaise.

		S1		S2	S3	S4
Concentrate Price	**Concentrate Milk price Ratio**	**BHG**	**BHC**	**BHC**	**BHC**	**BHG**
Base - €60/tonne	0.55	**27,092**	23,839	25,447	26,175	**28,210**
Base - €40/tonne	0.64	**26,513**	22,774	24,216	24,866	**27,482**

Base - €20/tonne	0.73	**25,935**	21,710	22,985	23,559	**26,763**
€205	0.83	**25,355**	20,646	21,753	22,259	**26,044**
Base + €20/tonne	0.92	**24,777**	19,582	20,522	20,945	**25,324**
Base + €40/tonne	1.01	**24,199**	18,518	19,290	19,639	**24,605**
Base + €60/tonne	1.10	**23,620**	17,454	18,059	18,332	**23,886**

5. Conclusions

The data show that in the northeast region of Ireland, high milk production can be achieved from pasture-based systems incorporating lower levels of supplementary concentrate. While the inclusion of additional concentrate in the diet of Holstein-Friesian dairy cows can result in a significant increase in milk production, at current day milk prices it is uneconomical to do so relative to the acquisition of extra cow grazing land.

The results of the present analysis indicate:

- The most profitable spring milk production system in Ballyhaise (in both a milk quota and non quota scenario) is where grazed grass is maximised where grazing land is not a limitation.
- The profitability of systems of milk productions based on high concentrate /high maize silage systems will be very much influenced by milk supplement price ratios. Using present day concentrate prices and projected future milk prices there is very little to be gained financially by changing to a high concentrate/high maize silage feeding system when full labour costs are charged.
- Increased labour efficiency is needed in all the expansion scenarios investigated to increase farm profit.
- In all the analyses carried out, grazing management was at the same level of efficiency in all three feeding systems (high grass, high concentrate and high maize). This may not be the case on most dairy farms because generally grazing efficiency is reduced in high supplementation situations, especially with forage.
- On farms limited by land availability, options to increase the cow grazable area should be investigated before looking at high input systems. Such options include land leasing, land swapping and or dairy farm partnerships.

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