Optimising Financial Return from Grazing in Temperate Pastures

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Key Points

1. The increased interest in pasture-based systems of milk production in recent years has been largely generated through lower product prices and rising costs of production.
2. Pasture based systems of milk production decrease unit production costs, through lower feed and labour expenses, and reduced capital investment.
3. Systems utilising grazed pasture will be optimised in regions where pasture production potential is high, variability in seasonal pasture supply and quality is low, manufacturing milk accounts for a large proportion of total production, and where large areas of land are available at relatively low cost.
4. Pasture based systems may allow greater global sustainability (through reduced use of fuel, herbicides and pesticides), increased product quality, improved animal welfare and increased labour efficiency.

Keywords: pasture based-system, confinement TMR system, cash cost, grazed grass

Introduction

The recently rejuvenated interest in grazing systems of milk production for dairy cows in many temperate and subtropical regions of the world (especially Europe and USA) is a result of lower inflation-adjusted milk prices, the proposed removal of some subsidies and tariffs, rising labour, machinery and housing costs, and perceived environment and animal welfare concerns associated with intensive dairying.

The decision to change from intensive feeding systems to grazing requires a thorough evaluation of the whole farm system (Parker *et al*., 1992). Clark and Jans (1995) outlined the advantages and disadvantages associated with grazed forage versus concentrate-based feeding systems (Table 1).

Studies by Hanson *et al*. (1998), Kriegl (2001) and the CIAS (2001) found that pasture-based dairy systems were more profitable than confinement systems of similar size. Pasture-based systems are capable of high milk output per ha at low cost (Penno *et al*., 1996). In contrast, confinement production systems have higher costs but are able to support higher milk output per cow than pasture based systems.

A key issue associated with grazing is the lack of control over feed quality and availability associated with feed intake, while the infrastructure associated with intensive dairies and cropping systems designed to supply concentrate feeds to these dairies, places a significant financial burden on intensive dairy operations. Grazing systems were associated with reduced feed and waste management costs when compared with confinement systems in the U.S. Capital investment changed from depreciating assets (machinery and buildings) to static or appreciating assets (cows and land) according to Hamilton *et al*. (2002).

Table 1 Comparison of grazed grass and confinement total mixed ration systems

System of production	Grazed grass based	Confinement/TMR
Feed costs	Low	High
Feed quantity	Variable	High
Stocking rate	Critical	Ignored
Milk supply profile	Seasonal	Constant
Labour requirements	Seasonal	Constant
Decision support	Rudimentary	Sophisticated
Automation opportunity	Low	High
Effluent management	Low	High
Agrochemical usage	Low	High
Energy usage	Low	High
Capital investment	Low	High

Agricultural policy has major implications for the type of production system that develops in different countries. The EU Common Agricultural Policy (CAP) set up in 1957 aimed to guarantee food security at stable and reasonable prices to producers, by maximising production and protecting domestic agriculture from foreign competitors (Whetstone, 1999). The continuing reform of the CAP with the desire to make production more market focused suggests more unstable and unpredictable milk prices in the future.

Similar challenges exist in many other regions. Several factors have caused structural changes in the US dairy industry in the last decade. A large number of traditional dairy operations were small. In 1994, 21% of the dairy farms had fewer than 30 milking cows in Wisconsin, and only 9 percent greater than 100 cows. Many of the dairy farmers with fewer than 100 cows had obsolete facilities and were approaching retirement age. In the US in 1993, farms with 100 cows or more making up 14% of the dairy operations, had over 50% of the cows and produced 55% of total milk production. By 2000, farms with 100 or more cows accounted for 20% of operations, had 66% of the cows and produced more than 70% of total milk production (NASS, February 2004). Furthermore, inflation adjusted milk price has been steadily declining at approximately 2.5% per year and profitability in dairying has been under pressure as a result of rising costs. Like Europe, a reduction in government involvement in price support is likely in the near future.

Some farmers in the U.S. have compensated for declining profitability by increasing scale and/or movement of dairying from traditional dairy regions (the North-East or mid-West) to drier climates (West) with accessible grain and forage supplements. The potential for dairy farmers in Europe to relocate or expand to compensate for increasing production and social costs is limited. EU policy of continuing milk quotas until at least 2015, while allowing milk prices to decline will require dairy farmers to become more efficient. Tighter operating margins globally are leading many dairy farmers to examine alternative methods of farming to cut costs and protect future investments and livelihoods.

The deregulation of the Australian industry began in 1999 and has meant the discontinuation of regulated sourcing and pricing of milk for liquid consumption. The overall impact of deregulation was to hasten the decline in the number of dairy farms, which has fallen from 22,000 in 1980 to fewer than 10,000 in 2004. Australian dairy farmers, like their New Zealand neighbours, now operate in a completely deregulated industry environment, where international prices are the major factors determining the price received for their milk. As a result of this, making greater use of grazed pasture as a base feed has gained more interest in the last decade.

Another factor driving the rejuvenation of interest in grazing systems is the consumer perception that intensive agriculture is not animal friendly. While animal productivity often increases, perceived environmental, ethical (e.g. animal welfare, genetic manipulation), and food safety issues (e.g. residues) associated with larger dairy operations (factory farming) are now receiving increased attention by consumers and policy makers. Compliance with legislation on the environment, food safety and animal welfare already pose problems for dairy farming systems and are likely to be of greater concern in the future. Future farming systems need to be seen to be sustainable in terms of the environment and animal welfare. Grazing dairy systems are perceived to be more animal friendly than total confinement but increased grazing intensity has been shown to have negative effects on aspects of the environment such as river nutrient loading.

Effect of location and climate on milk production systems

As the liberalisation of world trade continues and the international competition for dairy markets accelerates, farmers must consider the competitiveness of their production systems. A concerted effort must be made to understand the strengths and weaknesses of various systems of production by making comparisons of the performance of the component pieces of the business to international standards or benchmarks. For this reason, an analysis of the long term economic viability of various systems of milk production was undertaken to determine how competitive livestock systems in various regions might be in a world market.

Table 2 shows a comparison of the meteorological data for Southern Ireland (Moorepark Research Centre, Co. Cork Ireland, 52.1°N 8.3°W, approximately 60m above sea level; 1960-2003)**;** North Island of New Zealand (Ruakura, Research Centre, Hamilton, New Zealand, 37.3°S 175.1°E, approximately 40m above sea level; 1998-2001); South Island of New Zealand (Lincoln University, Canterbury, New Zealand, 43.5°S 172.5°E; approximately 40m above sea level; 2001-2004); Victoria, South-Eastern Australia, (Department of Primary Industries Ellinbank, Warragul, Victoria, Australia, 38.2°S 145.9°E; approximately 120m above sea level; 1995 to 1998) and Arlington University Farm, Columbia County, Wisconsin, USA (43.3°N 89.4°W; approximately 330m above sea level; 1961-1990).

Latitudinal positioning, continental and ocean current influences and other factors result in vastly different climates in the reported regions. For pasture-based systems of milk production approximately 1,000 mm of rainfall evenly distributed through the year is a requirement. In all five regions rainfall is evenly distributed throughout the year, but in the South Island of New Zealand total rainfall is less than adequate for optimum grass production. Lack of water is compensated for by irrigation for approximately 6 months.

Below average soil temperatures of 8 °C pre-vernalization (early-Winter) and 5.5 °C in late-winter/Spring grass growth is minimal. This occurs for one to two months in Southern Ireland and five months in Wisconsin, USA, while in Victoria, Australia and New Zealand's North and South Island mean air temperature rarely declines below 5 °C, suggesting that herbage growth rate seldom ceases. The high mid-summer temperatures (in particular minimum temperature) in Victoria Australia, Wisconsin USA and to a lesser extent the North Island of New Zealand can result in lower herbage growth (depending on rainfall) and poorer forage quality during summer, resulting in lower cow performance and/or a supplementation requirement to maintain milk yield.

Table 3 shows the seasonality of grass production and composition for Southern Ireland (Moorepark Research Centre; 300 kg N/ha/year), North Island of New Zealand (Ruakura, Research Centre; 200 kg N/ha/year), South Island of New Zealand (Lincoln University; 200 kg N/ha/year) and Victoria Australia (Ellinbank, Warragul; 300 kg N/ha/year). The highest grass production was obtained in both the North and South Islands of New Zealand, the lowest in Victoria Australia while Southern Ireland was intermediate. The greatest seasonality of grass production was obtained in Southern Ireland (26:1), the lowest in the North Island of New Zealand (4:1), while both South Island New Zealand (5:1) and Victoria Australia (7:1) were intermediate.

In Ireland the lowest herbage growth rates were the result of low winter temperatures while in both the North and South Islands in New Zealand and Victoria Australia they were the result of high summer temperatures and/or inadequate summer rainfall. Victoria Australia has lower winter growth rates than New Zealand's North Island, even though both regions are at similar latitude. The lower winter herbage production in Victoria is probably due to lower temperatures during the winter period, possibly a result of the continental influence. This continental influence appears equivalent to 5° latitude, as growth rates in Victoria are similar to those measured in Canterbury, New Zealand.

Winter herbage growth rates in the North Island of New Zealand allow cows to graze for the entire year on the home farm. Milk to supplement price differential means very little supplement is purchased. Low winter herbage growth rates in the South Island of New Zealand result in stock being moved onto other farms, where crops (usually brassica) are grown and fed *in situ* with cereal and grass silage, and straw. In southern Ireland cows are normally housed for two to three months and supplemented with conserved grass silage. In Victoria (Australia) the winters are mild and herbage growth rates of 15 to 30 kg DM/ha per day allow cows to graze year round. Growth rates rarely exceeded 75 kg DM/ha per day in spring and declined to less than 10 kg/ha per day during the summers of 1997 and 1998. Crushed barley is fed strategically at milking throughout the year.

Farming system

Table 4 shows a comparison of the physical characteristics of selected groups of dairy farmers in New Zealand (LIC, 2003), Victoria Australia (Dairy Australia 2003), Ireland (Fingleton, 2003) and USA (both confinement and pasture based systems) (IFCN, 2003). Dairy farming in New Zealand is characterized by large herd size, modest milk production per cow, low level of concentrate supplementation, high stocking rate (2.7 to 2.8 cows/ha) and a high number of cows per labour unit. Dairy farming in Victoria Australia is fairly similar to New Zealand with larger farm size and similar herd size and milk production level. Stocking rate is variable and dependent on concentrate supplementation level, while pasture as a proportion of total feed consumed is lower. Dairying in Ireland is characterized by smaller farm size, small herd size, lower milk production per ha than New Zealand and Australia, lower stocking rates, higher level of concentrate supplementation than New Zealand and lower number of cows per labour unit. In contrast both confinement and pasture based systems of milk production in Wisconsin, USA are characterised by medium herd size, high levels of milk production per cow, low stocking rates, high levels of concentrate supplementation and a low cow number per labour unit.

Table 2 Average rainfall, and maximum, minimum and mean temperature in southern Ireland, North Island New Zealand, South Island New Zealand, Gippsland (Victoria) Australia, and Columbia County, Wisconsin, U.S.A.

Month*		1	2	3	4	5	6	7	8	9	10	11	12	Annual
Ireland	Rainfall, mm/month	109	92	81	66	61	68	54	92	77	114	101	109	1024
	Mean Max Temp, °C	8.9	9.1	10.5	12.5	15.6	17.8	20.0	19.6	17.2	13.9	10.7	9.3	13.8
	Mean Min Temp, °C	2.3	2.2	3.2	3.8	6.3	9.2	11.4	10.9	8.8	6.7	3.9	2.7	6.0
	Mean Ave. Temp, °C	5.2	5.6	7.1	8.2	11	13.6	15.7	15.2	12.9	10.2	7.3	6	9.8
NZ North Island	Rainfall, mm/month	156	104	100	75	90	86	51	75	83	96	102	99	1117
	Mean Max Temp, °C	15.1	14.5	16.5	18.2	20.2	21.4	23.9	25.1	24.0	21.3	18.5	15.1	19.5
	Mean Min Temp, °C	6.1	3.7	6.0	8.0	9.9	11.4	12.4	13.6	12.3	10.4	8.3	5.4	9.0
	Mean Ave. Temp, °C	10.6	9.1	11.2	13.1	15.1	16.4	18.1	19.3	18.1	15.9	13.4	10.3	14.2
NZ South Island	Rainfall, mm/month	39	38	48	47	64	22	59	40	33	83	25	55	553
	Mean Max Temp, °C	10.8	12.6	15.6	16.4	18.0	21.2	21.8	20.4	20.5	15.6	15.6	13.5	16.8
	Mean Min Temp, °C	0.8	2.8	4.7	5.7	7.7	10.1	11.9	10.8	9.7	6.6	4.2	2.6	6.5
	Mean Ave. Temp, °C	8.0	5.5	7.8	10.1	10.9	12.7	15.5	16.6	15.3	14.7	11.0	9.7	11.5
Australia	Rainfall, mm/month	133	118	101	88	85	63	65	64	50	90	91	81	1029
	Mean Max Temp, °C	11.4	13.6	15.1	17.7	19.3	20.8	25.2	25.6	22.2	17.6	15.2	13.5	18.1
	Mean Min Temp, °C	4.2	5.5	5.7	7.7	8.8	9.3	12.8	12.8	10.7	8.1	7.6	5.6	8.2
	Mean Ave. Temp, °C	7.8	9.6	10.4	12.7	14.1	15.1	19.0	19.2	16.5	12.9	11.4	9.6	13.2
U.S.A.	Rainfall, mm/month	24	21	49	74	86	102	89	103	102	60	52	37	799
	Mean Max Temp, °C	-4.3	-1.5	5.1	14.1	21.1	26.1	28.2	26.8	22.3	15.7	6.7	-1.5	13.2
	Mean Min Temp, °C	-13.8	-11.3	-4.7	1.7	7.5	12.6	15.3	14.0	9.7	3.9	-2.4	-10.3	1.9
	Mean Ave. Temp, °C	-9.1	-6.3	0.2	7.9	14.3	19.3	21.8	20.5	16.0	9.8	2.1	-5.9	7.6

*Month 1 = January in the northern hemisphere and July in the southern hemisphere

Table 3 Pasture growth and quality in southern Ireland, North Island New Zealand, South Island New Zealand and Gippsland (Victoria) Australia

Month*		1	2	3	4	5	6	7	8	9	10	11	12	Total
Ireland	Pasture growth, kg/ha per day	3	7	29	53	78	70	59	56	41	18	6	4	12,726
	CP, % DM		19.0	18.5	19.3	17.7	15.6	16.0	17.2	15.3	16.2	20.4	19.0	
	NDF, % DM		40.2	40.5	41.5	41.5	44.6	46.1	47.9	45.2	46.0	45.5	46.0	
	ME, MJ/kg DM		11.4	12.4	12.2	12.4	11.0	10.8	10.6	11.0	10.7	11.2	10.5	
NZ North Island	Pasture growth, kg/ha per day	42	41	78	82	89	80	64	43	27	22	35	23	19,035
	CP, % DM	19.8	22.6	24.9	22.7	22.5	19.8	20.5	21.6	17.1	22.0	25.9	22.5	
	NDF, % DM	38.5	39.6	42.9	43.6	45.3	43.7	43.5	43.8	55.4	44.6	40.7	42.2	
	ME, MJ/kg DM	12.4	12.4	12.2	12.1	11.4	11.8	10.6	10.0	8.3	10.4	11.5	12.5	
NZ South Island	Pasture growth, kg/ha per day	18	24	43	59	70	80	78	67	63	40	33	23	18,182
	NDF, % DM	35.4	40.0	35.7	37.5	42.9	41.5	45.3	41.8	40.9	37.9	38.5	45.2	
	ME, MJ/kg DM	11.9	12.5	12.3	12.3	11.6	11.9	11.2	11.5	11.4	11.7	10.9	11.2	
Australia	Pasture growth, kg/ha per day	14	28	45	57	55	38	32	8	12	17	26	24	10,870
	CP, % DM	27.7	27.2	27.5	23.5	21.4	18.3	14.9	15.5	16.3	21.6	27.5	24.5	
	NDF, % DM	43.3	46.2	47.3	46.5	47.2	51.9	57.8	64.1	57.4	52.1	46.8	43.5	
	ME, MJ/kg DM	12.2	11.9	11.8	11.7	11.1	10.8	10.2	10.1	9.8	10.7	11.6	11.3	

*Month 1 = January in the northern hemisphere and July in the southern hemisphere.

Table 4 Physical characteristics of dairy farming systems in various countries

Variable	New Zealand	Australia	Ireland	US Grazing	US Confined
Farm size (ha)	103	229	24	80	168
Number of cows	271	312	45	64	115
Milk yield/ cow (l)	3,678	4,800	4,588	7,779	10,243
Fat + protein/ cow (kg)	323	350	343	544	832
Replacement rate (%)	18	15	19	-	33
Concentrate (kg/cow)	150	400	750	-	4,500
Stocking rate (cows/ha)	2.67	2.48	1.88	0.80	0.68
Cows/ labour Unit	97	80	44	-	40

Table 5 shows the milk production and live-weight profile for research herds in Ruakura**,** Research Centre New Zealand (3.3 cows/ha; no purchased supplement; Macdonald, 1999), Ellinbank, Victoria Australia (4.7 cows/ha; 1 tonne DM crushed barley; approximately 0.2 ha turnips/cow during summer; Grainger, 1998), and Moorepark Research Centre in Ireland (2.5 cows/ha; 350 kg purchased supplement (Horan *et al*., 2004). Milk production profile is highly seasonal in all three countries. The relative milk production per cow in the herds of the selected groups of dairy farmers were 79%, 85% and 67% compared to that in the research herds in New Zealand, Australia and Ireland respectively. This indicates a greater potential milk production from pasture in all three countries especially Ireland. The mechanism used to match feed demand to feed supply is to have calving concentrated in spring due to the seasonal nature of grass production and some climatic constraints. Concentrating calving in early spring allows maximum use of grazed grass during lactation. In Ireland calving is concentrated in the months of February and March, while in the North Island of New Zealand and Victoria, Australia it is concentrated in July and August. There is also a growing shift towards split calving in Victoria, Australia.

The system of milk production in the United States is primarily based on total confinement, with cows fed a high concentrate total mixed ration (TMR). Such dairy farms can be characterized as capital, labour, and management-intensive businesses. For the purposes of comparison, two distinct types of dairy enterprises have been characterised within the US (Wisconsin). A confinement system of milk production in the current study is where cows are housed and milked in adjoining barns. In such herds, cows are calved and milked all year round and are fed on mechanically harvested feed. The second US system of production is a rotational grazing system, where grazed grass constitutes more than 30% of the total forage eaten by the dairy cow. Similar to the confinement system, these herds are not seasonal, although calving may be ‘bunched’ into two periods of the year. Winter forages are grown on the farm, and grain/concentrate is likely to be fed in near conventional amounts, however unlike the confinement system, this grain is unlikely to be produced on farm.

Table 5 Milk production in southern Ireland, North Island New Zealand and Gippsland (Victoria) Australia

Month*		1	2	3	4	5	6	7	8	9	10	11	12	Total
Ireland	Milk yield, kg/d 6,832		17.4	25.6	29.6	28.6	27.4	26.2	23.2	19.7	16.4	10.8	10.0	
	Fat, %		4.14	3.85	3.75	3.59	4.08	3.69	3.91	4.17	4.26	4.66	4.00	4.01
	Protein, %		3.45	3.31	3.35	3.28	3.37	3.44	3.53	3.64	3.85	4.01	3.66	3.54
	Live weight		515	498	495	498	508	519	529	541	553	565	578	527
NZ North Island	Milk yield, kg/d 4,680		19.8	22.6	21.2	18.2	16.3	15.6	12.9	10.8	8.9	7.4		
	Fat, %		5.0	4.4	4.4	4.5	4.7	4.8	4.9	5.1	5.4	5.7		4.89
	Protein, %		3.4	3.3	3.4	3.5	3.6	3.5	3.4	3.6	3.9	4.1		3.57
	Live weight		448	450	456	470	477	477	476	469	479	492		469
Australia	Milk yield, kg/d 5,617	17.3	21.0	22.7	24.4	23.1	20.3	16.9	15.1	12.8	11.0			
	Fat, %	4.5	4.5	4.4	4.3	4.3	4.3	4.4	4.6	4.9	5.3			4.55
	Protein, %	3.5	3.2	3.1	3.1	3.1	3.1	3.1	3.2	3.4	3.5			3.23
	Live weight	525	484	465	490	496	512	522	513	519	529			506

*Month 1 = January in the northern hemisphere and July in the southern hemisphere.

All EU member states have experienced very significant structural changes in relation to milk production since the introduction of milk quotas in April 1984. Figure 1 shows the change in milk output per farm from 1983 to 2003 for EU countries as well as New Zealand and Australia. At the introduction of the milk quota scheme in the EU there were 32,700 and 62,010 milk producing farms in Denmark and Ireland respectively, while in 2004 this number has reduced to 6,600 (20%) and 26,500 (43%), respectively. Over this same period average milk quota per farm has increased from 152,000 and 73,790 kg to 675,000 and 215,000 kg for Denmark and Ireland, respectively. However in New Zealand the number of dairy farmers has only reduced from 15,881 to 12,751, while nationally the quantity of milk processed has doubled (6,956 to 14,599 million l). Over the same period cow numbers have increased from 2,280,273 to 3,851,302 and average herd size has increased from 114 to 302 cows (LIC, 2003).

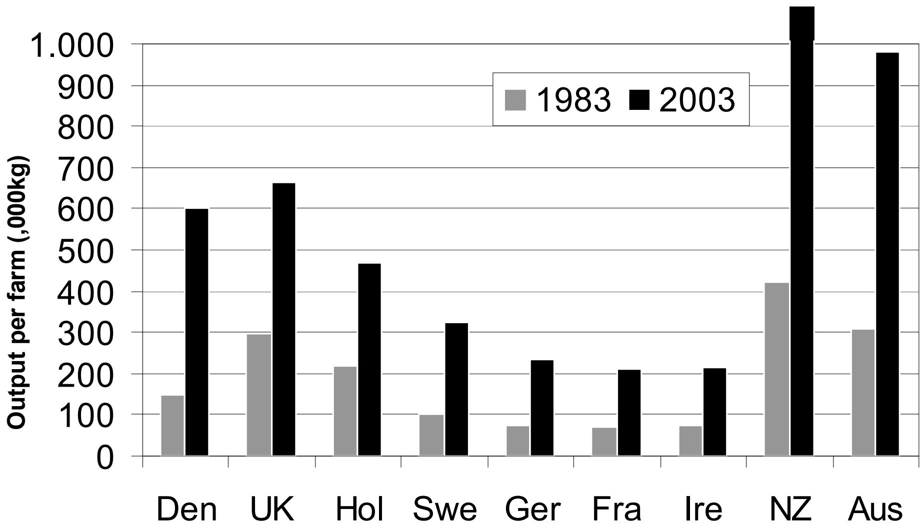

Figure 1 Development in milk output per farm over the period 1983 to 2003 in selected countries

A comparison of the profitability of various milk production systems

Table 6 shows a comparison of the receipts, cash costs, total costs and net margin of milk production for New Zealand (Dexcel, 2004), Ireland (Fingleton, 2003), Victoria Australia (Australian Dairy Industry, 2004) and Wisconsin, USA (both confinement and pasture-based) (Kriegl, personal communication) for three years (2001, 2002 and 2003). Cash costs included all costs directly incurred in the production of milk, for example feedstuffs, fertilizer etc. as well as external costs through to confinement systems within the US. Averaged over the three years the lowest milk price was obtained in New Zealand and Australia (19 and 18 € cent/l respectively), the highest in the US (33 and 32 € cent/l grazing and confinement systems respectively), while the Irish milk price (30 € cent/l) was similar to the US. The lowest cash costs per l were achieved in New Zealand and Australia (13 and 15 € cent/l respectively), the highest in the US (25 and 28 € cent/l grazing and confinement systems respectively), while the Irish costs were intermediate (22 € cent/l). The highest margin per l was obtained in the

Irish system (12 € cent/l), followed by US Grazing (10 € cent/l), similar for US Confinement and New Zealand (6 € cent/l) and lowest for Australia (4 € cent/l).

In general terms among the countries chosen, higher milk prices and higher costs of production are associated with systems incorporating more conserved feeds and higher concentrate supplementation while in more intensive pasture-based countries the costs of production are lower. Both the New Zealand and Australian dairy industries operate in a deregulated environment and consequently receive the prevailing world market price for their milk. In contrast, farm gate milk prices for Irish and US producers tend to be higher as a result of various price support mechanisms in operation in these regions. The between-year variability in milk price was greatest in the US, while milk price in Ireland under the CAP was the most stable of the countries studied. Total receipts incorporate both the revenue from the sale of livestock and surplus feeds as well as the revenue achieved from milk sales. The higher values for other income in both Ireland and the US reflect the greater value of livestock sales from the farm, again largely as a result of protectionist policies in both the EU and US in their respective beef systems.

The cash costs associated with milk production show large variation between systems. Costs associated with concentrate supplementation (feed, machinery repairs and maintenance) increase with system intensification, while in lower input pastoral systems, forage costs (fertiliser, contractor charges, etc.) will be more important. Overall cash costs tend to be lower on the pasture-based systems due to the reduction in feed and labour costs, and total cost/l tended to increase with increasing intensification. The highest costs of production were observed in both US systems of production, resulting mainly from higher feed, hired labour and repair and maintenance costs. New Zealand farmers had the lowest costs of production. Relative to both New Zealand and Australia, Irish farmers had higher costs associated with feed, repairs and maintenance as well as higher land rental charges.

Intensive pasture-based systems produce less milk/cow than confinement systems due to lower dry matter intakes. This can be seen in the US where the confinement farms produce an extra 2,464 l/cow compared to the grazing farms. However, the reduced cost of 4 € cent/l associated with the reduced requirement for facilities and equipment, the feeding of stored feeds, manure storage and disposal costs, and labour on the US grazing system results in a higher margin of 4 € cent/l of milk produced in the latter.

In non-cash costs, depreciation charges associated with the US and to a lesser extent Ireland were higher than those associated with Australia and New Zealand. These higher depreciation charges are a function of greater capital investment requirements. The cash and total costs of production observed in the current analysis compare very favourably with the costs observed for other EU systems of production displayed in Table 7 (Boyle *et al*., 2002). This study found that the costs of milk production in Ireland were among the lowest in the EU. Similar to the current study, it also showed that within the EU, systems of production based on conserved forages, high levels of concentrate supplementation and low pasture utilization (Denmark and Holland) had higher costs, which were attributed to higher feed costs and high annual interest and depreciation charges.

Table 6 International comparison of total receipts, cash costs and profitability per litre

Variable € cent/l	New Zealand			Australia			Ireland			US (Grazing)			US (Confinement)		
Year	00/01	01/02	02/03	00/01	01/02	02/03	00/01	01/02	02/03	00/01	01/02	02/03	00/01	01/02	02/03
Cash Receipts	19.0	21.2	16.0	18.4	20.7	15.0	29.5	31.3	27.8	30.8	37.8	30.6	30.0	36.0	30.5
Other Income	1.8	2.1	1.6	2.6	2.3	3.0	4.0	4.0	4.0	6.4	5.6	8.5	8.5	6.3	7.5
Total receipts	20.8	23.3	17.6	21.0	23.0	18.0	33.5	35.3	31.8	37.2	43.4	39.1	38.5	42.3	38.0
Feed	2.0	2.3	2.4	3.2	4.2	5.4	3.0	3.4	3.6	7.0	8.2	8.3	6.7	7.9	7.4
Hired labour	1.3	1.5	1.6	0.6	0.8	0.7	0.5	0.6	0.6	1.3	1.3	1.4	2.6	2.8	3.1
Fertilizer	1.8	1.9	1.6	1.1	1.0	1.0	1.5	1.7	2.1	1.1	1.0	0.6	0.8	0.9	0.7
Medicine/ Vet/ AI	1.0	1.1	1.0	2.0	2.0	2.0	1.2	1.1	1.3	1.2	1.4	1.5	1.5	1.7	1.7
Repairs/maintenance	1.1	1.2	1.0	1.1	1.3	1.1	1.7	1.5	1.6	2.0	2.5	1.8	2.0	2.3	2.0
Interest	2.4	2.5	2.9	1.4	1.3	1.4	0.8	1.1	0.8	2.0	2.1	2.0	2.6	2.5	2.1
Water charges/rates	1.0	1.0	1.0	0.6	0.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rental charges	0.0	0.0	0.0	0.3	0.3	0.3	2.4	2.3	2.0	1.8	2.0	2.2	3.0	3.3	3.2
Other	1.9	2.0	1.7	3.7	4.5	3.3	8.4	7.4	8.0	7.4	7.6	8.5	8.1	8.4	8.9
Total cash costs	12.5	13.5	13.2	14.0	16.0	16.0	19.5	19.1	20.0	23.8	26.1	26.3	27.3	29.8	29.1
Depreciation	1.1	0.5	1.3	1.5	1.3	1.5	2.3	1.8	2.2	4.6	4.6	3.9	4.6	4.7	4.6
Total costs	13.6	14.0	14.5	15.5	17.3	17.6	21.8	20.9	22.2	28.4	30.7	30.2	31.9	34.5	33.7
Net margin	7.2	9.3	3.1	5.6	5.7	0.4	11.7	14.4	9.6	8.9	12.7	8.9	6.6	7.8	4.3

Table 7 EU milk sector competitiveness: costs (€ cent/l) 1998/1999

	Ireland	Belgium	France	Germany	Holland	Denmark
Feed	5.2	4.3	4.5	4.8	5.6	7.6
Hired labour	2.2	0.1	0.2	0.4	0.3	2.2
Fertilizer	2.1	0.9	1.4	0.8	0.8	0.6
Medicine/ Vet/ AI	2.3	1.4	1.5	2.1	1.9	2.1
Repairs/maintenance	2.3	1.5	1.9	2.8	2.2	3.0
Interest	0.8	1.5	0.9	1.0	3.3	6.1
Rental charges	1.3	1.2	1.7	2.1	1.8	0.9
Other	2.2	3.7	8.1	6.2	6.6	5.8
Total cash costs	18.2	14.8	20.3	20.2	22.4	28.2
Depreciation	1.5	4.9	4.8	5.6	6.9	3.9
Total costs	19.8	19.8	25.1	25.8	29.3	32.1

Boyle *et al*. (2002) also showed that Ireland's cost advantage over the other EU countries had fallen gradually over the period 1989 to 1999, probably as a result of an introduced maize subsidy in Europe and the reduction in world grain prices, both of which favoured non-pasture based production. However the same study showed that in terms of economic costs (cash costs plus imputed costs for family labour, capital and owned land) Ireland has fared less well within the EU, due to relatively low scale and low land and labour productivity.

Figure 2 shows the relationship between costs of milk production per l and the proportion of grazed grass in the dairy cow diet (derived from data from Boyle *et al*., 2002; Clark and Jans, 1995). This relationship suggests that for a 10% increase in grazed grass in the feeding system the cost of milk produced will be reduced by 2.5 € cent/l. Consequently one strategy to reduce the impact of a lower milk price is to increase the grazed grass proportion of the diet.

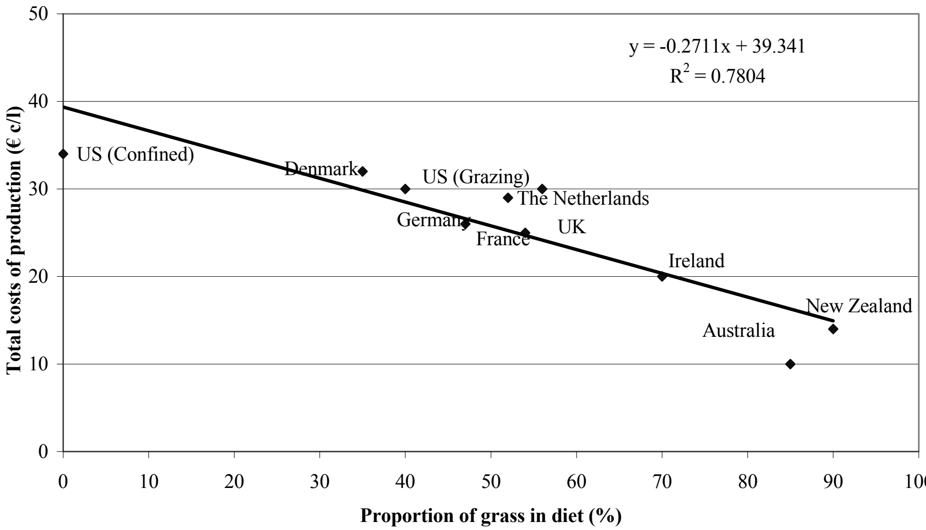

Figure 2 Relationship between total costs of production and proportion of grass in cows diet

Considerations in choosing a system of milk production

A spectrum of milk production systems exists from pasture-only to total confinement. Identifying the optimum system of milk production and the key drivers of profitability for any particular location is therefore extremely important. There are a number of prevailing economic factors that determine which production system is most suitable and these include milk price, supplement cost, land quality and availability, labour cost and availability, environment issues and consumer demand.

Milk price

The New Zealand dairy industry operates in a deregulated environment, which has resulted in a relatively low milk price, with large fluctuations from year to year. The deregulation of the Australian industry began in 1999 and has meant the discontinuation of regulated sourcing and pricing of milk for liquid consumption. This has resulted in a milk price similar to New Zealand. Milk price in Australia and New Zealand is also influenced by revaluation of domestic currency against the US$ dollar. In the EU the decoupling of direct payments from production as a result of CAP reform will result in a reduced milk price. Milk quota restrictions will require Irish producers to target lower costs of production, as increased scale to compensate for declining profitability is not an option in the short term. Like Europe, a reduction in government involvement in price support in the US has resulted in reduced milk price. In all countries the overall impact of reduced milk price has been a large reduction in dairy farm numbers, with a corresponding increase in scale of operation. However economies of scale will only be effective as long as unit cost of production is less than milk price. In scenarios where scale economies do not allow the unit cost of production to be less than milk price, then a lower cost milk production system will be required. These results indicate that grass-based systems have the potential to have the lowest cost per unit of production. A limiting feature of all grass-based systems is the lack of flexibility to rapidly increase milk production if milk price increases. However, increased production costs per l will be inevitable when farmers move to maximise profitability during periods of elevated milk price and /or depressed concentrate price.

Land value

The ability to avail of the increased profitability of pasture-based systems may be curtailed by land costs (both rental and purchase). Access to land at economically feasible prices is crucial to the future success of pasture based dairy systems. High land prices reduce the potential return on investment and lower the milk price (or raise the supplement price) at which intensification becomes more profitable than expansion.

High land costs are found in small farms in the US and large Irish farms while price of land is low in Australia. Land productivity ranges from 1,000 to 25,000 kg milk per ha, reflecting international variation in stocking rate of 0.3 to 2.5 cows/ha (IFCN, 2003). The differences in productivity result from differences in the production system, which differ from country to country as well as within country. In regions of high livestock density land prices reach very high levels due to the competition for land among producers. In New Zealand, high land prices are a result of strong demand due to scarcity of suitable land and the relatively small amounts traded annually. Similarly, in Ireland land ownership is very high among farmers (approximately 90%) and also has a high status value. Only 1% of the total land is traded each year, which increases competition in the market. Recent economic prosperity has resulted in much of the land traded being used for development purposes.

Cost of alternative feeds

The cost at which alternative feeds can be grown or purchased will also determine the suitability of confinement systems. It is envisaged that the cost of conserved forages will continue to increase due mainly to increases in contractor charges associated with inflation in labour, energy and machinery costs. There has been a movement in all countries regardless of the level of grass growth towards grazing management strategies that can increase the proportion of grazed grass and reduce the dependency on high cost conserved feeds. The profitability of concentrate supplementation is determined by the milk to concentrate price ratio and the level of additional milk production achieved in response to supplementation. If the market value of the additional milk achieved outweighs the costs of concentrate inclusion and pasture utilisation is not compromised, higher supplementation levels will yield greater farm profit. However, if milk price continues to decline, the economic feasibility of concentrate use within the dairy feed budget declines as the marginal benefit of increased milk output is outweighed by the cost of the additional supplementation.

Labour availability

With the cost of labour and the proportion of the cost of production represented by labour increasing annually, labour efficiency becomes an increasingly important performance measure to evaluate and monitor on dairy farms. Labour efficiency is related to the level of mechanisation, which may therefore translate into higher capital investments. Dairy farms with higher levels of labour and capital efficiency tend to have higher levels of labour and management income per operator. The efficiencies (capital and labour) of many labour saving technologies (e.g. milking parlours) are only captured with increasing herd size. Successful dairy farms will be those that can adapt to changing economic conditions and evaluate and adopt cost-effective labour saving new technologies. Using international comparisons of labour efficiency data from IFCN (2002), the labour efficiency (hours per milking cow) of a Waikato New Zealand 229 cow herd, South Island New Zealand 447 cow herd, Wisconsin US 70 cow herd and Wisconsin 600 cow herd were 20, 19, 106 and 61, respectively (comparable to 210, 247, 93 and 156 kg milk per hour, respectively). These results indicate that higher levels of labour efficiency can be achieved on pasture-based systems.

The industry demography shows a clear trend toward fewer, but larger and more productive herds. In the 40-year period form 1955 to 1995, the number of farms in the United States decreased from 2.7 million to 137,000, while the average herd size increased from 8 to 69 cows. Milk production per cow increased from less than 2,724 kg per cow per year to more than 7,265 kg. Tremendous development, adoption and management of new production-enhancing technologies over the past few decades has led to rapid increases in herd size and milk production levels. A recent Cornell University study reported that if current trends continue, in 2020, total milk production will be 17-20% greater, cow numbers will be 15% lower and the number of farms will decline by 85%.

Maintaining herd sizes large enough to obtain the major economies of scale and using capital resources efficiently is important across all farm systems. We can expect to see opportunities through an increase in the number of farm partnership operations. These operations will provide an opportunity to improve capital, labour efficiency, profitability, and quality of life, given an appropriate management structure. Facility and equipment replacement decisions will also be very important to the longer-term success of these as well as single-family operations. The economic advantages of pasture-based systems are greater for producers starting a dairy operation. Start up costs for grazing systems are only 40 to 50% of the initial costs associated with the traditional confined dairy facilities.

Environment

Nutrient management presents major challenges and opportunities for pasture-based agriculture. The challenge is to avoid environmental damage while increased nutrient efficiency could substantially improve farm profitability. Under current consideration in the EU is the Nitrates Directive (91/676/EEC) which states that 'the amount of livestock manure applied to land each year, including by the animals themselves, shall not exceed 170kg organic N per hectare', (OJEC, 1991, 91/L375/EEC; 7). Such legislation is likely to reduce production efficiency and potential profitability and may lead to higher input systems incorporating crops such as maize in the dairy diet. The cultivation of maize requires the ploughing of permanent grassland containing very large reserves of N (7 t N /ha approx.) in the plough layer (Gardiner and Radford, 1980; McGrath and Zhang, 2003). This N, which is otherwise stable, becomes exposed and therefore available when the soil is ploughed. Whitmore *et al*. (1992) suggested that cultivation of long-term grassland could result in the release of up to 500 kg of N/ha in the first year of cultivation. These quantities are beyond the uptake capacity of maize and hence lead to substantial losses of N to the environment. Similarly, there are few comparisons of greenhouse gases emissions from grazing ruminants and those fed TMR diets. However van der Nagel *et al*. (2003) states that total greenhouse gas emissions from TMR diets were nearly twice as much as from pasture (1.53 vs. 0.84 kg CO_2 equivalent/kg of milk). Such a shift to higher input systems may therefore be more damaging to the environment than the traditional grass based system.

The implementation of such legislation in grazing systems could reduce profitability and limit the potential for future expansion. Similar public concerns are echoed in New Zealand, Australia and US with different nutrients causing problems at different sites. Strategic approaches that increase the efficiency of N in the farming system, while at the same time maintaining animal performance are urgently needed.

Consumer preference and product quality

The primary drivers for changing consumption patterns in dairy products is consumer affluence and perceived health benefits. Lomborg (2001) reports that we are three times wealthier now than we were in 1950. Greater retailer awareness of food constituents and demand for healthier foods will be of significant importance in the coming years. Milk fat produced on pasture has higher levels of unsaturated fatty acids (42%) and particularly monounsaturated fatty acids (MUFA)(33%) compared to that produced in confinement (34 and 27% respectively). MUFA are superior to polyunsaturated fatty acids (PUFA) as they lower blood cholesterol through the reduction of detrimental low-density lipoprotein (LDL) cholesterol (Gibney, 1993). The second relative benefit of pasture derived milk products relates to the concentration of conjugated linoleic acid (CLA). CLA has been shown to be protective against heart disease (Lee *et al*., 1994), certain types of cancer (Schultz *et al*., 1992) and obesity (Pariza *et al*., 1996) and acts as an antioxidant (Ha *et al*., 1990) and growth promoter (Chin *et al*., 1994). More CLA is produced by cows on pasture than by cows on indoor diets with milk from cows on pasture containing approximately 16 mg CLA/g fat compared to approximately 5 mg/g fat indoors (Stanton *et al*., 1997; Murphy, 2000). With increasing health awareness among consumers, the requirement for healthier products will increase the demand for pasture derived milk products in future years.

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