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Extended grazing as an alternative to housing

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Introduction

Labour demands and production costs are two components of flock management that are commanding increasing significance for sheep producers. Both components have one unifying determinant that can reduce man-hours and costs, namely, grazed grass. Grass and how it is used is central to the competitiveness of the sheep sector and, in particular, to reducing the workload associated with winter housing. Results which reduce labour demand and input costs are summarised in this paper.

Two contrasting systems

Two systems of mid season lamb production are being compared on two self-contained farmlets at Knockbeg:

1. Grazing, silage and housing: 9.6 ha grass/clover pasture stocked at 14 ewes per ha including a silage budget of 0.6 t per ewe for a 100-day winter.
2. Extended grazing: 15.0 ha perennial ryegrass pasture stocked at 10 ewes per ha; only surplus grass is conserved for silage.

In 1999 and 2000 the ewes in both systems were housed for lambing but in 2001 the ewes in the extended grazing system lambed in the field.

The objectives of this project are:

(i) to improve the enterprise competitiveness of sheep production

(ii) to develop grassland management practices for all-year round grazing

(iii) to compare ewe lambing performance and output in flocks wintered and lambed down either indoor on silage or outdoor on grazing grass

(iv) to compare the labour inputs (man-hours) required for winter housing and extended grazing systems

Choice of lambing date

This was a key factor in the management plan. In order to minimise feed costs in spring, meal supplements post-lambing were ruled out. It was therefore necessary to maximise grass supplies in both systems for satisfying ewe peak feed demand post-lambing. A 70 kg ewe suckling twin lambs and producing 3 kg milk per day requires a daily intake of almost 3.5 kg grass DM. At 14 ewes per ha the feed demand is almost 50 kg grass DM/ha/day. Spring pastures in the Carlow region do not attain this level of production until mid April. However, for lambing in mid-March adequate supplies of grass can be accumulated by resting pastures from the previous December and by application of fertilizer N around February 1.

In 1999 and 2000 the lambing date chosen for both systems was March 21; in 2001 April 1 was chosen for outdoor lambing in the extended grazing system. Ewes were therefore joined with the rams on October 17 with the exception of the outdoor lambing flock for which the date was October 25. All rams were removed after 6 weeks. The management calendar was planned around these dates.

Fertilizer N

Nitrogen inputs were low, 75 kg and 80 kg N per ha in systems 1 and 2 respectively. In system 1 the clover content of the pasture was high and fertilizer N was restricted to 50 kg N around February 1 for early grass, 70 kg N in April for silage and 34 kg N for silage aftermath. In system 2, N inputs were based on the principle that the optimum amount of N depends on the stocking rate. For 10 ewes per ha only strategic dressings of N were applied: 50 kg N around February 1 for early grass and 34 kg N in autumn when closing paddocks for extended grazing.

Autumn saved pasture

Pasture for extended grazing was accumulated by closing a number of paddocks sequentially during September and October, applying 34 kg N per ha and resting them until December. Up to 50 % of the farmlet was closed; hence the stocking rate on the grazing area during the breeding season was high, e.g. up to 20 ewes per ha. The ewes were already in good condition prior to September as a result of lax grazing during August.

Grass budgeting 1998-2000

The ewes in system 1 were housed in mid December. In system 2 extended grazing was commenced in early December. The ewes were block grazed in daily shifts using electrified net fencing and offered a daily ration of 1.3 kg grass DM/ewe/day. A back fence was used to prevent access to ground already grazed. Grazing was completed in February; the ewes were then housed and offered silage *ad libitum* plus meal supplements.

Average results on the feeding capacity of extended grazing, days housed and ewe liveweight for the 2 years 1998-2000 are shown in Table 1. Grass supply was 1625 kg DM per ha and, when rationed as described, grazing extended to February 6. Thus, the housing period was reduced to 44 days. The adequacy of the grass allowance for satisfying the feed requirements for 70 kg ewes in mid pregnancy was confirmed by a 6 % increase in liveweight. Condition score was maintained. Moreover, lamb birth rate was significantly heavier (+ 0.4 kg) in the extended grazing system.

Table 1. Feeding capacity of extended grazing (1998-2000)

System	Silage and housing	Extended grazing
No. ewes	131	153
No. ha autumn saved pasture	-	6.5
Extended grazing commenced	-	December 7
Grass supply (kg DM/ha)	-	1625
Grass allowance (kg DM/ewe/day)	-	1.3
Date of housing	December 14	February 6
No. days housed	98	44
Ewe liveweight (kg), C. score):		
Mid pregnancy (December 12)	69.4	67.8 (3.5)
Late pregnancy (February 9)	N/A	72.0 (3.5)

Effects of extended grazing on management inputs

Conventional housing and silage feeding systems require the cutting and transport of grass to the farmyard for silage conservation, tractor transport and machinery for feeding, handling of straw on a regular basis for bedding pens, followed by the task of mucking out sheds and providing transport to the field for manure disposal. The shorter housing period resulting from extended grazing reduces demands for these management inputs. It is, however, necessary to purchase portable electric fencing for managing extended grazing.

Comparative estimates for winter management inputs including fencing are shown in Table 2. Requirements for silage and straw in the extended grazing system were reduced by two-thirds leading to a cost saving of €827 per 100 ewes at year 2000 prices. Straw was worth approximately €114 per ha (Teagasc 2000) which at a yield of 2.5 t per ha is equivalent to 4.6 cent per kg. The cost of straw varies widely depending on whether it is home grown or purchased. The fencing cost incurred by extended grazing must be set against these savings and may be discounted over 5 years as shown, resulting in net savings of €707 per 100 ewes.

Labour as measured by man-hours required for feeding and herding was reduced by over two-thirds. The financial savings attributable to this factor depend on the opportunity cost of the stockman's own labour. If it is included at the current agricultural wage of €9 per hour, labour cost is reduced by €783 per 100 ewes. In practice, however, the opportunity cost varies from farm to farm and the values shown here should be adjusted accordingly.

Table 2. Winter management in-puts and cost savings arising from extended grazing (1998-2000)

	Silage and housing	**Extended grazing**	**Savings* /100 ewes (€)**	
Housing period (days)	98	44		
Per 100 ewes:				
Silage (t)	60	20	610	
Straw (kg)	7480	2720	217	827
Less cost of electric fencing:				
300 m @ €2/m				
discounted over 5 yrs.			120	707
Labour (man-hours/day)	1.0	0.3		
Labour (man-hours)	100	13		
Wage @ €9/hour	900	117		783

*Costs: Silage €15.24/t; straw 4.6 cent/kg; electric fencing €100/50 metre roll

Grass supply in spring

The provision of adequate supplies of grass in spring is a critical point of management for cutting feed costs. Extended grazing reduces the resting period for grass recovery in spring and hence may be expected to impact on grass supply. The adequacy of grass supply however is relative to feed demand which, at the stocking rate practised in the extended grazing system, is low. To date, relative to feed demand, extended grazing has not adversely affected grass supply for ewes post-lambing. Indeed, after application of fertilizer N in February the fast recovery of pasture following extended grazing has been a notable feature of the daily block grazing system.

Grazing management

Six paddock rotational grazing was practised on both farmlets. Occasionally, 1 or 2 paddocks were sub-divided temporarily, e.g. for ewes rearing triplets. Creep feed was introduced to all lambs at 8 weeks of age and offered at the rate of 300g/head/day until slaughter. Length of grazing rotation depended on sward height, i.e. ewes and lambs were moved when the sward was grazed down to 4 cm in April, 5 cm in May, 6 cm in June and 8 cm in July/August for weaned lambs. (Sward height for sheep is measured to ground level). Grazing control proved difficult in the extensive system due to the lax grazing arising from the low stocking rate.

Output

Pooled results on lamb performance and output for the two years are shown in Table 3. Lamb birth weights, growth rates and carcass weights were significantly higher in the extensive system with its lower stocking rates of ewes and lambs. Due to the use of Belclare x Cheviot ewes, output per ewe was high in both systems of intensive and extensive production. Output per ha, however, was significantly reduced in the extensive system due to the lower stocking rate.

Table 3. Lamb performance and output (1998 – 2000)

	Intensive grazing	Extensive grazing
No. ewes/ha	14	10
No. lambs reared/ewe	1.77	1.78
No. lambs sold/ha	24	18
Growth rate (g/day):		
Birth to 5 weeks	271	286
5 to 14 weeks	238	267
Weaning wt. (kg)	29.0	31.1
Carcass wt. (kg)	18.8	19.3
Lamb carcass output:		
kg/ewe	33.3	34.2
kg/ha	451	347

Outdoor lambing 2001

To further develop an easy care approach, it was decided in 2001 to continue extended grazing for February/March and to allow the ewes lamb in the field. Concentrates were introduced at 6 weeks pre-lambing (February 7) at the rate of 400 g/ewe/day to supplement the daily grass ration of 1.3 kg DM. Lambing in the extended grazing system was delayed until April 1 firstly, to stagger the seasonal demand for labour and secondly, because this date coincided with the change to summer time. Ewes were scanned in January and 3 paddocks were reserved for single, twin and triplet bearing ewes to lamb separately. A fourth paddock was reserved for grazing post-lambing. These paddocks had already been grazed in December/January and were dressed with fertiliser N in February.

The date for the booster vaccine at 2 weeks pre-lambing was used for 'spread-out', i.e. the ewes were removed off block grazing, transferred to the 3 assigned paddocks and set stocked for lambing. At this time also, the concentrate supplements for ewes bearing multiples was increased to 700g/head/day. Ewes were allowed to lamb unassisted and no lambing supervision was conducted after dark. Creep feed was introduced to all lambs at 8 weeks of age and offered at the rate of 250 g/head/day.

Ewe productivity 2001

Results on ewe lambing performance are shown in Table 4. Ewe productivity was again high in both systems, i.e. about 1.8 lambs reared per ewe joined. Lamb birth weight was significantly higher (+ 0.6 kg) in the extended grazing system. It is possible that concentrate supplementation at grass was excessive. Current work is aimed at clarifying this issue. The advantage of 0.6 kg extra birth weight in the extended grazing system combined with the lower stocking rate resulted in significantly higher weaning weight.

Table 4. Ewe reproductive performance 2001

System	Silage and housing	Extended grazing
No. ewes to ram	140	152
Ewes lambing (%)	92.1	94.7
Litter size	2.19	2.17
Lamb mortality (%)*	13.1	10.6
No. lambs reared/ewe joined	1.76	1.84

*Figures relate to all lambs born (dead and alive)

Input costs

Comparative results on outputs, inputs and gross margins are shown in Table 5. Average price per kg carcass was 452 cent. Income from lamb sales, wool and premia was as shown. The net cost of replacing cull ewes in autumn 2000 was €14.73.

Direct costs are listed under seven headings and do not include labour. Silage making was costed at €19 per t. Concentrates for ewes and creep feed for lambs consisted of a pelleted compound costing €190 per t (crude protein content 190 g/kg DM). Flock health expenses were comprised mainly of pour-ons for fly strike prevention, cydectin for scab prevention, zinc sulphate for footbathing, fasinex and oramec for dosing against fluke and worms. Other costs included straw @ 64 cent per bale, shearing @ 152 cent per ewe and levies @ 80 cent per lamb.

Gross margin per ewe was almost 15% higher in the extensive system. Gross margin per ha was reduced considerably, reflecting the lower carcass output. Critical appraisal of Table 5 shows that creep feed was an expensive input. This component is being targeted for significant reduction, especially in view of the likely return of more normal lamb prices than those of 2001.

Cost per kg carcass

Production cost is a major determinant of enterprise competitiveness. The estimates shown in Table 6 provide a basis for estimating cost of production. Direct costs are as already listed in Table 5 and the fixed costs shown in Table 6 are those incurred by buildings and machinery maintenance, depreciation charges, fuel, etc; labour and interest charges are not included. Total costs per ewe amounted to €85.51 and €63.01 in the silage/housing and extended grazing systems, respectively. Using the carcass weights shown in Table 4 the relative costs of producing 1 kg of lamb carcass were calculated as shown. The effects of extensification in reducing costs (per ewe, lamb, kg) are clearly evident.

Table 5. Outputs, inputs and gross margins 2001 (€)

System		Silage and housing		Extended grazing	
No. ewes		140		152	
Output per ewe					
1.77 lambs		152.0			
1.84 lambs				151.4	
Wool + premium		12.84	164.85	12.84	164.21
Less replacement			14.73		14.73
			150.12		149.48
Direct costs per ewe					
1. Fertilizers for grazing		5.87		4.79	
2. Silage 0.6 t		11.43			
3. Concentrates:	Pre-lambing 20 kg	3.94			
	Pre-lambing 23 kg			4.52	
Post-lambing for ewes suckling triplets:					
23 ewes @ 1 kg/ewe/day for 6 weeks		1.30		1.30	
4. Creep feed	30 kg/lamb	10.11			
	26 kg/lamb			9.10	
5. Flock health		8.20		8.20	
6. Scanning				0.89	
7. Other		6.14	46.99	2.97	31.77
Gross margin per ewe (€)			**103**		**118**
Gross margin per ha (€)			**1494**		**1180**

Table 6. Production costs in 2001 (€)

System	Silage and housing		Extended grazing	
Gross output/ewe	150.12		149.48	
Direct costs/ewe	46.99		31.77	
Fixed costs/ewe	38.52	85.51	31.24	63.01
Net margin/ewe		64.61		86.47
Cost/kg carcass (cent)		254		188
Costs as percent of price		56%		42%

How many ewes?

It is of interest to estimate the flock size that is required to generate an income equivalent to the 2001 average industrial wage of €23,500 (£18,500). By deducting the costs per ewe (Table 6) from the gross outputs (Table 5), the net margins per ewe in the silage/housing and extended grazing systems were €64.61 and €86.47 respectively. Using these values the flock size required in each system for earning the average industrial wage is 364 and 272 ewes respectively, excluding labour and interest charges. These estimates are based on a lamb crop of about 180 lambs reared per 100 ewes joined.

Lamb prices in 2001 were exceptional. If prices drop significantly (and the history of sheep price trends almost demands it) or if levels of ewe productivity are lower than those discussed here, a larger flock would be needed to earn the equivalent wage.

Conclusion

Income is dependant on the volume of output and, hence, on flock size. Many mid season enterprises are relatively small - average flock size is about 100 ewes – and extensification must be accompanied by financial support measures to compensate for lower output per ha.

Extensification practices are an attractive option where flock size is of sufficient scale for producing enough output per labour unit to generate a commercially viable income. There is considerable scope for increasing profit margins by reducing unit costs of production, e.g. costs per ewe or per labour unit as shown by the results.

Developing easy-care lambing systems

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Introduction

The significant long-term decline in the margins from sheep production is having a major impact on the shape of the industry. In Northern Ireland, the gross margins of recorded lowland sheep production systems have declined by approximately 50% per ha in real terms over the past 20 years (DARD, 2001). In a bid to remain viable, sheep producers have increased flock size from 86 in 1982 to 119 in 2002 and/or have become increasingly dependent on income from off-farm sources. Currently 55% of sheep producers in Northern Ireland are part-time (DARD, 2000). These trends are likely to continue and the ratio of stock to stockpersons set to increase further.

Current systems of sheep production require relatively high levels of labour input. Survey data from Ireland, both North and South, indicates that 4 to 8 man hours per ewe are put into lowland sheep production systems (DARD, 1996; Connolly, 2001). The major labour input in sheep production occurs over the lambing period. Recent estimates indicate that approximately 19% of the total labour input in lowland sheep production systems occurs over this period (Connolly, 2001). Thus the intensive labour requirements of sheep production systems over this period represent a major limitation to the size of flock, which a producer can operate, particularly as hired labour costs continue to increase.

In view of this background a research programme was established in autumn 1999 to investigate the potential to develop lower labour input easy-care lambing systems. The main issues the programme is seeking to addressr are:-

1. The effect on labour input and lamb output of adopting an easy-care (grass-based) lambing system in comparison to indoor lambing systems.
2. The effect of herbage allowance and concentrate feed level in late pregnancy on ewe condition and lamb performance.
3. The effect of ewe and ram breed on lamb output in indoor and grass-based lambing systems.

Outline of research programme

The main study was carried out at ARINI, and on five commercial lowland farms across Northern Ireland. On each farm the experimental flock (n=90 on average per farm), consisting of Blue-Faced Leicester X Scottish Blackface (BLXB), Texel X Scottish Blackface (TXB), Suffolk X Cheviot (SXC) and Texel X Cheviot (TXC) ewes were mated with high lean growth index Suffolk (n=9), high lean index Texel (n=9) or double-muscled (DM) Texel (n=9) sires. Ewes in the indoor lambing system were mated to lamb down from mid to late March. Some but not all of the producers, mated ewes in the easy-care system 2 weeks later i.e. to lamb down late March to early April (2 out of the 6 farms in year 1).

Developing a complete out-wintering grazing system is only possible at low stocking rates. Thus in the current study ewes in the easy-care system were removed from the main grazing area in mid-pregnancy and fed supplementary grass silage on cereal stubble ground or indoors, or fed forage rape/turnips. Three to six weeks before lambing, ewes were turned out onto the grazing area and budgeted 2 kg of herbage dry matter (DM) per day above a pasture cover of 800 kg DM/ha. During the pre-lambing period, ewes were set-stocked with lambed ewes being drafted out 12 - 48 h after lambing. (Work in New Zealand indicates that it is critical that over the first 2 - 6 h after birth, the ewe and lamb are left alone on the birth site. This is the period when the maternal bonding between the ewe and lamb develops. The ewe and lamb learn to recognise each other and the maternal drive of the ewe is reinforced by the lamb).

In the indoor lambing system, ewes were housed in late pregnancy and offered grass silage *ad libitum* plus concentrates (level depending on silage quality, ewe condition and foetal number) and ewes and lambs were turned out to grass 1 to 7 days post-lambing. Ewes and lambs from the indoor and easy-care lambing systems were grazed together as a single group on each of the farms after the lambing period.

Effect of lambing system on lamb output

Lamb birth weight was higher in the ewes on the easy-care lambing system compared with those lambing indoors on silage-based diets (Table 1). In the first year of the study, lambing difficulty was greater in the easy-care lambing group due to a proportion of oversized lambs. This was due to higher than anticipated grass growth rates, resulting in grass allowances being higher than planned. In the second year of the study, grass covers were monitored more closely and producers ensured that ewes had access to only moderate grass covers in late pregnancy (1200 to 2000 kg DM at turnout to lambing pastures) with concentrates fed if grass supplies were inadequate.

Lamb mortality rates were similar in the easy-care and indoor lambing system (11 and 13% respectively) (Table 1). Lamb growth rates in the first six weeks of lambing were higher in the lambs born outdoors. This indicates that milk yield in the ewes was higher in the easy-care system, likely as a result of the ewes in the easy-care system lambing down in higher body condition score. Thereafter lamb growth rates between the systems were similar, thus the days to slaughter were marginally lower for ewes in the easy-care system (158 and 161 days to slaughter for the easy-care and indoor lambing systems respectively). The overall ewe output, expressed as the total weight of lambs weaned per ewe was similar in both systems.

Table 1. The effect of lambing system on lamb mortality

	Lambing system		
	Indoor	**Easy-care**	**Sig.**
No. lambs born/ewe	1.79	1.77	NS
Lamb birth weight	5.0	5.2 *	
No. lambs born dead/ewe	0.10	0.11	NS
No. lambs died (birth-weaning)	0.10	0.12	NS
No. lambs weaned/ewe	1.59	1.50	NS
Lamb growth rate			
Birth – 6 weeks	292	310	***
Birth – weaning	266	273	NS
Weaned lamb output (kg/ewe)	56.8	56.2	NS

NS = difference is not significant; * = significant; ** = highly significant, *** = very highly significant

Effect of lambing system on labour requirements

In the current study, ewes in the easy-care system were observed at regular intervals and the producers intervened as considered necessary when the life of the ewes or lambs was threatened. The necessity to collect research data (e.g. lamb birth weight, ewe milk score) resulted in more contact with the sheep than would normally be considered necessary. Nonetheless, the study yielded useful comparative data on the labour requirements of indoor versus easy-care lambing systems.

The time spent lambing was similar in the indoor and easy-care systems (Table 2). In the indoor system, the time spent catching ewes which required assistance to lamb plus the time spent moving ewes into lambing pens was greater than the time required to catch those ewes which required intervention in the easy-care lambing system. The time spent on lamb care was similar in both systems.

Feedback from the producers involved in the trial indicates that they are becoming increasingly confident of the performance of the easy-care system, and feel that in the future there is potential to further delay intervention.

Table 2. The effect of lambing system on labour inputs (year 2 of study)

Activity (min/ewe)	Lambing system		Sig.
	Indoor	Easy-care	
Lambing	2.2	2.0	NS
Catch/move ewes at lambing	6.5	4.6	**
Neonatal Lamb-care	1.6	1.7	NS
Moving ewes to grass	3.5	0.0	***

NS = difference is not significant; * = significant; ** = highly significant; *** = very highly significant

Ewe breed performance in easy-care systems

F1 crossbred ewes produced from a previous hill sheep study (Dawson and Carson, 2002) were used in the current study. These ewes were chosen due to the fact that each of the crosses contained 50% hardy hill breed genes and have the potential benefits of maternal hybrid vigour. This study enabled the performance of a highly prolific crossbred ewe type, the Bluefaced Leicester X Blackface ewe, to be compared with moderately prolific ewe breed types, Texel and Suffolk crosses, under indoor and easy-care lambing systems.

Lambing difficulty score was lower in Suffolk X Cheviot ewes compared with the other ewe breed types (Table 3). Consequently, the average time spent lambing each ewe was lowest in the Suffolk X Cheviot and highest in the prolific Bluefaced Leicester X Blackface in the easy-care system. Although lamb mortality tended to be higher in the Bluefaced Leicester X Blackface ewes in the easy-care compared with the indoor system, lamb output remained highest with this ewe breed. Nonetheless, the superiority of Bluefaced Leicester X Blackface was less in the easy-care system, with Suffolk X Cheviot ewes performing relatively better in the easy-care system.

Ram breed performance

Suffolk and Texel are the predominant terminal sire breeds in Northern Ireland. In the current study, animals were sourced from sire reference schemes and were selected to represent the top 10% of sires on the basis of estimated breeding values for lean growth indices. Double-muscled (DM)-sired lambs were also used in this trial as previous work at ARINI had found Texels selected for carcass conformation and less for growth rate produced relatively small lambs with a low incidence of lambing difficulty.

Table 3. The effect of ewe breed type on lamb output

	Indoor					Easy-care				
	Bluefaced Leicester × Blackface	Texel × Blackface	Suffolk × Cheviot	Texel × Cheviot	Sig	Bluefaced Leicester × Blackface	Texel × Blackface	Suffolk × Cheviot	Texel × Cheviot	Sig
No. lambs born/ewe	1.99	1.78	1.74	1.64	**	1.96	1.69	1.74	1.63	**
Lamb birth weight	4.94	4.63	4.91	5.01	NS	5.28	4.97	5.10	5.29	NS
Lambing difficulty score	1.3	1.3	1.2	1.3	NS	1.5	1.5	1.2	1.5	*
No. lambs born dead/ewe	0.10	0.16	0.07	0.05	NS	0.19	0.11	0.14	0.13	NS
No. lambs died (birth-weaning)	0.15	0.08	0.11	0.08	NS	0.16	0.16	0.08	0.06	NS
No. lambs weaned/ewe	1.74	1.54	1.58	1.50	NS	1.60	1.36	1.54	1.40	NS
Lamb growth rate										
Birth – 6 weeks	293	282	301	293	*	308	297	324	310	**
Birth – weaning	264	258	279	263	**	271	265	292	265	***
Weaned lamb output (kg/ewe)	64.2	55.9	56.1	53.7	*	58.6	52.6	56.2	51.4	NS
Labour inputs (min/ewe)										
Lambing	2.07	3.19	1.36	2.46	NS	4.08	1.42	0.69	2.54	*
Neonatal Lamb-care	1.65	2.03	1.34	2.00	NS	3.54	0.87	1.96	1.29	NS
Catch/move ewes	6.57	6.10	5.88	6.76	NS	6.53	4.47	4.05	5.47	NS
Moving ewes to grass	3.12	3.22	3.01	3.19	NS	0.00	0.00	0.00	0.00	NS

NS NS = difference is not significant; * = significant; ** = highly significant; *** = very highly significant

In the current study DM-Texel sired lambs were lighter at birth compared with Texel and Suffolk-sired lambs and had a slightly lower incidence of lambing difficulties. However sire breed did not significantly affect the time spent to lamb an ewe. The percentage of Suffolk-sired lambs born dead was higher compared with DM-Texel and Texel-sired lambs, resulting in a higher overall mortality rate in both the indoor and easy-care systems. Higher rates of lamb mortality in Suffolk compared with Texel sires have also been found in previous work (Carson *et al.*, 2001).

High lamb growth rates are an important component of low labour input systems through reducing days to slaughter. DM-Texel-sired lambs had significantly lower growth rates from birth to weaning compared with the Texel and Suffolk sires (Table 4). Consequently days to slaughter were greater for DM-Texel-sired lambs (173 days) compared with 151 and 155 days for Suffolk and Texel-sired lambs respectively, thus overriding any potential labour saving benefits of low lambing difficulties associated with DM-Texel-sired lambs. Growth rates were higher in Suffolk- compared with Texel-sired lambs produced in the indoor lambing system.

Table 4. Effect of ram breed on lamb output in indoor and easy-care lambing systems

	Indoor				Easy-care			
	DM Texel	Texel	Suffolk	Sig	DM Texel	Texel	Suffolk	Sig
Lamb birth weight	4.81	4.98	5.13	NS	4.90	5.18	5.43	**
Lambing difficulty score	1.2	1.3	1.4	NS	1.3	1.4	1.4	NS
Lamb mortality								
No. lambs born dead/ewe	0.07	0.07	0.15	NS	0.09	0.10	0.16	NS
No. lambs died (birth–weaning)	0.12	0.09	0.09	NS	0.15	0.09	0.13	NS
Lamb growth rates								
Birth-6 weeks	272	292	313	***	304	312	314	NS
Birth-weaning	247	268	283	***	263	279	277	*
Labour inputs (min)								
Lambing	1.7	1.9	2.9	NS	1.5	2.9	1.6	NS
Neonatal lamb-care	1.2	1.3	2.3	NS	1.1	1.5	2.6	NS

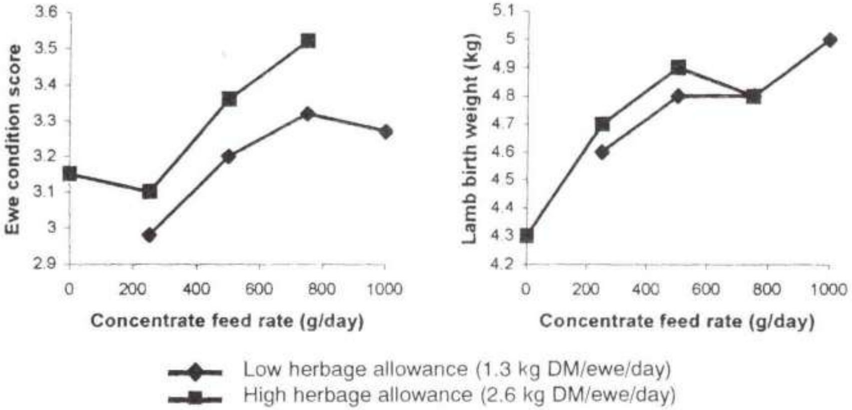
NS = difference is not significant; * = significant; ** = highly significant; *** = very highly significant

Developing appropriate grazing regimes for ewes in late pregnancy

Whilst there is a significant amount of information on the effect of conserved forage quality on ewe performance at lambing there is little or no information on the effect of herbage allowance and concentrate feed rates on which to base outdoor grass-based feeding strategies. Consequently studies are being carried out at ARINI to determine the effect of herbage allowance and concentrate feed level on ewe body condition, lamb birth weight and subsequent performance.

The first study in this programme investigated the responses to increasing levels of concentrates on low (1.3 kg DM/day) and high (2.6 kg DM/day) daily allowances of herbage. Provisional data indicates that ewe condition score and lamb birth weights at lambing increased linearly with increasing levels of concentrates on both the low and high herbage allowances (Figure 1). However, in the first of this series of planned studies little benefits of additional concentrate supplementation on subsequent lamb performance were achieved.

Figure 1. Effect of concentrate feed rate and herbage allowance on ewe condition score and lamb birth weight.



The work to date has shown the potential for grass-only diets to support the nutritional requirements of ewes in late pregnancy. A recent indoor study at ARINI has shown the higher intake characteristics of zero grazed grass compared with conserved forages (Table 5). In addition grass alone was shown to support relatively high levels of colostrum production. Work is planned to investigate further the effect of herbage allowance on subsequent performance to develop grazing strategies requiring no concentrate supplementation.

Table 5. The effects of forage type and concentrate supplementation on dry matter (DM) intake, lamb birth weight and colostrum yield (l)

Diet	DM intake	Lamb birth weight (kg)	Colostrum yield (l)
Grass-only	1.7	5.2	1.6
High D silage only	1.2	4.5	1.3
Restricted grass (1 kg DM/ewe/day) + conc	1.4	4.4	2.2
High D silage + conc	1.7	4.9	1.7
Medium D silage + conc	1.0	5.2	1.5

Shelter provision

In the current study, the easy-care system has been investigated over two years on six farms representing a wide range of farming conditions. On each of the farms, fields for lambing were chosen by the producers on the basis of ground conditions, shelter and convenience to the farmyard. Ewes have been noted to use shelter, particularly during periods of adverse weather conditions. (In Australia the provision of additional shelter for ewes around lambing has been shown to improve lamb survival (Alexander *et al.* 1980)). During the forthcoming lambing season a study is planned to investigate the effect of providing additional shelter on lamb survival and growth rates in grass-based lambing systems. The design and location within paddocks of shelter provisions over a range of farm sites will be examined.

Other management issues

Castration

In the current study all ram lambs were left entire eliminating one of the routine tasks of lamb production and enabling the producers to benefit from the higher growth potential of ram lambs. Entire males typically grow 10% faster than castrates and can be taken to heavier carcass weights at the same fat class (+0.7 kg) (Wylie *et al.*, 1997). In the current study there were few differences in meat quality between the male and female lambs. Cooking loss was slightly higher in males and tenderness slightly lower, however the differences were small and the instrumental meat quality values were indicative of good eating quality in both sexes.

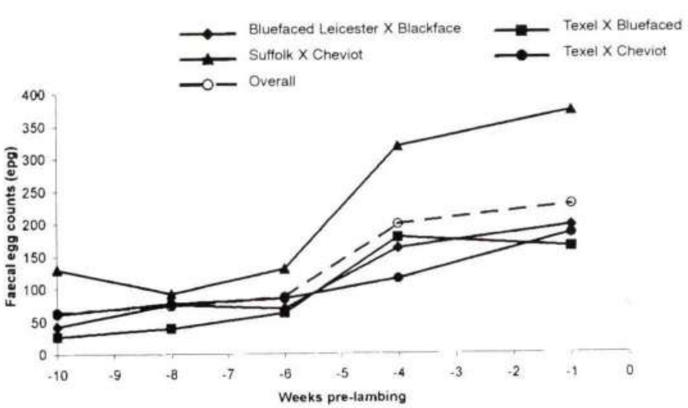
Worm dosing

Effective control of gastrointestinal parasites is crucial in maintaining good animal health and performance and thereby minimising labour requirements. The indiscriminant use of wormers is likely to be inefficient from a labour and economic point of view as well as raising concerns on the usage of chemicals in production systems. Thus, the current programme is evaluating the potential for on-farm monitoring of faecal egg counts to direct and monitor worm control strategies on a sound epidemiological basis.

In the first year of this component of the programme the periparturient rise in ewe faecal egg counts (FEC) was observed on each of the farms indicating the need to dose ewes in late pregnancy in a bid to minimise larval contamination of the pasture. As ewes in the easy-care system are at grass during this period the risk of larval contamination of pastures is likely to be reduced by ensuring that ewes are dosed at least four weeks before the commencement of lambing combined with good pasture management.

Provisional data from the first year of this study indicates that there are breed differences in the level of the periparturient rise in FEC (Figure 2). Suffolk X Cheviot ewes tended to have higher FEC's in late pregnancy than the other breed types. However, within each of the ewe breed types a large variation occurred between individuals in their worm egg count as assessed by FEC. Progress on increasing the genetic resistance to gastrointestinal parasites in sheep is being made through extensive research programmes being carried out in the UK and Ireland and this is likely to lead to considerable benefits in breeding sheep for easy-care systems.

Figure 2. Effect of crossbred ewe genotype on periparturient rise in faecal egg counts.



Conclusions

Grass-based lambing systems have been shown to have the potential to reduce the fixed costs associated with lowland sheep production. Averaged across a range of ewe breed types lamb output was similar in grass and indoor lambing systems. There are some indications that the superiority of highly prolific ewe types in terms of lamb output is less in grass-based systems. Sire breed has been found to affect lamb mortality rates. Breed improvement programmes are now taking into consideration traits such as resistance to worms. Suitable emphasis needs to be placed on traits of vital importance in easy-care systems such as ease of lambing and lamb vigour. Further work is required to investigate the effect of grass allowances in late pregnancy to develop grazing strategies, which ensure ewes lamb down in the correct body condition with lambs of optimum size.

Acknowledgments

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Lame Sheep – are they an inevitability of sheep farming?

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Introduction

As someone who has kept sheep for most of her life, the author knows that the utopian aim of eliminating all lameness from sheep flocks is impossible. Even if the diseases caused by the common bacteria *Fusobacterium necrophorum* (scald) and *Dichelobacter nodosus* (foot rot) are controlled (in the former) and eradicated (in the latter), there are other non-infectious problems affecting feet which continue to cause sporadic problems in individual sheep and sometimes in significant numbers within a flock. The author is particularly interested in these conditions, which seem to involve hoof quality.

However, it is certainly the case that scald and foot rot are the major causes of lameness at flock level. It is important to realise that the bacteria involved live under different conditions and this factor determines whether it is possible to eliminate them.

Scald

F. necrophorum, which causes the interdigital condition scald, is an organism that is found everywhere in the environment, particularly in dirty conditions and in faeces. It is therefore impossible to eliminate. It does not, on its own, cause an invasive foot condition. It is not known whether individual sheep or breeds are more resistant than others (based on a very small sample, the author's experience is that black sheep seem more resistant than white). No vaccine is available, so shepherds must try and reduce the factors that predispose to the condition developing, and to treat accordingly. Predisposing factors include: -

Dirty/muddy areas around feed troughs, water troughs and in gateways that keeps the skin of the interdigital space wet and in contact with the bacteria

Excessively long grass or other herbage that damages the interdigital space

Poorly bedded and damp conditions under-foot when sheep are housed

- Maintaining short swards is good for foot health as well as nutrition. Situating feed and water troughs on hard or well-drained ground will help to prevent areas of mud forming. The regular moving of non-fixed troughs will also help. Attention should also be paid to gateways to ensure that they do not become 'mud baths'. Placing builders lime in gateways can also help to keep these areas dry, and a slightly alkaline environment may reduce bacterial contamination.
- Despite these precautions, a number of cases will still occur which require treatment. Small numbers respond well to topical Oxytetracycline spray. If flock or group treatment is required, the best option is probably still walking through a formalin footbath at no more than 2 - 3% strength. Standing on a dry surface for half an hour after footbathing will ensure that the chemical is not immediately washed off.

Foot rot

This is caused by the combined effects of *F. necrophorum* and *D. nodosus*. After the initial interdigital damage caused by *F. necrophorum, D. nodosus* is able to invade the hoof causing the characteristic smelly necrosis and horn separation, which starts at the heels. The degree of invasiveness depends on virulence of the strain of the bacterium. It is important to realise that this is an infectious condition – merely treating obviously lame animals will never clear the disease from a flock. The organism can only live on the ground for 16 days, so if it is eliminated from the feet of all sheep and they are not put on ground that has recently had sheep on it, it is possible the eradicate it from a flock. This is worth considering for closed flocks. However, this is hard work and requires determination to achieve. In commercial open flocks it is more realistic to control the disease to an acceptable level. Measures which will to need be considered to achieve control include:-

- Regular foot paring (not too severe)
- Separation of uninfected from infected sheep by examination of all feet
- Foot bathing (preferably in 10% zinc sulphate)
- Possible use of vaccination
- Use of antibiotic injections for severely affected animals
- Culling of chronic cases
- Eradication demands much more scrupulous imposition of whichever combination of these control measures is to be applied.

Conclusion

Lame sheep suffer pain and therefore need to be treated as soon as is practically possible. Prevention of lameness, where suitable methods exist, should be the aim. More note needs to be taken of genetic factors impacting on the development of lameness, as it is known that there is varying susceptibility to foot rot. Hoof horn quality may also be influenced by genetics. Nutrition may also be a factor in horn quality. There is still plenty work to be done on the control of lameness in sheep.

Scrapie, a TSE that must be eliminated – an EU perspective

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Abstract

A number of Transmissible Spongiform Encephalopathies (TSE's) affect man and animals. Scrapie, a disease of sheep and goats, has been recognised for the longest period – approximately 300 years. While microscopic changes in the brain and spinal chord are common to all these conditions, clinical signs generally include alterations in "attitude", loss of control of movement and eventually death. In sheep and goats suffering from Scrapie, the loss of condition and movement control may also be accompanied by an itch associated with wool loss.

For precautionary reasons, member states of the EU have been obliged to eliminate Scrapie. Controls were initially implemented in the early 1990's. The disease was made notifiable; only sheep from 'Scrapie free' flocks were allowed to be exported for breeding; the feeding of Meat and Bone Meal (MBM) to sheep was banned, and tissues which might possibly be infected with TSE's have to be removed at slaughter. Ireland has been the first country in the world to actively look for Scrapie using a 'rapid test' on post-mortem tissues. The group with the highest risk of having the disease – culled ewes – has been targeted in the major slaughterhouses since 1998. Data obtain from such surveillance and information collected from clinical cases indicates that approximately 10 new flocks a year are detected in Ireland as having Scrapie. Using less sophisticated surveillance systems, reports indicate that approximately 150 new cases are found per year in the UK, 13 per year in Italy, 12 per year in the Netherlands, nine per year in Greece and four per year in Spain.

An EU Directive on TSE's has been put in place since July 1st 2001. This necessitates extra controls being put in place within the EU. Member States are obliged to actively look for TSE's in their sheep flocks. When identified, infected animals and their relations (and their parts after slaughter) must be identified and destroyed. Controls on sales of animals from infected flocks will be enacted for 3 years after infection has been identified.

While Scrapie, as a disease of small ruminants, is accepted to pose no human health risk, its capacity to mask BSE (as shown in laboratory controlled studies) has raised public health concerns. While BSE has not been shown to be present in commercial sheep, studies are on-going to investigate if sheep affected with what appears like Scrapie are in fact infected with BSE. This scenario may have arisen as Sheep were probably exposed to similar contaminated MBM as were cattle; 'BSE' could then cycle in the sheep population, but show the signs of Scrapie.

Traditionally the control of Scrapie in sheep and goats relied on eliminating infected animals and vacating premises, which were used by infected sheep. While it has been recognised for years that excluding Scrapie infected animals from the breeding pool was useful in controlling the disease, the underlying genetic explanation for this is now better understood. Eliminating genetically susceptible animals may be a useful tool in eliminating Scrapie. However, at present, there is insufficient evidence to assure public health concerns as genetic 'resistance' may only prevent clinical signs and mask infection.

Options being considered to allay public health concerns include rapid testing (for TSE infections) of all sheep going for slaughter, extending the list of Specified Risk Materials

to be removed from sheep at slaughter and only allowing sheep of specific genotypes to enter the food chain. Despite the practical and economic consequences of instigating these measures, there is, at present, insufficient knowledge to guarantee the safety of food products from sheep and goats if BSE were found in these species.

A number of investigations are being carried out by DAF into the nature of 'resistance' to prion diseases and the possible role of breeding for resistance to Scrapie, which will contribute to the understanding of what is meant, by 'resistance'. Breeding programmes have been set up in five commercial flocks, in which there was active Scrapie, with considerable co-operation of their owners. When the entire breeding stock on these farms has been changed to the "resistant" type, detailed laboratory examinations will be carried out on members of the flocks, to ensure that the Scrapie prion - PrPSc - has been eliminated from the flocks.

At present an interim policy to eliminate Scrapie positive flocks and vacate infected premises is being pursued by DAF. This policy will be reviewed on a regular basis and will respond to advances in knowledge on TSE's.

Scrapie: current knowledge on the genetics and infective agent

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Summary

Scrapie is an untreatable and fatal disease of the central nervous system of sheep and goats. It is one of a group of unconventional diseases known as transmissible spongiform encephalopathies. Other diseases in this group include Creutzfeld-Jakob Disease (CJD) in humans and Bovine Spongiform Encephalopathy (BSE) in cattle. Currently, the diagnosis of scrapie is dependent upon post mortem confirmation by histological examination of the brain. Another diagnostic characteristic of scrapie is the accumulation of an abnormal variant of the prion protein in the lymphoreticular system and in the central nervous system. The nature of the infectious agent is not known and is the cause of much scientific debate. The development of scrapie in sheep is dependent on a genetically susceptible animal being exposed to the infectious agent. Genetic variation at codons 136, 154 and 171 on the sheep PrP gene has been found to influence susceptibility to scrapie. There is considerable concern that BSE may have entered the sheep population following the inadvertent feeding of meat and bone meal to sheep. There is however, no scientific evidence to date to support this concern.

PrP^{Sc} as a biochemical marker of infectivity

One of the characteristics of the lymphoreticular system and central nervous system of sheep is the presence of prion protein. The function of the prion protein is unknown and does not appear to play any role in normal physiological functioning of the animal. However, the earliest sign that a sheep is developing scrapie is the transformation of this protein into an abnormal conformation that is very resistant to breakdown. Hence this protein accumulates in the cell preventing the cell from functioning normally. As the disease progresses, more and more cells accumulate the abnormal form of the prion protein. The accumulation of this protein in cells of the central nervous system causes cell death, which gives a spongiform type histopathological appearance under the microscope. Once the cells start to die, the behaviour of the animal changes and the characteristic clinical signs of scrapie develop. In the pre-clinical stages of scrapie the abnormal isoform (PrP^{Sc}) of prion protein has been detected in gut-associated lymphoid tissues, the spleen, lymph nodes, tonsil and nictitating membrane of the eye (Hadlow *et al.*, 1982; Van Keulen *et al.*, 1996; 1999; 2000; Schreuder *et al.*, 1996, 1998; O'Rourke *et al.*, 1998; Andreolliti *et al.*, 2000). The ileal Peyer's patch was identified as the likely primary entry site of the scrapie agent with subsequent replication and dissemination of the infectious agent occuring in the secondary lymphoid system via the lymphatic or vascular pathway (Andreoletti *et al.*, 2000). PrP can be detected in these tissues for many months/years before becoming detectable in the CNS. While a pre-clinical test is currently not available, screening peripheral lymphoid tissue for PrP^{Sc} offers a possibility of pre-clinical diagnosis in sheep scrapie (Schreuder *et al.*, 1996; O'Rourke *et al.*, 1998; Thuring *et al.*, 2001; 2002).

Genetic susceptibility to scrapie

The gene which determines whether an animal is resistant or susceptible to developing the clinical signs of scrapie, is the prion protein gene. Polymorphisms at codons 112, 136, 137, 138, 141, 151, 154 and 211 of exon 3 of the gene have been characterised.

There are three positions or codons on the prion protein gene showing variation associated with resistance or susceptibility to developing the clinical signs of scrapie; these are at codons 136, 154 and 171. The alanine (A) to valine (V) polymorphism at codon 136 and the glutamine (Q) to arginine (R) polymorphism at codon 171 contribute to susceptibility to developing clinical signs of scrapie (Laplanche *et al.*, 1993; Belt *et al.*, 1995; Clouscard *et al.*, 1995; Hunter *et al.*, 1996, 1997b; Junghans *et al.*, 1998; Elsen *et al.*, 1999; Tranulis *et al.*, 1999; Thorgeirsdottir *et al.*, 1999). The association between scrapie susceptibility and polymorphisms at codon 154 are currently unclear, but there is a possibility that histidine (H) at codon 154 may offer protection from scrapie in some breeds of sheep (Elsen *et al.*, 1999; Thorgeirsdottir *et al.*, 1999). Polymorphisms at codons 112, 137, 138, 141, 151 and 211 are rare and have not been associated with any disease phenotype in natural and experimental scrapie (Laplanche *et al.*, 1993; Bossers *et al.*, 1996; Tranulis *et al.*, 1999; Thorgeirsdottir *et al.*, 1999).

In the entire sheep population studied to-date around the world, five different alleles of the prion protein gene have been identified. These are ARR, ARH, ARQ, AHQ, VRQ. Each animal inherits two alleles (one from each parent), which gives rise to the animals' genotype. The most resistant allele has been found to be ARR. Based on a combination of these alleles, fifteen PrP genotypes have been identified. These genotypes can be graded from the most resistant genotype (AA_{136} RR_{154} RR_{171} or written another way $PrP^{ARR/ARR}$) to the most susceptible genotype (VV_{136} RR_{154} QQ_{171} or $PrP^{VRQ/VRQ}$).

The genotype frequencies of the 10 main breeds of sheep in Ireland have recently been published (O'Doherty *et al.*, 1991). There was significant variation between the different breeds. In a study of 154 scrapie-infected sheep in Ireland genotyped between 1998 and 2000, seven PrP genotypes were identified: VV_{136} RR_{154} QQ_{171} ($PrP^{VRQ/VRQ}$), VA_{136} RR_{154} QQ_{171} ($PrP^{VRQ/ARQ}$), AA_{136} RR_{154} QQ_{171} ($PrP^{ARQ/ARQ}$), VA_{136} RR_{154} QH_{171} ($PrP^{VRQ/ARH}$) VA_{136} RR_{154} QQ_{171} ($PrP^{VRQ/ARR}$), AA_{136} RR_{154} QH_{171} ($PrP^{ARQ/ARH}$), AA_{136} RR_{154} HH_{171} ($PrP^{ARH/ARH}$) (O'Doherty *et al.*, 2002). The results presented in this study show that there is a significant risk of developing the clinical signs of scrapie associated with particular PrP genotypes in the Irish sheep population. The association between the VRQ, ARQ and the ARH allele and scrapie was evident, as was the association between ARR and resistance to developing clinical signs of scrapie. It was also evident that the presence of the AHQ allele in the flocks examined resulted in a decreased risk of developing scrapie.

PrP^{Sc} distribution in sheep of different genotypes

Recent studies have suggested that the specific PrP genotype of an animal can have an influence on the distribution of PrP^{Sc} throughout the lymphoid system in natural scrapie. PrP^{Sc} has been detected in the spleen, lymph nodes, tonsil, nictitating membrane and gut-associated lymphoid peripheral lymphoid system of animals of the following genotypes: VV_{136} RR_{154} QQ_{171} ($PrP^{VRQ/VRQ}$), VA_{136} RR_{154} QQ_{171} ($PrP^{VRQ/ARQ}$), AA_{136} RR_{154} QQ_{171} ($PrP^{ARQ/ARQ}$), VA_{136} RR_{154} QH_{171} ($PrP^{VRQ/ARH}$) (Van Keulen *et al.*, 1996, Schreuder *et al.*, 1998, O'Rourke *et al.*, 1998, Andreolliti *et al.*, 2000). In contrast, PrP^{Sc} does not accumulate in the lymphoreticular system of VA_{136} RR_{154} QR_{171} ($PrP^{VRQ/ARR}$) sheep naturally affected with scrapie but is detected in the CNS

(Van Keulen *et al.* 1996; Schreuder *et al.* 1996, 1998; Andreolliti *et al.* 2000). Hence, it is imperative to characterise the distribution of PrP^{Sc} in the lymphoid tissues of animals with different PrP genotypes.

A current study underway in Europe is highlighting that the earliest time of detection of PrP^{Sc} in lambs appears to be influenced by the breed of sheep and the genotype. Taking the genotype: VV_{136} RR_{154} QQ_{171} ($PrP^{VRQ/VRQ}$), Romanov sheep express PrP^{Sc} as early as 3-5 months of age, Texels express PrP^{Sc} at 4-6 months of age, while Cheviots had not expressed PrP^{Sc} at 10 months of age.

What does "genetic resistance to scrapie" mean?

Genetically susceptible sheep with genotypes such as $PrP^{VRQ/VRQ}$, $PrP^{VRQ/ARQ}$, $PrP^{ARQ/ARQ}$, $PrP^{VRQ/ARH}$, $PrP^{VRQ/ARR}$, $PrP^{ARQ/ARH}$, $PrP^{ARH/ARH}$ that develop clinical signs of the disease following exposure to the infective agent are said to be 'genetic susceptibility'. One of the complex areas in transmissible spongiform encephalopathy research is to define 'genetic resistance' to scrapie. By saying that animals of the genotype $PrP^{ARR/ARR}$ are genetically resistant to scrapie, we mean that no animal of this genotype has ever been confirmed with scrapie with histopathology or detection of PrP^{Sc} in any tissue in the body. This includes animals that have died of old age and infectivity analysed by the subsequent innoculation of brain tissue into mice. There is the possibility that these animals had some residual PrP^{Sc} that could not be detected by current biochemical or mouse bioassay tests. However, the question has to be asked, if these tissues are not infective in the mouse bioassay test, is there still a risk to other sheep or to humans?

Scrapie strain types and BSE in the sheep population

Concerns have been raised about the possibility of natural transmission of the BSE agent to sheep as experimental studies have revealed that sheep develop signs that are indistinguishable from conventional scrapie following experimental infection with BSE (Foster *et al.*, 1993). Hence this is one of the most active areas of research on TSE's at present. Currently, the experimental innoculation of mice with brain from the affected animal is the standard recommended method for distinguishing different TSE strains. In the mouse bioassay, the incubation time of the disease and brain lesion profile pattern in the mice are used to differentiate the different strains. However, in these assays large numbers of animals (26 mice per line) from three different highly inbred mouse lines (C57Bl, VM95, RIII) plus their intercrosses need to be infected and subsequently analysed. Although the results obtained using this mouse inoculation procedure are considered reliable, the effort and time needed for conducting these experiments are considerable. Hence alternative criteria and techniques are currently being developed to characterize TSE agents. Glycotyping is a procedure involving the isolation, proteinase-K digestion and immunoblotting of PrP^{Sc} from infected animals. The protein normally segregates into three bands of different molecular mass on an SDS-PAGE gel. The different molecular masses are caused by the number of glycosylation chains on the protein molecule: di-glycosylated, mono-glycosylated and non-glycosylated. Different strains appear to have different sensitivities to proteinase-K and also the proportion of the three different glycoforms can vary with different strains.

The question, whether BSE can be detected in sheep scrapie cases by use of the above criteria, for the molecular characterization of PrP^{Sc} was addressed (Sweeney *et al.*, 2000). Samples from the central nervous system (thoracic cord, thalamus, basal ganglia, mediobasal hypothalamus, medulla and cortex) were collected from 16 scrapie infected sheep which had shown a wide variety of clinical signs and which were carrying the following PrP genotypes: $PrP^{ARQ/ARH}$, $PrP^{ARQ/ARQ}$; $PrP^{VRQ/ARQ}$; $PrP^{VRQ/ARH}$. Cerebellar and brain stem samples were also collected from BSE infected cattle. PrP^{Sc} in ovine scrapie samples from Ireland displayed clearly distinct molecular characteristics from PrP^{Sc} in bovine BSE samples. Sheep scrapie PrP^{Sc} was generally characterized by less than 55% diglycosylated PrP compounds in immunoblot, while in BSE PrP^{Sc} about 70% diglycosylated proteins were detected. It must be noted, however, that for a final characterization of the Irish scrapie cases, a mouse lesion profile scoring of these samples will be analysed.

Three other studies on the molecular characteristics of PrP^{Sc} from field scrapie cases have been published to date. Two research groups have reported a considerable degree of variation in PrP^{Sc} from British scrapie cases, which were assumed to reflect the diversity of different strain types in the country (Hill *et al.*, 1998; Hope *et al.*, 1999). In contrast to these results, French scientists found little diversity in French sheep scrapie cases, but glycotyping patterns which closely resembled BSE patterns (Baron *et al.*, 1999)

Conclusion

In conclusion, we now have significant information on the genotype variation within and between breeds as well as information on the genotypes that are more susceptible to developing the signs of scrapie. The distribution of the prion protein in scrapie infected sheep has been determined. While there is no evidence that BSE is present in sheep, experimental infection studies are underway to characterise BSE in sheep, and all European countries are developing the technology to identify such cases.

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Variety diversity in key characters determining grazing value in ryegrass (*Lolium perenne* L.) swards

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Introduction

Herbage yield is only a partial indicator of the overall value of a perennial ryegrass variety as animal productivity is the ultimate measure of its worth. Despite this, current variety testing programmes in the UK and Ireland are based primarily on cutting systems with animals rarely involved and only then to introduce grazing pressures or to assess grazing preferences, but not to measure animal output from varieties (Weddell *et al.*, 1997). This absence of a direct animal output assessment is recognised as a shortcoming of the testing systems (Orr *et al.*, 1988).

A total of 111 different perennial ryegrasses are currently recommended in the UK and Ireland and upwards of 40-50 new candidates are submitted annually for evaluation. It is both impractical and prohibitively expensive to measure animal output on such large numbers of varieties. Consequently, any grazing output studies that have been done only examine a very small number of varieties. So alternative ways of assessing the animal output potential of ryegrass varieties must be sought. Variety feeding value can be defined as a combination of the nutritive quality and intake potential of the grass, which will comprise chemical, morphological and yield factors. Characteristics such as sward surface height, herbage mass, bulk density and green leaf mass have all been implicated as having effect on intake during grazing (Penning *et al.*, 1994; Barrett *et al.*, 2001). Furthermore, nutritive value factors such as digestibility and water-soluble carbohydrate (WSC) have been shown to increase the output of milk or meat without increasing production costs (Davies *et al.*, 1991). In contrast, protein levels in grass are not normally limiting for ruminant nutrition and are therefore unlikely to be important parameters for variety evaluation.

In the present study, the potential value and practicality of incorporating the aforementioned parameters into routine testing procedures for compiling recommended lists of perennial ryegrass varieties is considered.

Materials and Methods

The study was conducted at the Plant Testing Station Northern Ireland using 12 perennial ryegrass varieties, comprising diploids and tetraploids of different maturity types (Table 1). The varieties were managed under the simulated rotational grazing system used for the Northern Ireland Recommended List (Weddell *et al.*, 1997) and so were cut with a plot harvester.

Table 1. Perennial ryegrass varieties examined

Early Maturing			
Frances	Sambin	AberTorch (T)	Tetramax (T)
Intermediate Maturing			
	AberDart	Merbo Calibra (T)	Missouri (T)
Late Maturing			
Choice	Foxtrot	Millennium (T)	Navan (T)

(T) indicates a tetraploid variety

At each of eight rotational grazing cuts between early May and October, representative samples were taken for five sward morphological characters (sward height, tiller length, bulk density, Leaf:Stem ratio and leaf weight), three nutritive value parameters (water-soluble carbohydrate 'WSC' concentration and WSC yield and *in vitro* digestibility by pepsin cellulase '%DMD') as well as for the standard test assessments of total annual and seasonal yields and sward density. In all cases the methods employed were as described by Gilliland *et al.*, (2002).

Current yield based assessments

The 12 ryegrass varieties differed significantly in total annual yield, in their seasonal distribution of yield across the growing season and also in sward density (Table 2). These data are supplied annually to farmers through the Northern Ireland Recommended List booklet and show that the tetraploids are among the highest total annual yielding varieties available. Importantly, the table shows that the total annual yield rankings do not remain fixed throughout the growing season. With the exception of Merbo, which maintains a relatively consistent performance throughout the year, the other varieties display periods of peak productivity at specific times. For example, Sambin outperforms all other varieties except for AberTorch in spring, despite it having the lowest total annual yield of all 12 varieties.

Table 2. Comparison of production and sward density of perennial ryegrass varieties under a simulated grazing management

Control Yield	Heading	Total Yield	Spring	Early Summer	Late Summer	Autumn	Sward Density
(*t DM ha*$^{-1}$)	date	12.5	1.9	5.1	3.9	1.5	0-9 high
AberTorch (T)	9 May	106	130	94	100	102	5.8
Frances	11 May	95	104	93	98	97	6.1
Sambin	16 May	87	122	88	85	91	6.9
Tetramax (T)	19 May	101	111	101	96	96	5.8
Merbo	21 May	93	95	98	96	92	5.8
AberDart	27 May	92	99	98	105	107	5.9
Calibra (T)	27 May	107	103	104	105	98	5.8
Missouri (T)	28 May	103	100	101	107	100	5.5
Navan (T)	6 June	109	91	104	114	105	5.1
Foxtrot	7 June	107	86	110	111	99	6.1
Choice	10 June	97	77	105	105	93	5.9
Millennium(T)	14 June	102	95	107	110	101	5.6
Average		100	101	100	103	98	5.9
Significance		***	***	***	***	***	***
Diploid		95	97	99	100	97	6.1
Tetraploid		105	105	102	105	100	5.6
Significance		***	**	NS	*	NS	***
Early		97	117	94	95	97	6.2
Intermediate		99	99	100	103	99	5.8
Late		104	87	107	110	100	5.7
Significance		NS	***	**	***	NS	***

Although the genetic-driven trend for earlier maturity to be associated with higher spring production is clearly expressed among these varieties, exceptions are again evident. For example, the total annual yield ranking of Foxtrot and Millennium are reversed in spring and there is a 4% difference between Merbo and AberDart at this time, despite them having a similar total yield potential. Following the spring period the late varieties optimise production during the main summer period and the high spring performers generally show a dip in performance particularly in early summer. In the autumn period, variety maturity has no influence on performance but again exceptional performances are evident. For example AberDart had the highest autumn yields despite its low total annual yield, Navan and Millennium were consistently high performing in summer and autumn following their relatively low spring performance, whereas Calibra excelled in spring and summer but its performance fell in autumn. Clearly such information is of value to farmers and seeds merchants as it identifies varieties and helps design mixtures that deliver productivity instep with the herd requirements throughout the season.

Sward morphology differences

Grass intake rates are a key factor in driving animal performance at grass. This is particularly true for dairy cows due to their requirement for up to 20 kg d^{-1} DM and the limited time in the day to graze such large quantities of grass (Gibb, 1998). From a grass variety evaluation perspective, it is known that grazing intakes are greatly affected by the canopy structure of the sward (Forbes, 1988), including characters such as sward surface height, tiller length, bulk density and leaf mass.

The results in Table 3 show that there are substantial differences between varieties in the structure of the swards they form, which can be expected to impact on the grazing animals ability to achieve high intakes of herbage.

Table 3. Comparison of perennial ryegrass varieties for sward morphological and nutritive characters under a simulated grazing management (seasonal averages)

Variety	Sward Height (cm)	Tiller Length (cm)	Bulk Density ($kgm^{-3}DM$)	Leaf Stem ratio	Leaf Weight ($kgha^{-1}DM$)	WSC Content ($gkg^{-1}DM$)	WSC Yield ($kgha^{-1}DM$)	*In vitro* Digestibility (%DM)
AberTorch (T)	17.2	24.0	0.80	0.85	1164	278.1	364.8	80.6
Frances	16.8	22.3	0.72	0.80	972	233.5	272.0	73.9
Sambin	16.5	22.0	0.68	0.75	828	231.7	247.2	71.0
Tetramax (T)	16.6	23.2	0.77	0.85	1076	259.1	322.4	79.0
Merbo	16.7	22.4	0.71	0.79	943	248.6	288.0	73.5
AberDart	16.7	22.6	0.70	0.86	1027	286.0	332.0	81.5
Calibra (T)	17.2	23.9	0.79	0.86	1180	277.5	369.8	80.1
Missouri (T)	17.4	23.9	0.75	0.83	1108	272.4	347.9	77.8
Navan (T)	15.8	23.2	0.87	0.88	1259	277.6	383.2	80.1
Foxtrot	15.7	21.7	0.85	0.84	1167	272.4	369.9	79.9
Choice	14.9	20.7	0.81	0.87	1094	245.6	297.4	79.5
Millennium(T)	15.4	22.0	0.84	0.91	1215	260.6	330.7	78.9
Average	16.4	22.7	0.77	0.84	1086	261.9	327.1	78.0
Significance	***	***	***	***	***	***	***	***
Diploid	16.2	22.0	0.74	0.82	1005	253.0	301.1	76.6
Tetraploid	16.6	23.4	0.80	0.86	1167	270.9	353.1	79.4
Significance	NS	***	**	*	**	NS	*	***
Early	16.8	22.9	0.74	0.81	1010	250.6	301.6	76.1
Intermediate	17.0	23.2	0.74	0.84	1064	271.1	334.4	78.2
Late	15.4	21.9	0.84	0.88	1184	264.0	345.3	79.6
Significance	**	*	***	NS	*	NS	NS	***

WSC = water soluble carbohydrate

As a general guide, the larger the values in Table 3 the more favourable is the characteristic for high grazing performances. In all these factors, substantial differences existed between the varieties and it was possible to identify those with characteristics that indicated a high or low intake potential. For example, Choice was a short low growing variety whereas the three tetraploid varieties AberTorch, Calibra and Missouri were tall growing with long tillers. Furthermore, Sambin scored poorly for density of growth and leaf content whereas Millinneum, which had a sorter sward with similar tiller lengths to Sambin, had very high leaf contents in a very dense growth. Across all characteristics, only the tetraploid varieties AberTorch and Calibra were above average in all cases, suggesting that they could be expected to provide greater levels of intake and support higher animal productivity than swards of many of the other varieties. Tetraploids in general, displayed excellent sward heights, tiller lengths and herbage density. Sward leafiness has been consistently found to associate with high intake potential, however, in addition to the wide range of differences between varieties in Table 3, there were much larger differences during the season linked closely to variety maturity. This makes this aspect of sward structure difficult to interpret. Overall, however, the tetraploids were again clearly superior to diploid varieties and the top two performers were the late tetraploids Navan and Millennium. This is consistent with the reports of O'Donnovan *et al.*, (1999), who recorded higher dry matter intakes with dairy cows for two late varieties (Portstewart and Millennium) in comparison with two intermediate varieties (Spelga and Napoleon), with the tetraploids performing best in each case.

These results show that existing recommended varieties differ substantially in such grazing value factors as leaf content and herbage presentation and that while maturity and ploidy may have an influence, individual varieties are not totally subordinate to these influences.

Nutritive value differences

Water-soluble carbohydrate concentration of pasture grasses increases the amount of readily available carbohydrate, so affecting the efficiency of conversion of nitrogen to microbial protein in the rumen. This has been shown to increase live weight gain in sheep (Lee *et al.*, 2000a) and in cattle (Lee *et al.*, 2000b) and to enhance the milk production and quality in dairy cows (Miller *et al.*, 2001). In the current study, WSC concentrations were generally higher in tetraploids than diploids, with the lowest concentration being in Sambin (Table 3). Despite this trend, the top variety was the diploid AberDart, which was specifically bred for high WSC. Other notable performances included Foxtrot in achieving a similar WSC concentration to the majority of tetraploids and to the relatively low WSC concentration of Millennium and Tetramax. When WSC yield was examined, the high performing AberDart no longer excelled due to its low overall production potential, but Foxtrot remained very high and as good as almost all the tetraploids, having a high herbage yield and WSC concentration combination. The importance of these variety differences of over 50 g kg^{-1} DM are apparent when it is considered that Miller *et al.*, (2001) found that WSC concentration differences of 40 g kg^{-1} DM significantly improved feed protein conversion to milk protein in dairy cows.

The digestibility differences between the varieties displayed a similar variety pattern to that found for WSC concentration. Clearly high WSC concentrations promote higher total digestibility, however around 30% of the variation in digestibility could not be accounted for by WSC differences alone and so other factors were also having an influence.

Recommending varieties for grazing

The presented variety data provides a very complex pattern of performances that are not easily translated into an overall measure of grazing value. Moreover, current knowledge is not sufficient to permit yield advantages to be compensated for in a quantitative way by any of the aforementioned value indicators. Clearly high values in all parameters are desirable, but converting them into a transparent indicator of grazing worth is a difficult task. One possible approach is to set positive and negative thresholds on the range that exists among the varieties in each character. A simple approach is to designate the top 33 percentile as a positive attribute and the bottom 33 percentile as negative, with the middle values as neutral. Therefore, if a variety produced a result that put it in the top third of performances among a group of varieties it would be awarded a +1 (or +2 or more depending on how important the character is for grazing). Similarly, if the result was in the bottom third of the performances the variety would score –1 (or-2 etc) and if it was in the middle third it would neither gain nor lose any marks. This is only one simple example of many possible different ways of how to apply such a weighted scoring system. The exact one chosen would depend on research backed information on how the different parameters interact and to what extent they impact on grazing performance. Even so, if this simple example is applied to the existing variety results, with the data combined to create four categories; 'total yield', 'sward structure', 'nutritive value' and 'sward density', then the variety comparisons are as shown in Table 4.

Table 4. Example variety comparison table for grazing use rankings.

Variety	Total Yield Ranking +1 to -1	Sward Structure Ranking +5 to -5	Nutritive Value Ranking +2 to -2	Sward Density Ranking +1 to -1	Ranking Ranking Total +9 to -9
Calibra (T)	+1	+4	+2	0	+7
AberTorch (T)	+1	+2	+2	0	+5
Navan (T)	+1	+3	+2	-1	+5
Foxtrot	+1	0	0	+1	+2
Tetramax (T)	0	+1	0	0	+1
Choice	0	0	-1	+1	0
Millennium (T)	0	+1	0	-1	0
AberDart	-1	-2	+2	+1	0
Missouri (T)	0	+1	-1	-1	-1
Frances	-1	-2	-2	+1	-4
Sambin	-1	-4	-2	+1	-6
Merbo	-1	-3	-2	0	-6

. All parameters were simply given the same weighting of +1/0/-1. As WSC yield was a direct calculation of total yield and WSC concentration it was excluded from the table to avoid double counting. The ranking total in the last column of the table shows how the varieties separated out overall. It is notable that the top three varieties were tetraploids. It is also clearly evident that total yield had a major impact on the overall grazing value ranking as only AberDart with its exceptionally high WSC concentrations had a final ranking that was totally inconsistent with its yield performance. However, this observation oversimplifies what is occurring, as it is possible to distinguish between varieties of similar yield potential but with different grazing values. For example Choice and Frances had a similar yield of 97% and 95% of the control (Table 3), yet their final value rankings of 0 and –4 respectively, were very different. Similarly Foxtrot and Calibra yielded 107% in Table 3 but had grazing value scores of +2 and +7 respectively. Furthermore, Missouri, Millennium and Tetramax had similar yields of 103,102 and 101 respectively but this order changed to –1, 0 and +1 respectively in the final rankings.

Clearly the value of such a ranking system is only as good as the information from which it is created. Specific research information is required to determine what weighting should be applied to each factor to account for its individual influence on grazing performance and to counteract the interactions that clearly occur between the different factors examined in this study.

Summary

The present study showed the existence of substantial differences among currently recommended varieties for a number of sward structure and nutritional factors associated with enhanced grazing performance. However, before this type of information can be incorporated into routine recommended testing protocols, better information is needed on the quantitative impact of each factor on the performance of the grazing animal. Furthermore, the workloads associated with assessing the sward structure parameters were very high. Some way of reducing the workloads is necessary, either by reducing the number of measurements taken or by estimating them from other information that is routinely measured on varieties, such as the detailed morphological examinations that are made during Plant Breeders Rights tests. In contrast, assessment of WSC appears more achievable on a routine basis, particularly if it could be conducted at a single time of year. Given the increasing evidence that high WSC concentration has measurable impacts on animal performance with no additional input costs to the farmer, inclusion in testing systems would seem justified.

Some time will be required to build up databases of information on all existing recommended varieties for any of the characteristics examined. Before this can be embarked upon, clear evidence of the value of the information to farmers must be established plus an unambiguous and non-complicating, yet scientifically valid way of presenting the information must be established.

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Improving cow performance at grass, what do grass cultivars offer?

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Introduction

High performance from dairy cows is central to achieving high financial returns from the farming enterprise (Stakelum *et al*, 1997). This is achieved when the cow consumes high levels of high quality feed. Grass when grazed efficiently is by far the cheapest feed available on the farm (Sheedy, 2000). Therefore, the production and utilisation of grass has a central role in maintaining the competitiveness of the Irish dairy industry. Much of the focus of grassland research has centred on grass utilisation and grass production. Very little focus has been given to identifying the most suitable grass for the grazing system. Perennial ryegrass cultivars are divided into three groups according to the date of ear emergence *viz.* early, intermediate and late. It is known that differences exist in maturity group thus, early heading cultivars decline in digestibility earlier than late heading cultivars during the early summer period (Gately, 1984). In the past few years, there have been dramatic changes in plant breeding and within the seed industry. Plant breeding has contributed a 0.08% increase in dry matter production annually over the past decade. However, the most recent published DAF figures show a growing trend of increased usage of late heading grass cultivars. Early heading grass cultivars now only constitute 2% of all grass seed sold.

It is a difficult task to make meaningful comparisons of herbage cultivars. All of the comparative work is completed in terms of dry matter production under cutting, which is the method of evaluation used by DAF in compiling recommended lists. A criticism of this method is that the cultivars are not subjected to an animal influence i.e. selective grazing, treading damage and the return of faeces and urine. It is essential to compare cultivars by using animal intake and performance as a measure of their productivity.

Gately, (1984) examined an early heading and late heading ryegrass at two stocking rates with dairy cows. At low stocking rate, cows grazing the late heading cultivars produced 8.8% more milk than cows grazing the early cultivars, however at the high stocking rate the cows grazing the early heading cultivar gave 6.6% more milk. The digestibility of the late heading ryegrass was significantly greater than that of the early heading ryegrass. Minson *et al.* (1960) reported that early maturing S24 perennial ryegrass was lower in digestibility at a given date in spring than the late maturing S23 cultivar. Tetraploid grass cultivars now constitute up to 30% of all grazing mixtures (Culleton *et al*, 1998). Vipond *et al.* (1993) found under continuous grazing with sheep, an advantage to tetraploids compared to diploid grass cultivars. Lantinga *et al*, (1996) reported a milk yield advantage to tetraploids relative to diploids over a short experimental period. In a grazing preference experiment (O'Riordan, 1997) found that tetraploid grasses predominated in the highest ranked grasses for grazing preferences.

This paper reports on the results of a 2 year investigation on the effect of perennial ryegrass cultivars differing in both heading date and ploidy on daily milk production and grass dry matter intake of spring calving dairy cows. The difference in sward characteristics between cultivars was also investigated.

Experimental Methodology

The experiment was carried out at the Moorepark Research Centre during the 1999 and 2000 grazing season. The soil type was a free-draining acid brown earth of sandy loam to loam texture. A permanent grassland site (17.2 ha) was reseeded in August 1998. Table 1 shows details of cultivar, heading date, ploidy, and seeding rate. A further 3.9 ha was reseeded in April 2000 and incorporated into the experimental area in that year.

Table 1. Grass cultivar, heading date, ploidy, seeding rate and experimental land area.

Cultivar	Heading date	Ploidy	Seeding rate (kg/ha)	Land area (ha)
Millenium	10-June (L)	Tetraploid	42	4.30
Portstewart	07-June (L)	Diploid	34	4.30
Napoleon	20-May (I)	Tetraploid	42	4.30
Spelga	17-May (I)	Diploid	34	4.30

Design and layout

At sowing, the experimental area was divided equally into the four treatments consisting of 4.3 ha each. This area was divided into 10 paddocks ranging in size from 0.35 to 0.47 ha. In 2000, the additional 3.9 ha was divided equally between treatments, thereby increasing the total area and paddock number per treatment to 5.28 ha and 12, respectively. Table 2 shows the stocking rate changes over the grazing area during the experimental periods of 1999 and 2000.

Table 2. Mean stocking rates (SR) (cows/ha) of the grass cultivars during the grazing seasons of 1999 and 2000.

1999		2000	
Date	SR	Date	SR
April – May	4.95	Apr- May	4.70
June – July	4.20	June - July	4.20
Aug - 26 Sept	4.20	Aug - 1 Oct	3.80

Animals

In 1999 and 2000, 72 and 80 respectively, spring calving holstein friesian dairy cows were blocked into groups of four. Each animal was randomly assigned to a grass cultivar treatment. Treatments were applied for 168 days in 1999 (April 12 to September 26) and 161 days in 2000 (April 24 to October 01). The trial start date was delayed in 2000 due to poor spring grass growth. In 1999 and 2000, treatment group size was 18 and 20, respectively. In both years prior to experiment start up, the animals grazed the experimental area and were supplemented with 5 - 6kg concentrate per cow/day during this grazing period.

Grazing Management

Rotational grazing management as described by (Dillon *et al.*, 1995) was applied. Individual paddock residency time ranged from 2 to 2.5 days in both years. Grass supply was monitored weekly by completion of a farm grass cover (O' Donovan, 2000). Grass supply was considered to be in excess when supply exceeded 280 kg DM/cow. When a similar surplus occurred in each cultivar, grass was harvested as round bale silage. This occurred on May 5th and July 7th in 1999, and May 8th in 2000. When a grass surplus was not common across cultivars, non-experimental dairy cows were used to graze the surplus, this was recorded as 'extra cow grazing days' for each cultivar. A total of 1.06 ha and 0.89 ha per treatment was conserved as round bale silage in 1999 and 2000, respectively.

A soil moisture deficit occurred in mid July and extended into mid August (1999), during which all treatments were supplemented with silage and concentrate. Each paddock was mechanically topped or cut as round bale silage once in 1999. In 2000, only three paddocks were mechanically topped, with a further 2 paddocks from each treatment harvested as round bale silage. Rotation lengths in 1999 averaged 24 days from mid April to late June, 17 days for July and 23 days from August to late September. In 2000, rotation lengths averaged 19 days from late April to mid July and 23 days from mid July to late September. In both years the first application of nitrogen, (granular urea) was in early January, at a rate of 57 kg N/ha. Nitrogen was applied in the form of calcium ammonium nitrate (CAN) at rates of 33 and 50 kg N/ha after each subsequent grazing for the duration of the experiment in both years. Concentrate supplementation for the experimental period averaged 1.40 and 0.28 kg/cow day in 1999 and 2000, respectively.

Results

Weather and grass production

Total rainfall (mm) for 1999 and 2000 was 973 and 1082 respectively compared to the 33 year average of 1001 mm. Duration of sunshine (hours) in 1999 and 2000 was 1184 and 1318 respectively, compared to the 33 year average of 1297 hours. Mean daily temperature (°C) for 1999 and 2000 was 10.3 and 9.9 compared to the 33 year average of 10.0 degrees. Grass production was measured in a separate experiment at the Moorepark Research Centre using the method described by Corral and Felon (1978). Total grass production averaged 15.7 and 15.5 tonnes of DM/ha in 1999 and 2000, respectively. This is compared to the average of 13.8 tonnes of DM/ha from 1982 to 2000. Therefore, total grass production was above normal in both years.

Herbage analysis

Chemical analysis of the herbage consumed during periods of intake measurement in 1999 and 2000 is shown Table 3. In 1999, during intake period 1, late heading grass cultivars had significantly higher ($P<0.05$) grass digestibility. No other chemical parameter was significant. Herbage digestibility did not differ significantly between cultivars in period 2, however grass ploidy had a significant ($P<0.05$) effect on ash content. In 2000, late heading grass cultivars were found to have a significantly ($P<0.05$) higher NDF content than intermediate heading cultivars.

Table 3. Chemical analysis of the herbage selected by the animals during intake measurements of each grass cultivar in 1999 and 2000.

	Cultivar					Significance	
	Millennium	Portstewart	Napoleon	Spelga	s.e.d	Heading date	Ploidy
	Period 1 (May 14-May 20 & June 30 – July 6) 1999						
CP (g/kg)	194.5	186.0	205.3	195.5	12.6	NS	NS
NDF (g/kg)	356.8	363.1	362.6	381.7	13.4	NS	NS
Ash (g/kg)	86.2	83.5	82.4	77.7	4.7	NS	NS
OMD (g/kg)	855.4	850.3	843.9	835.1	6.2	*	NS

	Period 2 (Sept 1 –Sept 6) 1999						
CP (g/kg)	237.1	269.2	243.0	250.2	15.0	Ns	Ns
NDF (g/kg)	379.8	376.3	369.5	378.1	7.5	Ns	Ns
Ash (g/kg)	77.6	88.5	86.2	89.2	3.5	Ns	*
OMD (g/kg)	857.3	852.8	843.9	840.5	7.7	0.08	Ns
	(July 9 –July 14) 2000						
CP (g/kg)	200.9	176.1	178.0	179.0	18.8	Ns	Ns
NDF (g/kg)	387.9	394.0	412.4	413.8	13.4	*	Ns
Ash (g/kg)	88.7	81.7	82.3	81.1	2.9	Ns	Ns
OMD (g/kg)	847.1	837.0	829.8	829.2	10.4	Ns	Ns

CP – Crude protein; NDF – Neutral detergent fibre; OMD – Organic matter digestibility

Sward Measurements

Average pre-grazing yields and pre- and post grazing sward surface heights over the 1999 and 2000 grazing seasons are outlined in Table 4. Late heading cultivars had significantly higher pre grazing herbage yields ($P<0.01$) and post grazing sward surface height ($P<0.05$) in 1999. Grass ploidy had a significant ($P<0.05$) effect on pre grazing herbage yield. Tetraploid cultivars had lower pre grazing yield. In 2000, late heading cultivars had significantly ($P<0.001$) higher pre grazing herbage mass.

Table 4. Pre-grazing herbage yields, and pre and post-grazing sward surface height for each cultivar during the 1999 and 2000 grazing season.

	Cultivar					Significance	
	Millennium	Portstewart	Napoleon	Spelga	s.e.d	Heading date	Ploidy
	1999						
Pre yield (kg DM/ha)	2243	2426	2056	2210	96.8	**	*
Pre height (cm)	19.2	19.2	19.1	18.9	0.65	NS	NS
Post height (cm)	7.27	7.53	7.13	7.21	0.01	*	Ns
Bulk density (kg DM/m^3)	1.51	1.65	1.40	1.52	0.07	*	***
Tiller density/m^2	4411	5767	4804	6106	128	***	***
Leaf content	0.65	0.57	0.61	0.63	0.02	Ns	*
Stem content	0.26	0.32	0.30	0.27	0.02	Ns	Ns
Dead content	0.09	0.11	0.08	0.10	0.01	Ns	0.064
	2000						
Pre yield kg DM/ha)	2384	2601	2235	2579	82.4	NS	***
Pre height (cm)	21.3	21.8	21.0	21.7	0.48	NS	0.07
Post height (cm)	7.81	7.78	7.41	7.82	0.15	NS	0.07
Bulk density (kg DM/m^3)	1.40	1.47	1.34	1.46	0.05	NS	***
Tiller density/m^2	4691	6519	5878	6634	0.08	0.076	***
Leaf content	0.68	0.62	0.63	0.63	0.01	*	***
Stem content	0.23	0.28	0.26	0.25	0.02	NS	NS
Dead content	0.09	0.10	0.11	0.13	0.01	*	0.072

As each cultivar has different seasonality of production, the extra DM production was measured in extra cow grazing days and higher pre-grazing DM yields. Table 5 shows the surplus of grass for each treatment removed by non-experimental cows. In 1999 late heading cultivars had substantially more cow grazing days than the intermediate heading cultivars (163 versus 61). The majority of the extra grazing days were recorded in early July and late August. In 2000, there were substantially less cow grazing days than the previous year (which was a primary reseed). The late heading cultivars recorded a higher amount of cow grazing days (56 versus 40). However, the intermediate heading cultivars recorded their extra cow grazing days in May.

Table 5. Extra cow grazing days recorded for each cultivar during 1999 and 2000 grazing seasons.

	Cultivar			
	Millenium	Portstewart	Napoleon	Spelga
	1999			
May	38	4	20	
June	12	12	28	4
July	48	52		
August	76	84		70
Total	**174**	**152**	**48**	**74**
	2000			
May			64	20
June	86	25		
July				
Total	**86**	**25**	**64**	**20**

Milk Production and milk composition

Table 6 shows the effect of grass cultivar on milk yield, milk constituents and milk composition for both years. In 1999, there was a significant ($P<0.05$) interaction between heading date and ploidy on milk yield, lactose yield and milk fat concentration. Late heading grass cultivars had significantly ($P<0.05$) higher milk fat and protein yields. In 2000, milk yield ($P<0.01$), fat yield ($P<0.05$), protein yield ($P<0.001$), lactose yield ($P<0.01$) and protein concentration ($P<0.01$) were significantly higher for late heading grass cultivars. There was no effect of grass ploidy for any milk production parameter in 1999 or 2000. Figures 1 and 2 show the milk yield, milk protein and fat yield profiles for each cultivar during the 1999 and 2000 grazing seasons.

Table 6. The effect of grass cultivar on milk production and milk composition for 1999 and 2000.

	Cultivar					**Significance**	
	Millennium	Portstewart	Napoleon	Spelga	s.e.d	Head date	Ploidy
	1999						
Milk yield (kg/cow/day)	22.9	22.3	21.2	22.1	0.27	*	NS
Fat yield (kg/cow/day)	0.87	0.87 0	.84	0.82	0.01	*	NS
Protein yield (kg/cow day)	0.74	0.74	0.69	0.72	0.01	*	NS
Lact yield (kg/cow day)	1.07	1.03	0.98	1.03	0.01	*	NS

Fat conc (g/kg)	3.83	3.93	3.96	3.77	0.05	NS	NS
Protein conc (g/kg)	3.28	3.35	3.30	3.25	0.02	NS	NS
Lact conc (g/kg)	4.66	4.62	4.63	4.62	0.01	NS	NS
	2000						
Milk yield (kg/cow/day)	21.9	21.9	20.3	20.7	0.33	**	NS
Fat yield (kg/cow/day)	0.86	0.85	0.79	0.82	0.02	*	NS
Protein yield (kg/cow/day)	0.75	0.75	0.69	0.69	0.01	***	NS
Lact yield (kg/cow/day)	1.01	1.02	0.94	0.95	0.02	**	NS
Fat conc (g/kg)	3.98	3.95	3.95	4.00	0.05	NS	NS
Protein conc (g/kg)	3.46	3.45	3.40	3.37	0.02	**	NS
Lact conc (g/kg)	4.62	4.63	4.61	4.54	0.02	0.08	NS

conc – concentration

The different levels of grass dry matter intake achieved with the grass cultivars during four different grass intake measurements is shown in Table 7. In 1999, during intake period 1, late heading cultivars had a significantly ($P<0.001$) higher total dry matter intake compared to intermediate heading cultivars (16.0 versus 14.1). The late heading tetraploid (Millennium) had a substantially higher total dry matter intake. In intake measurement 3 (autumn) there was no significant difference between grass cultivars. In 2000, only one intake measurement was completed (mid June), during which there was a significant ($P<0.05$) effect of heading date.

Table 7. The effect of grass cultivar on dry matter intake (DMI) in 1999 (3 intake runs) and 2000 (one intake run).

	Cultivar					Significance	
	Millennium	Portstewart	Napoleon	Spelga	s.e.d	Head date	Ploidy
DMI	**1999**						
May 14 (kg/cow/day)	16.7	15.3	14.0	14.1	0.66	***	NS
Jun 30 (kg/cow/day)	18.5	17.9	14.3	16.2	0.84	***	
NS Sept 1 (kg/cow/day)	17.8	16.7	18.6	17.8	0.82	0.07	0.08
	2000						
July 9 (kg/cow/day)	16.6	16.1	15.8	15.3	0.62	*	NS

Figure 1. The effect of grass cultivar on a) milk yield, b) milk protein, and c) milk fat in 1999.

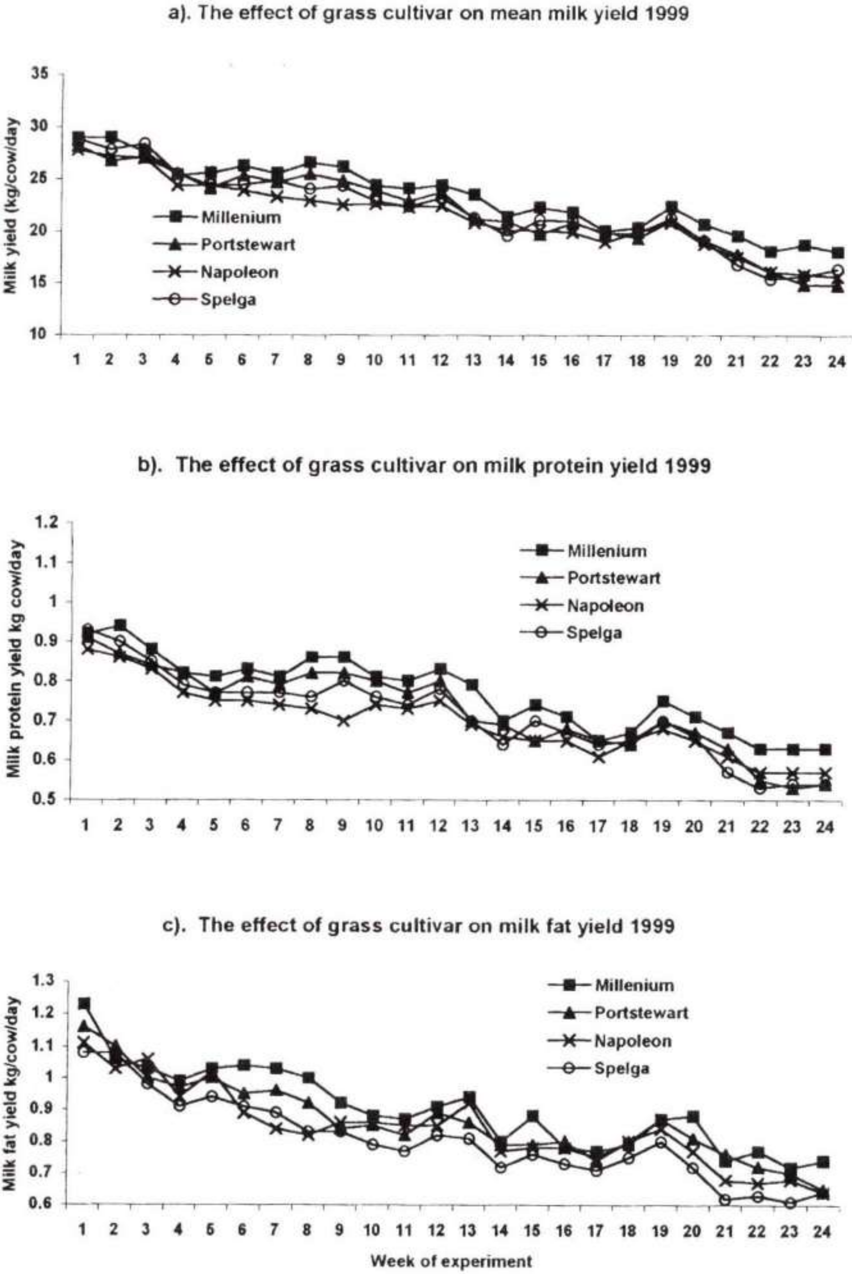

Figure 2. The effect of grass cultivar on a) milk yield, b) milk protein, and c) milk fat in 2000.

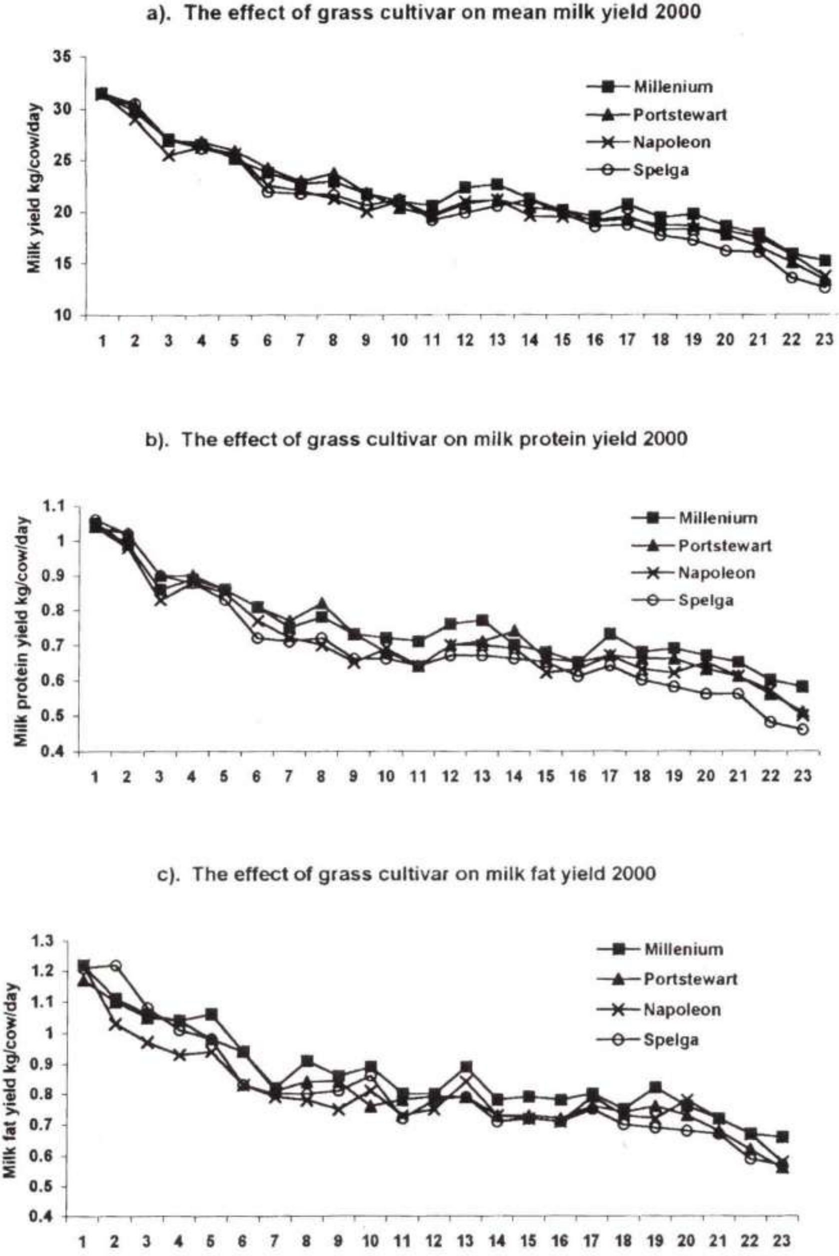

Table 8 shows the effect of treatment on live weight and body condition score for 1999 and 2000. Cows grazing intermediate heading cultivars had a significantly ($P<0.01$) higher bodyweight in 1999. However in 2000, cows grazing tetraploid cultivars had a significantly ($P<0.01$) higher bodyweight, whilst those grazing diploid cultivars had a significantly ($P<0.001$) higher body condition score.

Table 8. The effect of grass cultivar on live weight and body condition score in 1999 and 2000

	Cultivar					Significance	
	Millenium	Portstewart	Napoleon	Spelga	s.e.d.	Head date	Ploidy
	1999						
Live weight (kg)	506.7	503.2	510.6	512.7	3.16	**	NS
Condition Score	2.97	2.84	2.92	2.89	0.03	NS	**
	2000						
Live weight (kg)	539.5	533.5	538.0	534.3	2.34	NS	**
Condition Score	2.87	2.89	2.94	2.93	0.02	***	NS

Conclusions

Milk production

In 1999, there was a significant ($P<0.05$) interaction between heading date and grass ploidy for milk yield, lactose yield and fat concentration. The main source of this interaction was the reduction in milk yield on Napoleon (intermediate, tetraploid) compared to Millennium (late, tetraploid) swards, especially during rotations 2 and 3 (coinciding with the cultivars heading date). In rotation 2 and 3 the difference in milk yield between both cultivars was 1.3 and 2.8 kg milk/cow/day, respectively. In 2000, the cows grazing late heading grass cultivars had a significantly ($P<0.01$) higher milk yield. The reduction in milk yield was again most pronounced during rotation 3. The difference in milk yield between late heading and intermediate heading grass cultivars was 1.4 kg milk/cow/day. Figures 1 and 2 clearly illustrate the reduction in milk yield between the grass cultivars at their time of heading. The results of this study is consistent with Gately (1984). Grass ploidy had no significant effect on any milk production parameter in this study, which is in contrast to other experiments. Previously (Hageman *et al.*, 1993) obtained promising results from experiments comparing diploid and tetraploid cultivars of perennial ryegrass. (Castle and Watson, 1971., Vipond *et al.*, 1993) found tetraploid perennial ryegrass cultivars superior to diploid cultivars in terms of animal performance. The poor performance of Napoleon in both years of the trial however may have reduced the impact of tetraploids in this study. In both years late heading grass cultivars had significantly higher milk protein and lactose yield. They also had significantly higher fat yield ($P<0.001$) and protein concentration ($P<0.01$) in 2000 compared to intermediate heading cultivars. The trend for milk protein yield was similar to that for milk yield. The late heading grass cultivars had continually higher milk protein yield during the main grazing season i.e. rotations 2, 3 and 4.

Dry matter intake (DMI)

Previously Hageman *et a.,l* (1990), and Lantinga and Groot (1996) both found higher grass DMI with tetraploid cultivars. However, in this study there was no significant difference in DMI between tetraploid and diploid cultivars. Whilst late heading cultivars had superior DMI relative to intermediate heading cultivars in all but one intake measurement, intermediate heading cultivars had a higher DMI during the autumn measurement period. The reduced DMI of intermediate heading cultivars early in the grazing season would suggest that the (heading) inflorescence period is antagonistic to high DMI (Greenhalgh, 1966). High pre-grazing sward surface heights and low leaf to stem ratios during this period decreases grass dry matter intake. Hodgson (1982) concluded that tall swards were more prehensible, but conceded that the presence of leaf sheath in the grazed horizon may contribute to or cause a decline in herbage intake. Greenhalgh (1966) reported that herbage intake falls by 2.2 kg DM/cow/day between vegetative and reproductive stages, however the difference in this study was 1.9 kg DM/cow/day.

In this experiment it appears that leaf and stem content and their association with grass digestibility is an overriding feature influencing the DMI from the individual cultivars. During intake measurements I, II and IV, the late tetraploid cultivar maintained a high leaf to stem ratio, high organic mater digestibility and consequently highest DMI. The positive relationship between high leaf content and high DMI of late heading cultivars is amplified by the position of free leaf lamina lower in the grazing canopy. (O'Donovan, personal communication) suggests that the pseudostem height and lowest ligule height of intermediate cultivars is higher than in late heading cultivars. This indicates that as the cow grazes into the sward canopy there is a higher proportion of leaf material deeper in the sward especially at low post grazing height. Quantifying the height and proportion of free leaf lamina within the sward profile and also the pseudostem and lowest ligule height (which is mainly composed of ligin) within the sward could lead to a better understanding of apparent DM intake differences between grass cultivars.

Sward structure and digestibility

Digestibility differences in grazed swards are most often associated with changes in sward structure such as height, distribution of leaf material, sheath or dead material. The intake of green leaves is greater than the intake of stems even at the same digestibility (Laredo and Minson, 1975). Therefore a sward supporting a high green leaf mass supports high dry matter intake (Parga *et al*, 2000). It is clear that green leaf content is directly related to digestibility. A 5.5 percentage unit change in leaf content is equal to a 1 unit change in digestibility (Stakelum and O'Donovan, 2000). The higher grass digestibility's recorded by the late heading cultivars during both initial intake periods in 1999 is mainly due to the proportion of live leaf available in the sward. The largest difference in live leaf content takes place between the cultivars at their time of heading. Post heading, when the swards reach their vegetative stage, the differences in digestibility are relatively small. It is clear that cultivars with an even DM distribution of grass production (late heading cultivars) may produce more live leaf than cultivars which concentrate their production in early summer.

Tiller density

Diploid cultivars had a significantly higher tiller density compared to tetraploid cultivars in both years of the study (22% higher in 1999, 25% higher in 2000). In general tetraploid cultivars are less persistent than diploid cultivars. This is reflected in a more open sward attenuated by tetraploids having fewer but larger tillers.

Conclusions and implications

The study shows clearly the milk production advantage to using late heading grass cultivars compared to intermediate heading cultivars. Therefore, the use of late heading cultivars in intensive grazing systems is recommended.

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The impact of grazing management on improving milk solids production

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Introduction

The information presented here is derived from a number of monitor farms, which are part of a Joint programme between Carbery Milk Products and Teagasc. Carbery Milk Products is the processing arm of the four West Cork Co-ops; Bandon, Barryroe, Drinagh and Lisavaird.

In looking at milk solids production, the main focus should be on protein, as this is not constrained by quota. However, increasing milk protein is only one of several ways of increasing the value of milk output from a farm in a quota situation. The impact of grazing management on milk protein production can be considered under four headings: Topping, Grass Allocation, Leader-Follower system and Overgrazing.

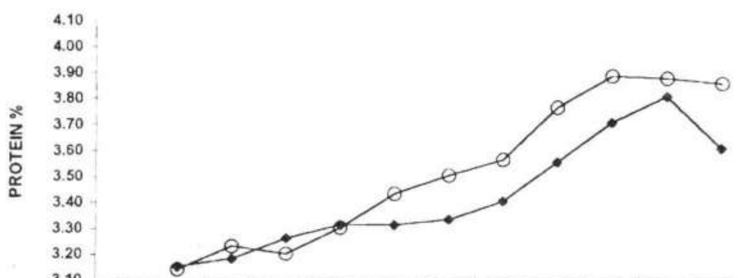
Topping

It is the view of the author that topping should always err on the side of undergrazing. It is accepted that there will be some wastage of grass in this way, but the cost of this wastage is small relative to the benefit in cow performance. There is little point in topping in order to have the field looking nice for the neighbours. If you are going to top anyway, get the benefit from the cow performance by erring on the side of undergrazing.

Figure 1 illustrates the protein graphs for Farms A and D. Farm A achieves a minimum of +0.05 increase per month after March each year. This contrasts with the typical spring calving protein profile, which we see for Farm D. Farm A is topping after most rotations. Herd performance is not hit on the current rotation and the quality of grass is always excellent on the next rotation, because if anything, grazing is always to a height greater than 6 cms.

Provided there is a topper on the farm, then in practise the cost of topping is mainly the man-hours involved. It is contended that for the farm mentioned here the opportunity cost of the labour was small, and that the farmer's time was well spent by doing the topping. Obviously at some point topping does become unprofitable.

Farm A 3.48% Farm D 3.38%



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A		3.14	3.23	3.20	3.30	3.43	3.50	3.56	3.76	3.88	3.87	3.85
D		3.15	3.18	3.26	3.31	3.31	3.33	3.40	3.55	3.70	3.80	3.60

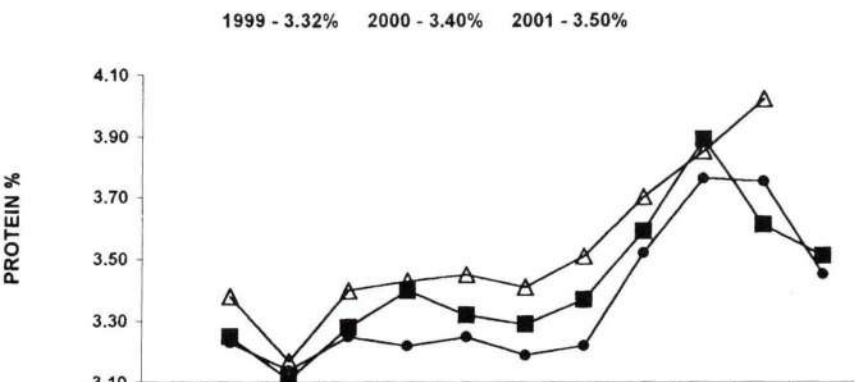
Figure 1. Milk protein profile (2001) for Farms A and D involved in the Joint programme between Carbery Milk Products and Teagasc

Grass Allocation

It can be argued that the strip-wire as a method of grazing should be banned when there is plenty of grass on the farm. If it is accepted that grazed grass is the cheapest source of dry matter we can produce, then the objective must be to get as much as of this product, as possible, into the cow **each milking**. Surely the cow is the best judge of how much grass she will eat between each milking? If this is so, then she should be allowed to make that decision as often as possible. Allocate the herd sufficient grass for up to three milkings at a time. This way the herd is only restricted in grass intake once every day and a half. The added bonus is less time and effort shifting strip-wires.

Figure 2 shows for Farm B the change in milk protein over three years. Note the dramatic difference in protein between May 1999 and May 2000. In late April 2000, this farm began allocating grass for up to four milkings at a time. There was no other significant change in either the management or the herd in 2000 over 1999. The improvement in milk protein was 0.08. From the graph it can be seen that there was an issue regarding grass quality during the mid-season 2000, as there had been each previous mid-season. In 2001 a regime of topping after each grazing was put in place, which helped to correct this mid-season grass quality issue. Milk protein increased a further 0.10. The challenge now is how to achieve this same effect more cost effectively?

Figure 2. Milk protein profile from 1999 to 2001 for Farm B involved in the Joint programme between Carbery Milk Products and Teagasc



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01-Prt		3.38	3.17	3.40	3.43	3.45	3.41	3.51	3.70	3.85	4.02	
00-Prt		3.25	3.11	3.28	3.40	3.32	3.29	3.37	3.59	3.89	3.61	3.51
99-Prt		3.23	3.14	3.25	3.22	3.25	3.19	3.22	3.52	3.76	3.75	3.45

Leader - Follower Grazing

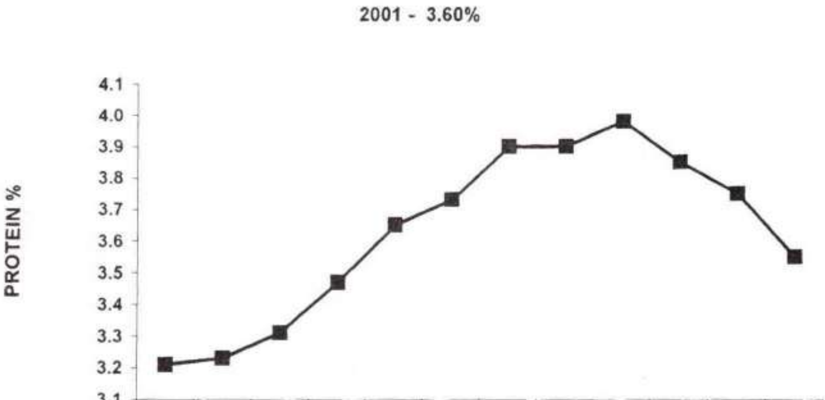
Anyone currently grazing drystock on land that could be grazed by milking cows should assess the possibility for a leader-follower cow system. Figure 3 shows the protein percentage for a split autumn / spring calving herd. This farm is achieving exceptional protein levels and averaged 3.60% protein for 2001.

In a leader-follower system, the followers need to be at least 30% of the L.U. of the cows to derive benefits from the system. The demand for grass from the drystock followers decides when the cows move on from the paddock. The higher the cover the cows are leaving behind, the higher the quality of material they will have grazed. Well-laid out paddocks with good access and entrances make operating this system non-labour intensive. Some labour can be saved due to the reduced need for topping.

Ideally all stock should be in and out of the paddock in three days (i.e. three milkings for cows and then 36 hours, the equivalent of three milkings, for the drystock). If all the paddocks are the same size it simplifies the system.

Based on visual estimates, performance of the followers (drystock) is not compromised. In fact it maybe that grass quality is higher because they are on cow ground. This system is a compromise between grazing hard and immediately affecting cow performance, or grazing laxly and affecting grass quality and therefore subsequent performance.

Figure 3. Milk protein profile (2001) for Farm C involved in the Joint programme between Carbery Milk Products and Teagasc



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prt %	3.21	3.23	3.31	3.47	3.65	3.73	3.90	3.90	3.98	3.85	3.75	3.55

Overgrazing

Despite guidelines from Moorepark re. grazing recommendations, there is considerable confusion as to what a field grazed to 6 cm looks like during the different months of the year. Arguably, on some farms we are erring on the side of overgrazing.

The following farm is typical of an overgrazing scenario. Ironically the same situation occurs on a farm where grass quality deteriorates midseason. The quality of the grass on this farm in front of the cows is always excellent. However this quality is not being exploited to the maximum. Figure 1 shows the milk protein production for 2001 for Farm D. This farm has improved its solids production since 1998. However the target of increasing protein percentage by a minimum of 0.05 each month from March is not being achieved. The high volume milk months from April to August are showing too flat a protein curve. These are the months that even a small improvement in milk composition can yield significant milk cheque increases.

Conclusion

At farm level, grazing management can have a significant impact on milk solids production. Regular topping and a 36-hour grass allocation have a positive effect on milk composition. Running milking cows as the leaders in a leader-follower system also has a positive effect. Each of the farms profiled have increased farm profitability. Increasing milk composition is a clear objective and the results are easily identified. However, it may not increase profit if it is achieved through increased costs. The overall cost benefit of the grazing management methods mentioned here will vary from farm to farm. The decision to use any of them should be based on their effect on your farm profitability not just milk solids production.

Acknowledgment

The author is indebted to the farmers involved for allowing the use of data collected from their farms.

Dairy cow improvements using selection and crossbreeding

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Introduction

Genetic *change* is readily obtained by the selection of individuals, strains or breeds with performance that differs from average. In contrast, genetic *improvement* is more difficult to achieve – it requires a balance of genetic change in favourable characteristics without simultaneous erosion in others - this does not typically come about by chance – but from careful analysis of the impacts of the likely genetic change in the context of the whole farm system.

Farmers have been the architects of genetic change far more often than the beneficiaries of genetic improvement. They have for example, changed breeds or strains without careful consideration of consequences from a whole farm perspective. This paper introduces a systematic approach to animal improvement.

Determination of the Goal

The first step in the logical development of an improvement programme is definition of the goal. Suppose the selection or breeding goal is to improve farm profitability. Livestock Improvement, an artificial breeding company in New Zealand, summarises this thinking in one of its advertising campaigns, "if you are not breeding for profit, we wish you well in your hobby".

Defining the Selection Objective

A selection objective cannot be developed until the goal has been clearly defined. The selection objective can then be developed in a two-step procedure. First, the list of traits that influence the goal must be identified. This is usually a straightforward task. Second, the relative emphasis that should be placed on each trait in the list must be determined. This is a difficult task in practice, due to the complexity of the farming system and the predictive nature of future circumstances. Many of the disappointments that have been experienced by farmers that have changed breeds or strains may have been avoided if those individuals had given careful, comprehensive prior thought to their selection objective in the context of their farm system.

The construction of a selection objective can be simplified by partitioning the problem into manageable pieces. Given a profit-based goal, and recalling the obvious definition of profit as income less expenses, the objective should include all traits that influence income and all traits that influence costs. The income traits include those influencing milk revenue and beef revenue. The cost traits might include those that influence feed costs, reproductive costs, replacement costs and animal health costs. Fixed costs such as rates, or accounting need not be included as these apply to the farm business rather than the individual animals.

The systematic approach quantifies the economic impact of the traits in the list, before consideration of the availability of information on individual cows and bulls for each trait in the list. This calculation needs to be undertaken for each trait in the list one at a time, and must consider the impact on profit of a unit change in the trait with all other traits in the list being held constant. The calculation can be undertaken using a partial budget of the farming system. Bear in mind that due to the time delays between ranking parents and the milking of the resultant offspring, it is the *future* economic and management circumstances that must be considered in this partial budget exercise.

In practice, a common error has been to discard many traits (such as fertility) from further consideration at this stage, due to the absence of information allowing animals to be ranked. One could easily reduce the list to including only those traits influencing milk revenue, such as milk volume and concentrations of fat and protein. This leads to undue focus on per head milk income, and ignores feed costs, body size and fertility. Accordingly, farmers may be tempted to alter their milking strain solely on the basis of per head income without due account for changes in feed costs, stocking rates, reproductive costs and replacement rates. Such an oversight was one of the main factors responsible for the rapid Holsteinisation of international dairying.

Including milk volume and composition traits in the selection objective

One approach to determining future milk payment is based on the current industry payment system. This might be appropriate in a perfect market system but few markets are perfect. In New Zealand, farmers have been paid the average international market returns of their dairy products, less the processing, marketing and transport costs. Payment has been partitioned according to an assessment of the relative contributions of fat and protein. In respect to the value of fat in the form of butter, the actual market realisation often varies markedly according to the product destination. Some butter is sold at high prices whereas the remainder may be sold at prices below the cost of production. The market signals based on these average returns do not reflect the real market circumstances. Rewarding farmers for fat sold below its marginal cost does not make long-term economic sense.

A more informed approach to value future milk is to model the collection and processing of milk and the marketing of dairy products in order to derive the true value of milk from the expected market realisation of the resultant products, less manufacturing, marketing and transport costs. The value of milk assessed in this manner is shown in Table 1. More details on this topic are in Garrick & Lopez-Villalobos (2000).

Table 1. The value of milk (EUR/litre) of average composition and from Holstein (H), Holstein-Friesian (HF), Jersey (J), crossbred (XB) and Ayrshire (A) breeds when 10% or 70% milk is processed as a fluid product and the residual is processed into cheese, or a mixture of cheese, whole milk powder, skim milk powder, casein & butter.

Product Mix		**Milk Source**					
Fluid	Residual	Average	H	HF	J	XB	A
10%	Cheese	0.21	0.19	0.20	0.24	0.21	0.21
10%	Mix	0.23	0.21	0.23	0.26	0.24	0.23
70%	Cheese	0.39	0.38	0.39	0.40	0.39	0.39
70%	WMP-Cheese	0.39	0.39	0.39	0.40	0.40	0.39

Table 1 shows that the value of the milk varies markedly depending upon the breed it comes from (i.e. its composition) and the product mix for which the milk is used. Milk has its greatest value when used for fluid supply. The difference in value between milk of different breeds is greatest when most of the milk is processed rather than sold in standardised fluid form.

The marginal value of each milk component can be calculated from the true value of milk, accounting for the average composition of the milk supplied and the product mix for which the milk will be used. Some milk payment systems based on milk-solids or yields of fat and protein less volume-related costs are shown in Table 2 for a subset of the circumstances in Table 1.

Table 2. A milk-solids (EUR/kg) and multi component payment systems for fat, protein and volume of milk from Holstein (H), Holstein-Friesian (HF), Jersey (J) and crossbred (XB) cows when 10% is used for fluid milk and the residual processed into a comprehensive mix (Row 2 Table 1) or 70% fluid and residual into whole milk powder and cheese (Row 4 Table 1).

			Multi-component payment		
Market	Breed	Milk-solids	Fat	Protein	Volume
10%	H	3.15	1.20	6.17	-0.03
70%	H	5.83	0.65	12.04	-0.02
10%	HF	2.90	1.45	5.62	-0.03
70%	HF	5.05	2.36	9.03	-0.02
10%	J	2.65	1.33	5.26	-0.03
70%	J	4.10	2.14	7.39	-0.02
10% X	B	2.81	1.40	5.50	-0.03
70% X	B	4.67	2.29	8.47	-0.02

The results in Table 2 show that the value of milk-solids varies with the breed (i.e. milk composition) and the product mix. Even when 70% milk is used for fluid sales, a yield based payment system would be characterised with a small volume charge. The fat to protein relativity varies with the milk composition and product mix. Note in Table 2 that for a given product mix the value to a processor of marginal components such as fat or protein depends upon the nature of the milk provided by other suppliers.

Farmers need to appreciate that the calculation of milk value is not trivial. Ideally, the assessment of milk value and the value of its components should not be based on the current market circumstances, but an informed analysis that accounts for future expectations in terms of milk supply, its composition, resultant products and consumer demands.

Cow size as an objective trait

In comparing dairy breeds such as Jerseys, Friesians, Holstein-Friesians and Holsteins, farmers have noted the larger strains tend to produce more milk. Farmers have also identified the fact that within a breed or strain, larger cows tend to produce greater volumes. Some farmers may therefore have deliberately selected for cow size, in order to improve production. Given a goal of income per cow, larger cows would be an advantage. However, given a goal of profit per farm (or per unit of land or unit of feed) the implications of selection including the size of cow needs to be carefully considered.

Suppose mature cow size and production is known for a strain of cows. A feed and financial budget can be undertaken to determine the likely physical and economic performance of such a farm system (Garrick 1996). The resultant economic information can then be used to determine the worth of any cow given knowledge of her likely performance with respect to each of the traits in the objective.

Consider a simple calculation to demonstrate this thinking. Suppose a herd of cows produce an average of 200 kg fat, 183 kg protein, 5500 kg of milk and weigh 500 kg. From the viewpoint of animal improvement, the actual profitability of this herd is of no particular interest. What really matters is the extent to which profit changes when herd performance is modified.

Suppose fat production increased by 1 kg, all other factors unchanged. The milk revenue would increase by the value of 1 kg fat. In addition, the feed requirements would increase. Assuming it requires 56 MJ ME (metabolisable energy) to produce 1 kg fat, an animal fed pasture would require almost 6 kg DM (dry matter) to produce the additional fat. The economic value for a unit increase in fat would therefore be the income from the extra fat less the cost of supplying about 6 kg DM. The cost of supplying the DM could be obtained from the cost of purchased feed, or from the *opportunity* cost of DM in the production system. Suppose the fat price was €1.00 per kg, DM opportunity cost was €0.15 per kg, the economic value for fat would be 1.00 – 6 x 0.15 = €0.10. That is profit would increase by €0.10 for a unit increase in fat, all other traits held constant. A similar approach can be used to obtain an economic value for protein and for milk volume.

Suppose the mature live-weight of the cows was increased by 1 kg. This would increase the maintenance feed requirements and the beef revenue and may be associated with an increase in lactation production. It is not necessary to calculate the value of extra milk production, (as shown in the previous paragraph) if milk yield traits are included in the list of traits in their own right. To determine the value of cow size, only the beef revenue and feed costs need be assessed. The aggregate worth of an individual animal, strain or breed, will then be obtained using the assessed performance for each trait in the objective along with its associated economic value.

Assuming a 49% dressing out percentage and a beef price of €3 per kg carcass, the beef revenue would increase by 3 x 0.49 = €1.47 per kg live-weight. However, if the average cow has five lactations, only 1/5 of the herd will have a salvage value each year. Accordingly, the beef revenue component of the live-weight increase is 1/5 x 1.47 = €0.29. The maintenance feed costs of a cow on an annual basis is about 231 MJ ME per $kg^{0.75}$. Assuming a ME concentration of 10.8 MJ ME per kg DM, a 500 kg cow requires $(231 \times 500^{0.75})/10.8 = 2261.6$ kg maintenance and a 501 kg cow requires 2265.0, an increase of about $3^{1/2}$ kg DM. The value of cow size is therefore €0.29 less the cost of $3^{1/2}$ kg DM. Assuming the DM cost €0.15 per kg, the value of cow size is $0.29 - 3^{1/2} \times 0.15 = -$ €0.24. That is, the profit erodes by €0.24 for a unit increase in live-weight, other traits held constant.

Combining the above results it is apparent that a 1 kg heavier cow would need to produce an extra 0.24/0.10 = 2.4 kg fat to have the same profit as the lighter cow, given the assumed feed costs, milk fat and beef prices.

The values of fertility and longevity

The economic values of longevity and fertility are much more difficult to calculate compared to lactation yields or live-weight. Modifications to longevity can alter the age structure of the herd, which will in turn alter its productivity and its feed requirements as younger cows and very old cows produce less than mature equivalent cows. Longevity can also influence the number of replacements required, therefore modifying beef revenue, AI and feed costs. It also affects the level of voluntary and involuntary culling, therefore modifying salvage beef returns and the influence of culling on production.

Changes to fertility will influence longevity, in addition to modifying the calving distribution of the herd, which will influence milk production and AI costs with carryover effects for a number of years. In contrast to measures of lactation yield, there are no universally accepted methods of describing fertility or longevity. The economic values for these traits are also sensitive to the average levels of performance. Economic values are higher in seasonal calving than in continuous calving herds. In herds with high reproductive performance, fertility is less important than in herds that are struggling to obtain sufficient AI-bred early born heifer replacements.

The NZ selection objective

The development of a selection objective for dairy cattle in New Zealand has been rapidly developing and further changes are likely. The original selection objective was based solely on milk-fat yield and the index was Fat BI (Breeding Index). In 1986, the objective was modified to reflect milk payment, by the addition of milk volume and protein yield. The resulting *a+b-c* index was known as *Payment BI* and was really an income rather than a profit index. In 1991, an index known as *Total BI* was developed to include live-weight and survival information. It was not until 1996 that the feed costs for lactation traits were introduced to the index. At that time, the indexing went across breeds and was renamed *Breeding Worth* (BW).

The index is currently being revised to directly include fertility and will likely involve the lactation yields of milk volume, fat and protein, mature live-weight, functional longevity (days of productive life adjusted for lactation yield) and fertility. The economic values are updated annually and the most recent update (excluding fertility) is in Table 3 (www.aeu.org.nz). The principle behind the calculation of these weights is as discussed in this paper, although the derivation is much more involved to account for future prices and costs, to discount traits based on the timing and numbers of expressions and to account for the calving distribution and age structure of the herd.

Table 3. Economic values and traits in the NZ selection objective

Trait	Milk-fat (kg)	Protein (kg)	Volume (litres)	Live-weight (kg)	Longevity (days)
Economic Value	1.23	5.97	-0.07	-0.92	0.03

It is worth noting that type traits such as udder scores are not explicitly included in the selection objective, as these do not directly influence income or costs. Scores for all the recorded traits other than production (TOP) are used along with other information to predict the remaining life of cows that are currently still alive in the national herd – the influence of these traits is therefore through their impact on longevity. However, type scores may also be the basis of independent culling, regardless of BW.

Concurrent changes in cow size and production

Analysis of the economic trade-off between cow size and lactation yields using the weights in Table 3 demonstrates that a 1 kg heavier cow would need to produce an additional 0.92/1.23 = 0.75 kg fat or 0.92/5.97 = 0.15 kg protein to have the same profit as a lighter cow. If, as a consequence of being heavier, the production increase is greater than 0.75 kg fat or 0.15 kg protein, the heavier cow will be more profitable and will be favoured in index selection.

This approach to valuing the worth of cows neither favours nor discriminates large or small cows specifically. Rather it values their production while accounting for their costs of production. Larger cows or strains will be rewarded if their extra productivity more than pays for their increased maintenance.

A consequence of these tradeoffs between size and production is that there exists large efficient dairy cattle and small efficient dairy cattle. Inspection of the bull evaluations in terms of their BW index and their live-weight EBV will quickly confirm this finding. A consequence of this fact is that if the goal is to improve economic efficiency (defined as profit) it is better to select for profit than to select on indirect indicators such as cow size. This is particularly true when selection is across breeds or strains of cows.

Industry determinants of within-breed rate of improvement

The dairy industry is often held up as a glowing example of a livestock industry with a high rate of annual genetic progress relative to say beef cattle or sheep industries. Most dairy farmers probably pat themselves on their backs when they hear such comment. However, in considering the people that control the nature and direction of industry progress, it turns out that farmers have little direct influence.

Dairy improvement programmes in use today are, at best, fine-tuned examples of a scheme that was researched and communicated some 50 years ago. The rate of progress achieved in the scheme is determined by the ages of the animals and the selection practices that exist in the four so-called pathways of selection. The scheme involves two conceptual populations – one for breeding replacement bulls and the other for breeding replacement cows. The pathways represent the selection of bull fathers, bull mothers, cow fathers and cow mothers. The number of young bulls that are progeny tested, the number of graduate sires required and the number of progeny per bull are major determinants of both the rate of gain and the cost of the breeding scheme.

Farmers choose the cows they will use to produce replacements. However, in the absence of yearling AI, the opportunity to select among cows is negligible when one accounts for the sex ratio, calf losses and the calving spread. Farmers choose the bulls they will mate to their cows to produce replacements, but this is only among the bulls the AB company has chosen to make available to them.

The AB companies choose the bulls they will use to produce sons, and the elite cows they would like to mate with these bulls. Farmers of course decide whether to accept such contract matings. About five years later, the AB company chooses among the bulls graduating the progeny test to determine those that will be made available to the farmer. Thus three of the four pathways are controlled by the AB company rather than the farmer. The path the farmer controls is the one with the least impact on industry gain.

The primary basis for selection in the three pathways controlled by two major NZ AB companies is BW using weights such as presented in Table 3. The within-breed response to this selection on BW, accounting for the four pathways of selection, is an annual increase of about 1.5 kg fat/cow, 1.6 kg protein/cow, 23 litres volume/cow and a negligible change in live-weight. Note that the response in the component traits is determined by the genetic relationships between the traits as well as their economic values. Despite a negative economic value for volume, it increases as a result of selection. Further, the negative economic value for live-weight does not result in cows getting smaller.

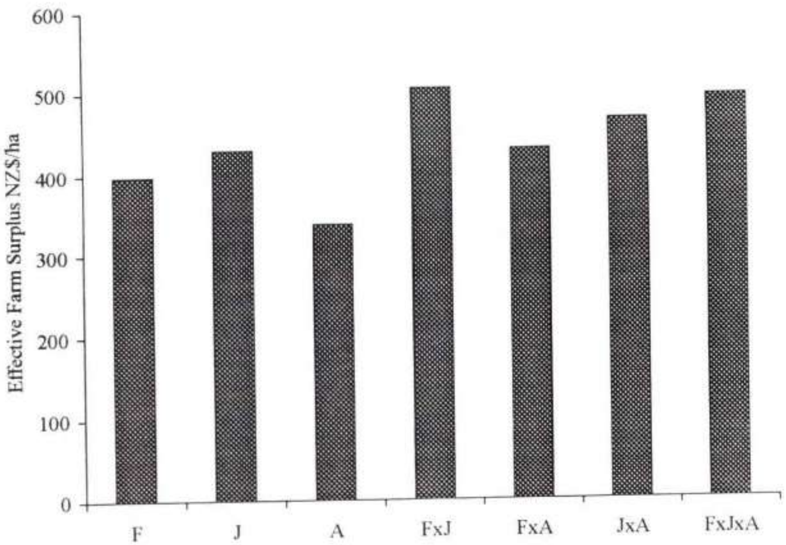
This four pathway co-operative scheme will continue to be successful providing a significant proportion of farmers herd test (allowing identification of prospective bull mothers), use AI (providing linkages between herds and cash flow to the AB company to pay for the progeny testing) and relinquish sons from elite matings for subsequent progeny test.

Strain comparison and selection among strains

The previous section argued farmers have relatively little impact on the annual rate of progress provided they continue herd-testing and purchasing semen from their respective breeds/AB companies. In contrast, farmers can have enormous impact on genetic progress and AB company business by their choice of breed/strain/AB company. In some countries farmers have changed strain (e.g. to Holstein) eroding the semen revenue of their existing AB companies. In extreme cases, AB companies may have been forced out of business. From the perspective of the farmer, such quantum genetic change is highly desirable if it results in progress towards their goal. However, genetic improvement may not result if proper account has not been considered for the effects on all the traits (particularly feed costs and fertility) in the selection objective.

Given a sound selection objective and knowledge of breed and heterotic effects, it is possible to make objective comparison among existing and new strains of dairy cattle. In NZ production, management and economic circumstances, such analysis (Figure 1, from Lopez-Villalobos *et al.*, 2000) shows that farming systems using crossbred cattle are more profitable than purebred Holstein-Friesian (F), Jersey (J) or Ayrshire (A) systems.

Figure 1. Profitabilities of straight-breeding and some cross-breeding systems.



However, with respect to individual bulls or cows there is enormous overlap between strains. A list of the most profitable bulls will likely include Jerseys, Holstein-Friesian and Holstein representatives and these strains will also be represented in the list of least profitable bulls. In such circumstances, uninformed breed change is unlikely to guarantee an increase in farm profitability.

Summary

Animal improvement schemes in practice are all about compromise. In selection, there needs to be compromise between the progress in individual traits that contribute to the objective, and compromise in terms of the rate of progress in relation to the cost of the progress. In comparing strains or breeds there is never a perfect animal - some attributes will normally be enhanced whereas others will be eroded. Such compromises must be quantified in order to provide *informed* decision among alternatives.

A systematic approach to making informed decisions about dairy cattle selection and strain choice begins with the definition of a goal, followed by the construction of a selection objective. The objective includes a list of traits that influence the goal and the relative emphasis that should be attributed to each trait in the list. The calculation of relative emphasis should account for future production, economic and management circumstances including the manner in which milk sales will be rewarded.

Dairy farmers are part of an integrative business that requires many skills to achieve repeated success. It is important that dairy farmers and other players in the dairy industry work together with animal breeders and animal recording agencies if they are to be early exploiters of new opportunities while avoiding costly mistakes.

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Breeding objectives for a seasonal calving pasture based system of milk production

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Introduction

Milk production in Ireland is characterised by relatively low milk production per cow and low costs of production. This is primarily due to the pasture based, seasonal calving system of milk production (Dillon *et al.*, 1995). For the foreseeable future, it is envisaged that this system of milk production will pre-dominate in Ireland, making the country unique within Europe.

Irish dairy farmers have many options to breed herd replacements. In recent times, the practice has been to use semen from Holstein-Friesian dairy bulls sourced mainly abroad. However, the potential of other breeds to replace Holstein-Friesians, or crossbreeding is attracting much interest, the latter originating from the perceived lower reproductive performance and survival of to-days Holstein-Friesian dairy cow, and from questions about the suitability of Holstein-Friesian cows to Irish production systems. The objective of this paper is to investigate ways of producing dairy herd replacements that result in the highest profit under Irish milk production systems.

Irish trends in milk production and reproduction

Until the mid-1980's, the predominant dairy cow breed in Ireland was the British Friesian, which had been upgraded from the dairy Shorthorn from the late 1960's. Table 1 shows the change in the proportion of North American Holstein-Friesian genes (NAHF) in cows registered with the Holstein UK and Ireland (HUKI) from 1977 to 1998. This proportion of NAHF in bulls has increased from 10% in 1977 to 80% in 1998. Therefore in the Irish dairy cow population, replacement of the British Friesian by the NAHF has occurred at a rapid rate since the late 1980's. Average milk production per cow, for all milk recorded cows, increased from 5,400 kg in 1990 to 5,884 kg in 2000, or an increase of 19 kg per cow per year (ICBF 2000).

Table 1. Change in the proportion of Holstein-Friesian (HF) genetics in cows (by year of birth) registered with Holstein UK and Ireland (HUKI) from 1977 to 1998.

Year of Birth	Holstein %
1977	<10
1990	50
1998	80

The reproductive performance of the Irish dairy herd was accessed in a number of early surveys (Crowley *et al.*, 1967; Roche *et al.*, 1978; Cunningham *et al.*, 1978; Cunningham and O'Byrne, 1980). All of these surveys indicated a calving rate to first service in excess of 60 %, and a culling rate for infertility of less than 10%. However since these surveys, milk production per cow has almost doubled as a result of the increased genetic merit for milk production, as well as better feeding and management. A more recent survey on 32 spring calving herds showed that calving rate to first service decreased from 59% in 1991 to 54% in 1998 (Mee *et. al.*, 1998). Over this period there was a significant decline in calving rate to first service of approximately 0.9 % per year. This reduction in reproductive performance was associated with a significant increase of 108 kg in milk yield per cow per annum.

Table 2 shows the results of three long-term strain comparison studies carried out at Moorepark in recent years. The objective of these studies was to compare the biological and economic efficiency of different genotypes in seasonal grass based systems of milk production. The results show that cows with higher genetic potential for milk production and a greater proportion of NAHF genetics had reduced reproductive performance (Buckley *et al.*, 2000). As the proportion of NAHF genetics approached 100%, conception rate to first service was reduced to approximately 40%, calving to conception interval increased to > 90 days, and the proportion of cows empty at the end of the breeding season was greater than 20%.

Table 2. Studies at Moorepark (CRT = Curtins; CLY = Castlelyons) comparing milk production and reproduction from high genetic merit (HM) and medium genetic merit (MM) cows.

	CRT (96-97)		CRT (99-00)		CLY (96-00)
	HM	MM	HM	MM	HM
Proportion of Holstein-Friesian (%)	92	50	80	60	94
Milk yield (kg)	7779	6862	7841	6855	6471
Submission rate (%)	88	93	85	90	75
Pregnancy rate to 1st service (%)	41	53	48	54	37
Calving to conception Interval (days)	87	89	91	89	99
Services per cow (No)	2.1	1.8	1.9	1.8	2.8
Empty rate (%)	23	6	19	13	26

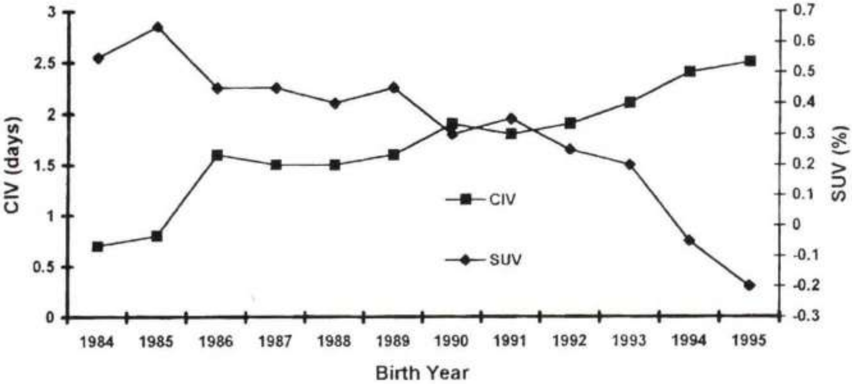
In the past three years a more comprehensive study on 74 commercial spring calving herds in the south of Ireland has been carried out (Evans *et al.*, 2002). In the first year of this study the average calving to conception interval, pregnancy rate to first service and proportion of cows conceiving in the first 200 days of the breeding season were 90 days, 48% and 87% respectively. Similar results have been obtained in the second year of the study. The pregnancy rate of 48% to first service is much lower than that found in previous studies. The average proportion of NAHF genetics of the cows in the study was 51%. This figure may be an underestimate since the proportion was calculated as 50 %* sire plus 25 %* maternal grand sire, and it was assumed that the maternal grand dam had zero NAHF.

Table 3 shows the genetic correlation between milk production and fertility traits for spring-calving Holstein-Friesian cows in Ireland, after adjusting for both milk yield and fertility for proportion of NAHF (Evans et al., 2002). The results indicate that selection for milk yield alone leads to deterioration in fertility performance.

Table 3. Genetic correlation (and standard errors) between milk production and fertility traits for spring-calving Holstein-Friesian cows in Ireland.

	Milk yield	
Trait[a]	Correlation	s.e.
Calving to first service interval (CFS)	-0.09	(0.25)
Number of services per cow (NS)	0.98	(0.35)
Pregnancy at day 42 of the breeding season (PR42)	-0.51	(0.51)
Pregnancy rate to first service (PRFS)	-0.51	(0.61)

Figure 1 shows the genetic trend for calving interval and survival for bulls born between 1984 and 1995 (Olori *et al.*, 2002). These latest results from ICBF show that in genetic terms, calving interval has increased by about 0.5 days per year for the last 6 years. Similarly survival has decreased by about 1 % the over the last 4 years.



These results confirm the international trend that a reduction in reproductive performance in the Irish dairy cow population can be ascribed to both selection for higher milk yield, and an increased proportion of NAHF genetics.

Selecting within the Holstein Friesian

(a) *Using the Economic Breeding Index (EBI)*

Selection of bulls for improved reproductive efficiency is one possible solution to the problem of reduced reproductive performance. Careful genetic selection may allow dairy producers the use of high milk production genetics from NAHF and still maintain acceptable reproductive rates. Reproductive traits have a low heritability, but the coefficient of variation of reproductive traits is very large (Philipsson, 1981; Evans *et al.*, 2002). A recent study in the Netherlands showed genetic standard deviations of 9 days, for days to first service and calving interval, 0.25 for number of services, and 5 % for conception to first service (Veerkamp *et al.*, 2001). Therefore, genetic selection for improved daughter fertility is feasible in dairy cattle. Scandinavian breeding programmes have included non-production traits (fertility, mastitis resistance etc.) in addition to production traits in their selection indices for many years (Philipsson *et al.*, 1994). Prior to 1990 the genetic trend in days open (reduced reproductive performance) was increasing, but this has now reversed. Although progress towards increase milk production is less, their models suggest that better economic efficiency is achievable when functional non-production traits are included in selection programmes.

In Ireland, the Irish Cattle Breeding Federation (ICBF) introduced a new economic breeding index (EBI) for dairy cattle breeding in Spring 2001. The new index is different to the old 'RBI' in that it contains 2 new traits (survival and calving interval) as well as 3 milk production traits (Veerkamp *et al.*, 2002). The weightings on the five traits in the new index are as follows:-

EBI (€) = -0.76* PD milk (kg) + 0.9* PD fat (kg) + 5.7* PD protein (kg) + 11.4* PD survival (%) – 2.0* PD calving interval (days)

Therefore the index indicates that increasing protein yield at farm level will improve farm profit by €5.70/kg produced. Reduced culling percentage by 1 % will increase farm profit by about €11.40 for each cow in the herd. Likewise each one-day increase on calving interval will reduce farm profit by €2.00 for each cow in the herd. In terms of relative importance of the traits, improving protein yield is the most important, followed by survival and milk yield, calving interval and fat yield. Survival and calving interval contribute almost 30 % of the weighting in the EBI index.

The EBI index was further improved in 2002, to include more information (multiple lactation data, type traits and condition score) to improve the reliability of the survival and calving interval traits. Data are also available on survival and calving interval for most imported semen. The new index has resulted in the re-ranking of many sires. The best example of this is Delta Cleitus Jabot (DCJ), which in the old RBI system was ranked No.1 in Ireland, now ranks 954 in the new EBI Index. This is mainly because of his + 8.6 days in calving interval and - 3.4 % in survival. For the spring of 2003, Irish dairy farmers should first look to the top 25 active sires ranked in EBI. If fertility and longevity is an issue for the herd, more cognisance should be placed on the survival and calving interval traits in the index. There is a selection of bulls available, which will improve survival and reduce calving interval, and simultaneously increases milk yield.

(b) *Current research within the Holstein-Friesian*

Genotype by feeding system comparison studies: A study compared 2 levels of genetic merit by 3 levels of concentrate feeding on a spring calving system of milk production over three years at Moorepark. A total of 48 high genetic merit (HM) and 48 medium genetic merit (MM) Holstein-Friesian cows were randomly assigned to the three concentrate feeding levels. The mean PD (00) for the HM and MM groups is shown in Table 4.

Table 4. Predicted difference PD (00) and (SD) for the high genetic merit (HM) and medium genetic merit (MM) cows.

	Milk (kg)	Fat (kg)	Protein (kg)	Fat (g/kg)	Protein (g/kg)	Holst (%)
HM	+276	+8.9	+9.7	-0.03	+0.01	75
	(100.1)	(4.75)	(3.19)	(0.086)	(0.035)	
MM	+81	+3.8	+4.3	+0.013	+0.031	
	(94.9)	(4.95)	(2.59)	(0.099)	(0.036)	65

All cows were first lactation animals in 1998. In May 1998, cows were grouped into blocks of three within genotype, on the basis of calving date and milk yield, and randomly assigned to one of three concentrate feeding levels. Cows remained on these feeding systems for the duration of the trial. The low concentrate (LC), medium concentrate (MC), and high concentrate (HC) feeding systems were allocated 376, 810 and 1540 kg/cow/lactation, on average over the three years. The aim was to have similar grazing management across all three concentrate feeding levels and this was successfully carried out for each of the three years of the trial.

Both genotype and concentrate feeding level had a significant effect on yield of milk, SCM, fat, protein and lactose ($P<0.001$) (Table 5). There was a significant genotype by concentrate feeding level interaction for fat yield and milk fat concentration. Regression analyses showed a significant interaction ($P<0.05$) between concentrate feeding level and Predicted Differences (PD) for milk and protein yield (as used) (Figure 2). Similarly when pre-experimental milk and milk protein yield were used as covariates, interactions approached significance (P = 0.08 for milk yield; P = 0.12 for protein yield). The differences in protein yield between the concentrate feeding systems increased as both pre-experimental protein yield and pedigree index for protein yield increased.

Figure 2. The relationship between predicted difference (PD00) for protein yield and pre-experimental protein yield on cow performance (`` JC; □ □MC; ——— HC)

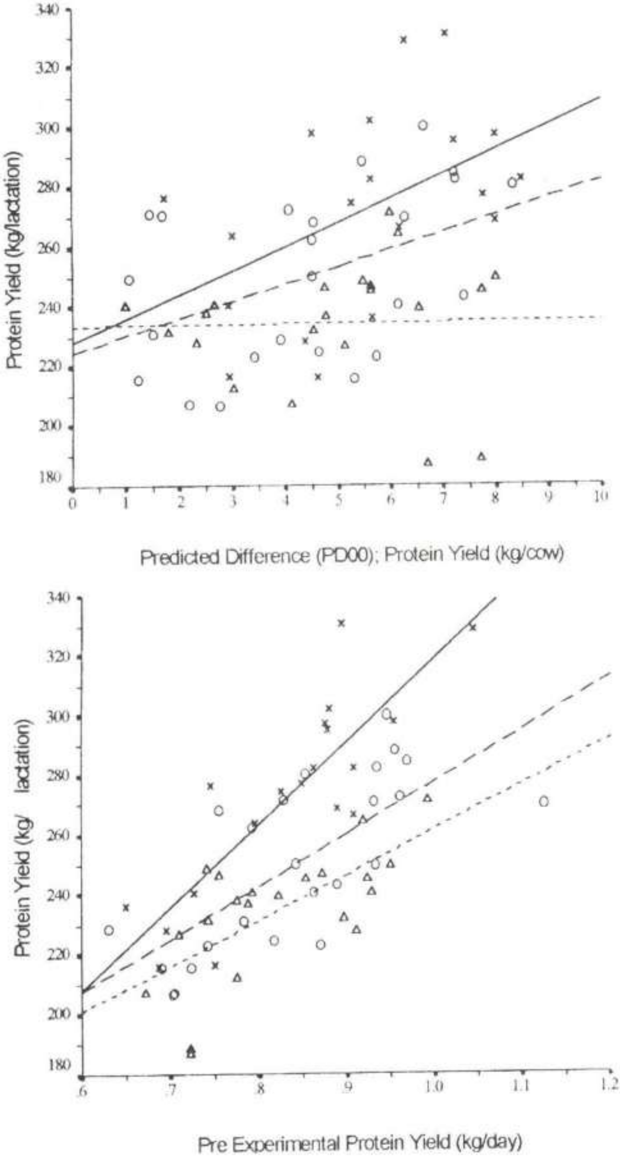
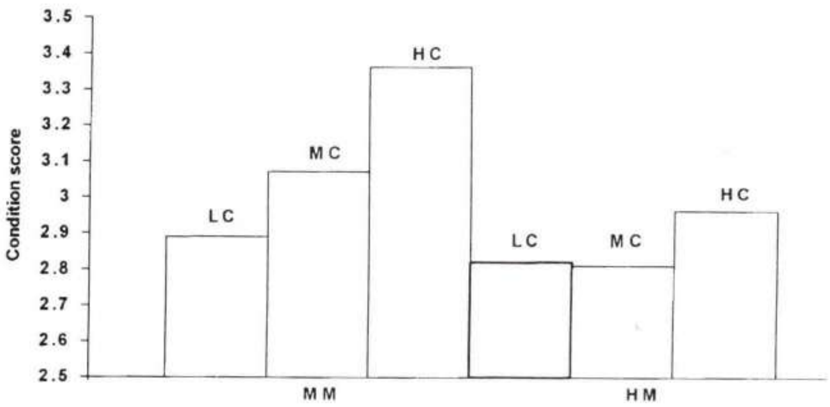


Table 5. The effect of genotype and concentrate feeding on milk production 1998 - 2000

Genotype	HM			MM						P Value
Feed	LC	MC	HC	LC	MC	HC	SE	Feed	Geno	G x F
(kg/cow)										
Milk	7389	7739	8461	6421	6681	7196	86.4	***	***	0.21
Fat	274	288	313	247	269	272	4.0	***	***	0.07
Protein	247	261	288	217	232	250	3.0	***	***	0.02
(g/kg)										
Fat	37.2	37.3	37.2	38.6	40.6	38.0	0.50	***	***	0.03
Protein	33.5	33.8	34.1	34.0	34.8	34.9	0.24	***	**	0.60

Responses to concentrate varied from 0.44 kg milk per kg of additional concentrate for cows with PD Milk of less than 100 kg, up to 1.33 kg milk for cows with PD Milk of 200 to 300 kg. The results suggest the value of increased genetic merit for milk production is much less on a low concentrate grass based system than on a high concentrate grass based system, and also that feeding additional concentrates to HM is much more beneficial. Genotype had no significant effect on live-weight, however the condition score of the medium genetic merit cows was higher at all stages of lactation. There was a significant ($P<0.05$) genotype by feeding system interaction for body condition score at the end of lactation (Figure 3). These results indicate that even in a high concentrate system the HM cows continued to direct feed towards milk production rather than repletion of body reserves.

Figure 3. The effect of genotype (HM and MM) and feeding system (LC, MC and HC) on condition score at the end of lactation.

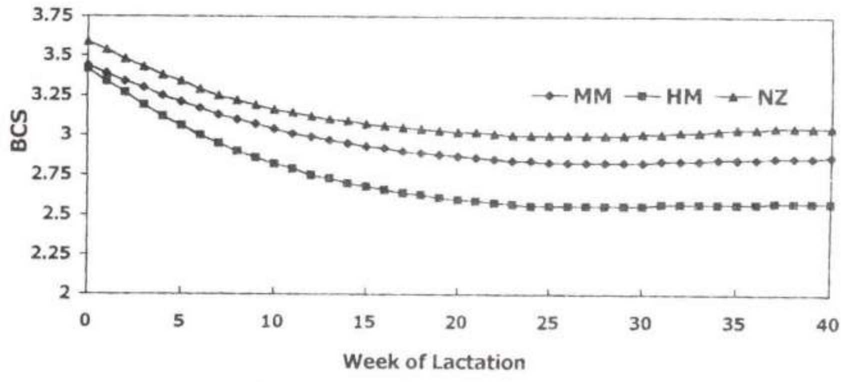


Genotype or feeding system had no significant effect on reproductive performance, however there was a tendency for poorer reproductive performance with the high genetic merit cows, especially in the third year of the trial. Cows that did not conceive to first service had greater weight loss from calving to AI and lower energy balance in the first three weeks of the breeding season.

Condition score: Because of the low heritability of fertility traits (Evans *et al.*, 2001), there is increasing interest in accruing alternative traits which may be more easily measured, possess moderate to large heritabilities and are genetically correlated with fertility. These traits will allow indirect selection for improved fertility within the HF breed. Examples of such traits include body condition score (BCS), live weight, and other type traits. BCS throughout lactation has shown moderate heritabilities (0.27 to 0.37) (Berry *et al.*, 2002), this means that 27 % to 37 % of the variation in BCS observed on Irish dairy farms is due to the genetic background of the animal. The heritability for BCS tended to be greatest when mean BCS was minimum (Day 60). BCS change in early lactation exhibited a lower heritability (0.09) but was still greater than that of all the fertility traits measured on the same data set (Evans *et al.*, 2001). Genetically superior milk producing cows tend to have genetically lower BCS and lose the most BCS in early lactation. Most recent results confirm strong and significant genetic correlation between BCS and fertility traits. There are indications that mating a sire with an EBV for BCS at calving of +0.5 BCS units, with an average cow, will result in a genetic reduction in calving interval of 1.25 days and an increase in pregnancy rate to first service of 3.7 percentage units in the subsequent progeny.

In the current trial on Curtins Farm, Moorepark, obvious different phenotypic trends in BCS have been observed between the three HF strains (Figure 4). All animals were in first lactation and were managed in a similar manner. The HM strain consists of HF cows selected intensively for increased milk yield while the MM strain animals were selected for both improved milk yield and management traits (e.g., muscularity). The NZ strain originated from embryos imported from New Zealand, and have less than 20 % NAHF genetics. The NZ strain had a significantly greater BCS throughout lactation than either of the other two HF strains. Although the difference between the HM and the MM were not significantly different at first calving, significant difference did arise at Week 40, with the MM having significantly higher body condition that their HM counterparts. No difference in reproductive performance was observed in the first year of the study (when all animals were first lactation).

Figure 4. Body Condition Score (BCS) of Medium Merit (MM), High Merit (HM) and New Zealand (NZ) Holstein Friesian cows



Alternative breeds and crossbreeding

At present greater than 95 % of the dairy cow population in Ireland is Holstein-Friesian. Therefore, in the short term, the best practical way to introduce a new breed or strain of dairy cow is through cross breeding. Cross breeding has an advantage in that we normally would expect the offspring to produce mid-way between their parents (on average), but in crosses heterosis (hybrid vigour) is expected to play a role. This is illustrated in Figure 5. Hybrid vigour is generally important for traits associated with reproduction, survival and overall fitness, and the effect might be that the offspring are better than either of the parents. This approach may also represent a "fast track" solution for the improvement of the reproductive performance of Irish dairy cows. Cross breeding can be a step towards breed or strain substitution, or it can be used in a systematic way to maximise hybrid vigour. It should be noted however that hybrid vigour is only expressed in a crossbred animal and is not all passed on to the offspring. When the crossbred is mated to one of the original breeds, half of the hybrid vigour is lost in the offspring. However the additive genetic merit is passed on to the offspring, and it is then that the average breeding values of each bull from the alternative breed become very important.

In New Zealand and to a lesser extent in Australia, systematic crossbreeding has been used to maximise hybrid vigour. Table 6 shows the results of a study that investigated the milk production, live weight, fertility and survival of Jersey (J), NZHF, NAHF and their crosses in New Zealand (Harris *et al.*, 2001). Crossbreeding increased milk production and live-weight, but also a favourable effect on the fertility and survival traits. The hybrid vigour effect was largest for the NAHF*Jersey cross, and smallest for the NAHF*NZHF cross. Crossbreeding increased the proportion of cows surviving from 1st to 2nd lactation and from 1st to 5th lactation.

Figure 5. Heterosis or hybrid vigour is defined as the advantage in performance of crossbred animals above the mid-parent mean of the two parent breeds.

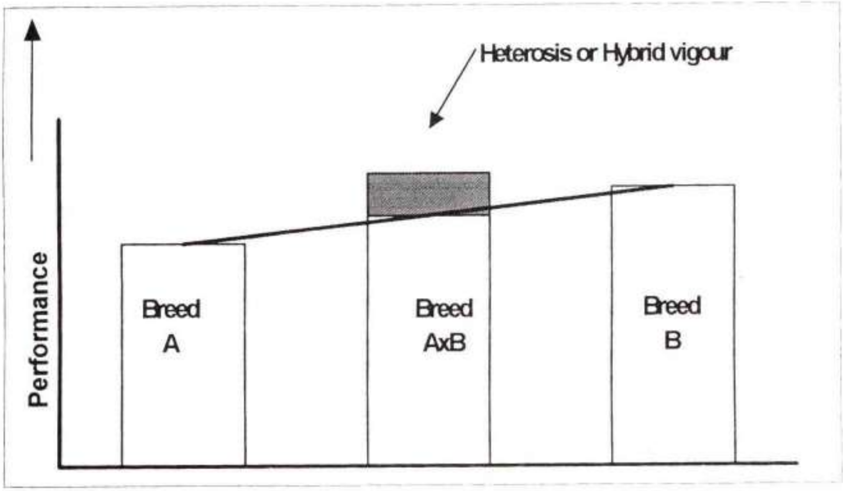


Table 6. Estimates of heterosis effect for breeds in New Zealand

	NZHF X Jersey	NAHF X Jersey	NZHF X NAHF
Fat yield (kg)	7.5	9.6	2.6
Protein yield (kg)	5.5	6.2	2.1
Milk yield (kg)	147	157	67
Live weight (kg)	9.2	10.4	5.0
Successful AI calf (%)	6.8	10.1	3.3
Survival 1st to 2nd lactation (%)	3.4	8.8	2.7
Survival 1st to 5th lactation (%)	9.6	18.3	6.3

The decision on whether to opt for a crossbreeding breeding strategy in an Irish scenario may depend on the system of milk production being carried out. In low concentrate, seasonal calving grass-based systems, the relative difference in milk production between Holstein-Friesian and alternative dual-purpose breeds will not be as large as high concentrate input systems. Recent results from Moorepark showed a higher milk yield response to concentrate supplementation at pasture (>1 kg milk per kg concentrate DM) with high merit Holstein-Friesian cows than with lower genetic merit dual-purpose breeds such as the Montbeliarde and Normande (<0.75 kg milk per kg concentrate DM). Therefore, in a low concentrate input system the milk production of the F1 cross (i.e. the first cross) will be much closer to the Holstein-Friesian milk production than it will be in the high concentrate system. Likewise, health traits such as reproduction, survival and overall fitness may be more important in a low concentrate, seasonal calving grass-based systems. Therefore the reproductive performance and survival of the Irish cow population could be improved by crossing the Irish Holstein-Friesian with a dairy breed already selected for important production and non-production traits. The two breeds that could be considered at present are the Montbeliarde and the Scandinavian Red breeds. The Jersey breed could not be recommended in a milk quota scenario because of the large increase in milk fat content and reduced cull cow and calf values. However, it is important to remember, that similar to the Holstein-Friesian breed, there is large underlying genetic variation within both the Montbeliarde and the Scandinavian Red breeds. Until it is possibile to include alternative breeds within the EBI, the selection of bulls from an alternative breed will be based on proofs from the country of origin, and it will have to be assumed that a superior animal in the country of origin will retain its superiority in Ireland.

Summary

The future economic efficiency of Irish dairy farmers will be affected by the genetic make-up of the dairy cow population. The reproductive performance of the Irish dairy cow population has reduced in recent years. Genetic selection for improved reproductive performance has a role to play in reversing this decline. This will be achieved by including functional non-production traits in a selection index, as in the new EBI index. Further development of the index in the future will be important, including other important traits relevant to Irish dairy farmers. There is a requirement for an increased level of milk recording and progeny testing in the Irish dairy industry. In the short-term there may be a place for crossbreeding with breeds like the Montbeliarde and the Scandinavian Red breeds. The genetic merit for milk production of these two breeds would not be as high as the Holstein-Friesian, however their genetic merit for fertility traits would on average be better. However for this to be a success all breeds and strains require to be evaluated within the one index, as differences between sires within a breed for any one trait may be as large as between breeds.

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Crossbreeding results at farm level in the Dungarvan area

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Introduction

Five years ago in 1997, a number of farmers in a local discussion group embarked on a 3 year project to compare crossbred heifers from different dual-purpose breeds to Holstein Friesian heifers within their own herds, under the same management and conditions.

The breeds used for crossing in 1997, 1998 and 1999 were Montbeliarde, Normande, and Robunt. In 1999 a fourth breed, Norwegian Red was also included. Friesian heifers (New Zealand or otherwise) could also be considered for crossing but may not exhibit as high levels of hybrid vigour. In the future it may be possible to inciude some Swedish Red semen in this comparison.

Dual-purpose breeds cross well, with most benefit derived from crossing them on the more extreme Holstein type cows. Crossbreds can produce good levels of fat & protein through high percentages, which increases the value per gallon. Crossbreeding also increases the sale value of calves, stores cattle, finished cattle & cull cows (see Table 5).

Why Crossbreed?

Profitable Spring milk production in Ireland is based on a compact calving pattern, with cows calving as close as possible to early grass. However, maintaining a compact calving pattern, without a high replacement rate, is proving difficult. Infertility associated with increased usage of high milk volume Holstein bulls is now a significant problem on many farms. This has come about because in general the Holstein breed societies concentrated mostly on milk production at the expense of health factors and fertility. Also many of the Holstein bulls are related and unless proper records are kept, inbreeding can easily occur. In contrast, the Scandinavian countries have included health and fertility in their bull selection programs since the 1970's.

The crossing of two different breeds results in hybrid vigour. This in turn should result in healthier animals with better fertility and higher milk solids/milk price per gallon.

Bull Selection Criteria:

High protein bulls within each breed were selected, with similar or lower fat figures, medium milk volume, and above average muscularity. It was the intention that bulls would not increase the size of heifers when crossed with the more extreme Holstein cows (big, heavy cows are not desirable for a grass based system, they have a higher maintenance requirement and are not suitable for heavy land).

The Rotbunt and Norwegian Red heifer crosses are small, compact animals. The Normande & Montbeliarde crosses are bigger - the Montbeliarde bull used initially had an above average figure for stature, which was not taken into account at the time. Subsequently, average stature was added to the selection criteria for bulls.

The Montbeliarde and Normande distinctly mark their progeny when crossed with black and white. The first crosses when crossed back with a Holstein (i.e. Holstein, 25% Montbeliarde) still look like Montbeliarde/Normande. The Rotbunt crosses are similar to Holstein Friesian but can still be picked out. Some are red and white. The Norwegian Reds are mostly black or dark red.

Production Performance - 1st and 2nd Lactation:

The average overall performance of each breed in their first and second lactations are summarised in Tables 1 to 4. A total of 29 crossbred heifers (9 Montbeliardes, 10 Normandes, 10 Rotbunts) and 28 Holstein Friesians heifers are now in their first lactation. The Montbeliardes are off the bulls Electro (ELO), and Vassal (VSL). The Normande are off Diametre (IAM), Bunuelo (BNO) and a stock bull on one farm. The Rotbunts are mostly off Parole (PAE) and also Pebe. The Holstein Friesians are off the positive protein Dairygold bulls MAU, JOS, ELC and 1 LEW. These are now in their 3rd lactation with more crossbreeds following on in their 1st and 2nd lactation.

The average production of all crossbreds taken together is slightly lower than the Holstein Friesians. The average protein % for all breeds, including the Holsteins is very good. Individually the Montbeliardes in their 1st lactation had the highest kg and % of fat and protein, and milk value. This is interesting because most of the Montbeliarde heifers are off Electro whose milk lift proof has fallen to zero since 1997 - yet the heifers have done well.

The Rotbunts also performed well and produced good cattle.

Normandes had the lowest production figures - even heifers off Diametre who was ranked as one of the top bulls in that breed in 1997. There were no foot problems worth talking about, which found favour with some farmers. The Norwegian Red heifers milking this year are smaller, more compact than the other crossbreds. The 2nd lactation results show similar production and milk value for the Holstein Friesian and Rotbunts. The Montbeliardes had the highest price per gallon in both lactations.

Fertility:

All crossbreds went back in calf, but three of the Holstein Friesians did not. Two more did not make it to their second lactation - injury/TB. Farmers find that heifers that milk very well in their first lactation are difficult to get back in-calf, end up calving late or not going in-calf at all. Most of the crossbred heifers were subsequently bred back to a Holstein bull (Eastland Cash) and Norwegian Red (Kommisrud and Nordbo).

Calves/Cattle:

The bull calves from these breeds sold well and commanded a higher price than their black & white counterparts. Most of the crossbred cattle that were finished at 2 years graded O with a small number making the R grade and slightly better kill out.

Summary

Caution must be exercised with the results as they are from a small base. However they show that dual-purpose breeds can cross well giving satisfactory production. The biggest benefit may be healthier cows with better fertility. It is however important that there are good Holstein Friesian cows to cross with, and that the better dual purpose bulls within each breed are used.

Crossbreds can produce good levels of fat & protein through high percentages. This increases the value per gallon. Crossbreeding also increases the value of the bull calf and store cattle with smaller benefits in finished cattle and cull cows. Crossbred heifers are very docile/easy to milk from the start (their SCC's were also lower than the Holstein Friesians in the first lactation).

Acknowledgements

Our Thanks to the Farmers Journal Trust for supporting this project and the AI companies and breed societies involved.

Table 1. 1st Lactation - 2000

	Montbeliarde (9)	Normande (10)	Robunt (10)	Holstein/ Friesian
Calving Date	12/2/00	17/2/00	14/2/00	14/2/00
Production Index	104	92	99	100
Price/gal	1.08	1.03	1.04	1.05
Milk Value	1114	1015	1084	1087

Table 2. 1st Lactation - 2000

	Montbeliarde (9)	Normande (10)	Robunt (10)	Holstein/ Friesian
Days Milking	259	163	258	255
Yield	1037	971	1041	1038
Fat %	3.93	3.75	3.69	3.93
Protein %	3.61	3.42	3.52	3.45
Kgs Fat & Protein	366	326	351	358

Table 3. 2nd Lactation - 2001

	Montbeliarde (9)	Normande (10)	Robunt (10)	Holstein/ Friesian
Calving Date	3/3/01	14/2/01	21/2/01	24/2/01
Calving Interval	386	363	373	374
Production Index	105	96	105	109
Price/gal	1.14	1.09	1.09	1.10
Milk Value	1354	1334	1415	1414

Table 4. 2nd Lactation - 2001

	Montbeliarde (9)	Normande (10)	Robunt (10)	Holstein/ Friesian
Days Milking	243	273	257	255
Yield	1188	1230	1301	1282
Fat %	3.94	3.80	3.65	3.86
Protein %	3.60	3.41	3.48	3.43
Fat & Protein (kg)	416	411	433	436

Table 5. Cattle sales - 2000

Breed	Average Birth Date	Live Weight 3/3/00 (kg)	Carcase Wt. 10/3/00 (kg)	Kill Out (%)	Value (€)
Holstein/Friesian (6)	14/2/98	658	344	52.3	857
Montbeliarde/ Normande (4)	1/3/98	684	371	54.2	923

All the cattle graded 04L/04H except for 1 Montbeliarde - R5

Table 6. Two year old steer performance – 2000

Breed	Live Weight 7/2/00 (kg)	Carcase 10/2/00 (kg)	Kill Out (%)	Price cent/kg	Value (€)
Holstein/Friesian	634	314	50	246	772
Normande (2)	608	322	53	249	801
Montbeliarde (2)	628	333	53	249	825

Table 7. Two year old steer performance – 2001

Breed	Carcase (kg)	Price cent/kg	Value (€)
Holstein Friesian (10)	286	240	687
Montbeliarde (7)	296	244	724
Rotbunt (3)	335	244	819

Table 8. Two year old steer performance – 2001

Breed	Birth Date	Carcase 23/2/01 (kg)	(kg) Price cent/kg	Value (€)
Holstein Friesian (6)	19/02/99	344	229	789
Montbeliarde (5)	12/02/99	340	231	785
Rotbunt (2)	03/03/99	353	232	819

A blueprint for growing maize

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Introduction

Research and practical experience have established that, when a high proportion (50-75%) of grass silage is replaced by alternative high dry matter forage like maize or whole-crop cereals, there invariably follows an increase in DM intake. Whether this is converted into increased output (beef or milk), depends largely on the quality of the alternative feed offered - quality being measured in terms of dry matter content (>25%), starch content (>22%) and digestibility (>65%). Over the past number of years maize has become a significant feature on many livestock farms. In cropping terms, at around 20,000 ha (50,000 ac) it is now the third largest crop in the country after cereals and sugar beet. While good quality maize (DM @ 28%; starch @ 25%) is the best winter forage to have on the farm, much of the maize harvested in recent years falls short of these targets.

With the huge expansion in the maize area over the past two years, the country is fast approaching the point where Area Aid on maize will be reduced in line with the % overshoot of our National Base Area of 345,500 ha. This is unlikely to have any effect on the maize area sown in the more favourable areas of the country, but could (and possibly should), slow expansion into the more marginal areas in the country.

To grow maize successfully every effort must be made to produce a high quality product at minimum cost by following carefully the well-established guidelines outlined below.

How much maize to grow?

The answer depends on a number of factors including the expected yield and the length of the feeding period (see Table 1).

Table 1. The area (ha) of maize required assuming daily intake = 15 kg forage DM x number of cows x 200 day feeding period x inclusion levels, divided by the expected yield (12.5 t/ha DM =16 tonnes fresh at 27% DM)

	Inclusion rate (% of forage)			
No. of cows	30	40	50	70
20	1.5	2.5	2.5	3.5
40	3.0	5.0	5.0	7.0
80	6.0	10.0	10.0	14.0
120	9.0	15.0	15.0	21.0

To benefit from feeding good quality maize silage an inclusion rate of at least 50% is required. The optimum for dairy cows is closer to 75%. Fattening beef can be fed 100% maize.

The real benefits of maize follow only if the crop meets the following standards of yield and quality. A DM yield of 12.5 t/ha with a DM % between 26-30% and starch levels of 20-25%. The main factors affecting performance are site, seedbed preparation, variety, sowing date, weed control and, at the end of the season, harvest date.

Where to sow?

Maize can be successfully grown south and east of a line roughly from Limerick to Dundalk, but site selection is more critical than location. Avoid fields over 120 m (400 ft) above sea level and heavy poorly drained soils (remember that heavy harvest machinery will be working up to the end of October!). Equally, light drought-prone soils will in the odd drought years, produce poor yields. Ideally sites should have immediate access to a roadway. Maize can be grown on a wide range of soil types provided the pH is above 6.0. If pH is 6.0 or below, spread lime and postpone growing maize for a year. Soil sampling is an essential first step, particularly where planning to plough up grassland.

Seedbed preparation

Perennial weeds such as docks and scutch should be eliminated before ploughing. These weeds are very difficult and costly to control once maize is sown. As a crop, maize is very sensitive to compaction, and with its deep rooting requirement, will suffer badly if the site is compacted. Where compaction is known to be a problem, sub-soiling will be necessary. Sub-soiling is best carried out in late summer when soils are dry.

Plough deep (25-30 cm) and bury all trash and organic manures. Ideally organic manures should be spread as early as possible and ploughed in immediately. Early ploughing is recommended on heavy soils. A single slow pass of a power cultivator tiller, fitted with deep wheel-track eradicators (to at least 10 cm) is the best approach. The seedbed does not need to be too fine, but should be ready by mid-April. Drill the seed at 104 - 112,000 seeds/ha. (Maize can be established via a one-pass cereal drill, but results are variable. Calibration of the drill is difficult and must be undertaken for each variety. Research figures suggest that in well-distributed stands, yields are marginally increased but the starch content is reduced relative to precision drilling).

Varieties

The value of maize lies in its ability to produce high DM (+28%) and high starch (+25%) conserved feed. To achieve these values it is essential to use early or medium-early varieties described in the Department of Agriculture's recommended list published each year. Match the variety to the potential of the site e.g., Alcyone for very favourable sites; Loft, Hudson etc. for less favourable ones.

Sowing date

Sow early but not too early. The optimum date is from mid-April to May 10. Later sowing can lead to reduced grain yield (% starch) and DM content – the two quality factors that gives maize its advantages over grass. The trends shown in Tables 2 and 2a have been repeated in many trials.

Table 2. The effect of sowing date on the yield and quality of maize silage

Sowing date	April 3	April 11	April 23	May 3	May 13
DM yield (t/ha)	13.9	13.0	14.3	14.1	13.2
DM%	33.7	33.4	31.6	30.2	28.4
Feed value ME (MJ/kg DM)	11.3	11.4	11.3	11.1	11.0

*Normal light, MGA. UK 1992

Table 2a. The effect of sowing date on yield (t/ha), DM% and grain yield (t/ha)

Sowing date	April 10	April 20	May 10	May 20
DM yield (t/ha)	11.75	13.38	12.50	11.9
DM%	30.00	28.9	24.8	22.1
Grain yield (t/ha)	5.27	6.02	5.0	3.88

*J. Crowley, Teagasc, Oak Park, 1996

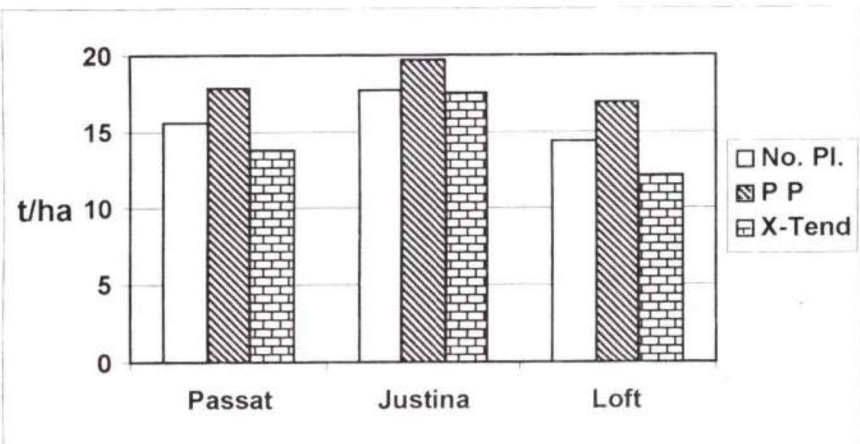
In the two sets of data the best combination of yield and quality was recorded at the late-April sowing.

Sowing under plastic

Growing maize under plastic film is one way of significantly increasing total DM yield and quality of the maize crop. On average the Punch Plastic system has increased DM yield by 4.2 t/ha (1.7 t/ac) within the range 2.5-5.0 t/ha. The higher increases were obtained in poor production years, on marginal sites, or in late-sown crops where the conventional or no-plastic crops failed to reach a good level of maturity. For most crops grown under plastic, over 80 % of the measured yield increase comes in the form of grain.

The complete Cover or X-Tend system (first introduced in 1996) has given variable results over the years. Trial results at Oak Park have shown that at best this system produces yields equivalent to those produced by the Punch system, with a slightly higher grain yield. Damage caused to the young plants during the period of three to four weeks while they break through the plastic cover significantly reduces the potential of the system. This was particularly evident in the results from Oak Park trials in 2001 (Figure 1).

Figure 1. Dry matter yield (t/ha) of three maize varieties using three production systems – sown April 23, 2001



In general, 2001 was a very good year for maize, with a long warm growing season. High autumn temperatures combined with no frost, meant that the conventional (no plastic plots) produced high yields of mature maize. The data (Fig. 1) shows clearly that (a) different varieties behave differently under the X-Tend system and (b) the Punch system produced the highest yield across all three varieties. Due to the strength of the plastic film used, not all varieties will suit the X-Tend system. Selecting the wrong variety will result in significant yield losses. Changes from year to year in the nature and strength of the plastic film used in the X-Tend system mean it is not possible to predict the outcome for 2002.

Fertiliser

The fertiliser recommendations for maize are presented in Table 3.

Table 3. N, P and K fertiliser recommendations for maize (kg/ha)

N, P, K Index	Nitrogen	Phosphorus	Potassium
4	75	Nil	Nil
3	100	40	190
2	110	50	225
1	150	70	250

*Assumes no slurry applied

Since most maize receives organic manure, an application of 54,000 l/ha (5000 g/ac) will supply all or most of the P and K requirements of the crop. Nitrogen supply is more difficult to predict. For ground that has not received regular applications of slurry, an application of 125 kg/ha of N is sufficient. On ground receiving regular application of organic manures this can be reduced to 60 kg/ha. Too much nitrogen will delay crop maturity without increasing yield.

Maize sown without plastic should receive at least 20 kg/ha of phosphorus drilled with the seed in the form of superphosphate or one of the proprietary maize starter products which will deliver 24 kg N and 20 kg/ha P at a rate of 125 kg/ha of product.

Potassium is vital for maize and the crop requires more potassium than nitrogen. It plays a vital role is the transfer and conversion of soluble sugars into starch and should not be restricted.

Pests and Diseases

Frit fly, leatherjackets, wireworms and rooks are the main pests of establishing maize crops. All maize seed is now treated with fungicides and Mesurol, which gives full protection against bird damage and almost 100% protection against Frit fly. Where maize is preceded by grass, wireworm and leatherjackets must be controlled for a year or two. In this situation spray Dursban on the seedbed and incorporate before sowing, or use Yaltox drilled with the seed. There is no need to use insecticides in continuous maize or where maize is grown in an arable rotation.

The only leaf disease to cause concern is Eyespot (*Kabatulla zeae*). It has shown up on many crops in the last few years but rarely causes yield loss. The fungus spreads under cool damp conditions appearing in September. It has been more prevalent in the West Cork area. Since there is no way of applying a fungicide to maize in August/September, good hygiene practice and the use of resistant varieties are the only control methods available. The spores overwinter on maize stubble and trash. Maize ground should be ploughed as early and cleanly as possible. There is some suggestion (from field observations), that some varieties are more resistant than others, but to-date no variety is fully resistant.

Weed control

Despite its size and growth rate from July onwards, maize cannot tolerate weed competition from sowing to late June. Effective herbicides are available but timing of application is vital. The crop must be kept clear of weeds at all times and post-emergence herbicides must be applied to small weeds, i.e. before the four-leaf growth stage. The following herbicide programmes are the best available: -

(i) For fields/farms new to maize apply Atrazine @ 3.75 to 5.0 l/ha. Atrazine incorporated before sowing will produce the most reliable results. It can be applied post-sowing or post-emergence.

(ii) From year two onwards Atrazine resistant weeds, Nightshade, Orache, and Groundsel will appear, so switch to the following post-emergence control programmes:-

   (a) Atrazine + Bromotril-P at 2.0 + 2.5 l/ha in two splits
   (b) Atrazine + Lentagran at 2.0 l + 2.0 kg/ha again in two splits
   (c) Atrazine + Stomp at 2.0 + 3.7 l/ha; one application when weeds are emerged
   (d) Stomp + Lentagran 3.75 l + 2.0 kg/ha; one application when the crop is at the 2-4 leaf stage

Docks, thistles and volunteer potatoes can occasionally cause problems in maize. Starane at 0.5 to 1.0 l/ha will control docks and potatoes but will set back the maize. Dow Shield at 1 l/ha will control thistles. It is expensive and is best used as a spot treatment on dense patches only. Once the crop is well established and weed free (mid- to late-June), no further action is required until the crop approaches maturity from late September to late October.

Harvesting

The decision as to when to harvest can have a very profound effect on the quality of the silage produced. The objective is to harvest the crop when the cob has matured to the extent that the cob DM%, (i.e. grain + central core (rachis) minus the covering leaves) has reached 50 to 55% and the stover (stem + leaves) are still in a healthy green state. This will result in a total crop dry matter content of 28-33%. Crops harvested much before or too far beyond this stage will reduce the value of the ensiled crop (Table 4).

Table 4. The relationship between crop DM%, quality and ensiling losses

Whole crop DM%	Organic matter Digestibility (%)	Effluent losses	Fermentation losses %
15	66.7	6.9	17.7
20	69.6	4.2	14.5
25	70.3	2.0	11.4
30	71.1	0.2	8.3
35	71.9	Nil	5.1

The best field guide as when to harvest is provided by the maturity of the cobs. The relationship between cob maturity and overall crop DM is set out in Table 5.

Table 5. The relationship between cob maturity (cob DM%) and crop dry matter content (DM%)

Cob DM%	Crop DM%	% Cob DM*
30	18-22	25-35
40	21-26	35-45
50	27-33	45-55

*% of the total DM made up of cob material

The optimum harvest point is when the cob reaches a dry matter content (DM%) of 50% or more. Once this point is reached it does not matter if the rest of the plant is green. Harvest date should be based on the cob rather than on the overall look of the crop. With a little experience the DM% of the cob can be very accurately assessed by an examination of individual grains on the cob (Table 6).

Table 6. Stages of maturity in maize cobs

Cob DM%	Description of maize grains
20-25	Completely formed but white
30-35	Milky soft-pale yellow
35-40	Some milky material – darker yellow
40-45	Beginning of dough stage
50-55	Grain hard – bright yellow

For confirmation, select 3-5 cobs at random from the crop. Chop into 1 cm thick rings, and dry overnight in an oven at 100°C. This will confirm your visual assessment.

$$DM\% = \frac{\text{Dry wt.}}{\text{Fresh wt.}} \times 100$$

Ensiling

Since all maize harvesting is carried out by contractor, the biggest problem in getting maize cut at the optimum stage is getting the contractor to turn up on time. The main focus now should be on chop length and the degree to which the grain is processed. No grain should get through without some "damage". The harvester must be set to deliver a fine chop of 4-6 mm, or animals will not eat leaf portions. If you have mature grains, then insist that the machine "corn cracker" is being used.

A narrow clamp filled quickly, with the cut material spread out in thin layers – inches rather than feet thickness is essential for successful ensiling. Roll the pit continuously and use salt at 3-5 kg/m^2 on the surface to avoid spoilage, particularly at the corners. Sheet down and maintain close contact between the plastic cover and the maize. Protect the clamp and the open face from birds. Most growers now use a net. Bait to prevent rats invading the pit.

Maize ensiles easily and preservation rarely causes problems. If pit management is good, additives will not be necessary when ensiling maize. However, there are two situations where maize silage will benefit from a good inoculant, (i) where the DM% of the harvested crop is above 35% and (ii) where there is the intention of relocating the clamp later in the year.

Environment

With all agricultural systems under close scrutiny regarding pollution it is only a matter of time before the spotlight falls on maize. On the continent and particularly in France, maize production has acquired a very bad reputation regarding pollution. Maize has a very strong visual impact on the environment and has the potential to cause serious nitrogen and phosphorus pollution of waterways. Now that the area sown in Ireland has exceeded 20,000 hectare, the crop will not go unnoticed. The overuse of organic and inorganic fertiliser, both nitrogen and phosphorus is of no benefit to the crop and will increase rather than reduce production cost.

Allowing maize stubble to lie bare over the winter can lead to nitrogen leaching, and soil erosion may carry phosphorus into waterways. While ploughing early across the slope will reduce run-off, it does little for nitrogen leaching. Maize stubble would benefit from a green cover crop over the winter. Undersowing or in some case establishing a crop after the harvest would significantly reduced worries about nutrient losses from the system.

There is little doubt that the use of plastic will be questioned. With the continuing improvement in maize varieties the use of plastic is becoming no longer necessary in many areas. Unless the degradability of the plastic film on offer to growers improves significantly it will become more and more difficult to justify its use.

Conclusions

- Maize will give high yields (12.5-15 t/ha DM) at a competitive cost with or without Area Aid.
- Achieving high yields of high DM, high starch maize is vital in achieving increased output.
- The provision of a high DM, high starch feed such as maize fed in conjunction with grass silage will help in improving both the performance and well-being of animals in intensive beef, dairying and possibly sheep enterprises.
- To achieve high returns on maize particular care and attention must be paid to the details outlined in growing and ensiling the crop.

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What are the advantages to using maize silage for a spring calving system

Eamon Phelan

Ballyneety, Dungarvan, Co. Waterford.

Introduction:

After leaving school in 1981, and following a 2-year certificate in Agricultural Science at Waterford Regional & Kildalton Agricultural College, the author spent 9 months in New Zealand working for Marvin Farm Relief Services, managing herds up to 280 cows. Next came Australia where he worked in Western Australia during the wheat-planting season.

On returning home with the intention of starting farming, I quickly realised that the home farm was too small and the father too young, to allow me to realise my ambitions. Subsequently, I left and went to work for Masstock Saudia Ltd., where I spent five years managing a 1200 cow herd (average yield of over 9,000 litres on 4 times a day milking). Here I came to experience maize for the first time and subsequently learned a lot about this crop. I also travelled to America with Masstock and have visited large dairy herds in Phoenix Arizona, Chino Valley, California and Masstock Macon in Georgia. During this time I also got married, returning to Ireland permanently during the Gulf War of 1990.

The home farm

In 1990, the home farm comprised 85 acres, 10 of which were rented. A 78,000-gallon milk quota included 14,000 gallons of liquid milk and winter milk. Of the total quota, 10,000 gallons were leased. Ten acres of land and 5,000 gallons of quota were purchased in 1991, which was reclaimed, drained and fenced in 1992.

In 1994 a 52-acre block of land with 25,500-gallon quota was leased. This land was in poor order and needed a lot of work, but it had a modern wintering unit with 44 cubicles and a slatted tank. Subsequently this property was bought in 1998 and is still being developed to-day.

Table 1. Farm profile - 2002

Adjusted acres owned	126
Acres rented	29
Total acres	155
Quota (gallons)	114,439
Cows	80
Bulling heifers	20
Bullocks for autumn sale	22
Male bull calves	20
Female replacement calves	24
Bulls	2

Farm Profile:

The farm is divided into 4 blocks: -

1. **Home Farm (52 adjusted acres);**

   This is the only land available to the milking cows to graze and is divided into 21 paddocks. Silage is cut here only when grass is in surplus.

2. **Killadangan (25.5 adjusted acres);**

   This is used for a 2 cut silage system and grazed in the autumn.

3. **Quinlans (49 adjusted acres);**

   Comprises 15 acres of maize and 34 acres of grazing. The grazing area is under development and has yet to reach it's full potential. At present 15 acres have been re-seeded and improved. More work remains to be done.

4. **Rented Block (29 adjusted acres);**

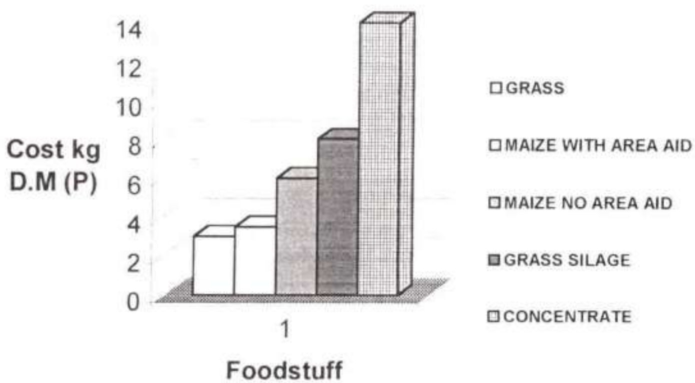
   This block is in one field and will be sown to maize for sale.

Why Maize?

With only 52 acres of grazing available for 80 cows, this represents a stocking rate of 0.65 acres/cow for the year. Prior to 2000 the farm serviced a winter milk scheme. 2000 was the first year in spring milk. Initially maize was grown as an alternative forage for winter milk production, but as the farm is also susceptible to drought, maize is an ideal supplement during grass shortage. This proved very successful, easy to operate and held milk yield while keeping cows happy.

As a member of the Dungarvan Discussion Group, most of who were in spring milk, I looked at them and was jealous of their life style. I had 80 cows, a fragmented farm, was in winter milk and was working life a fool and for what? After examining the costs with my Teagasc advisor (Figure 1), I finally made the decision to opt out of winter milk.

Figure 1. Cost kg Dry matter of various supplements



It is intended to replace acres of grazed grass with acres of maize silage. At present the farm is two years into the system. It is too early to give a definitive answer, but the system is a lot easier than winter milk, with feeding confined from July to December as opposed to starting in October, and continuing for the following 12 months. I feel I am competing financially with other spring calving systems despite my small grazing base.

Table 2. Dairy MIS 2000

	Yield (gal)	Conc. fed x 50 kgs	Cost (p/gal)	Margin over feed & fertilizer (£) £/cow	£/acre	£1,000 gall
E. Phelan	1478	13	6	1284	1130	921
Gp. average	1176	11.1	6	1044	951	887

Table 3. Profit monitor 2000

	Dairy GM/acre (£)	Dairy GM/cow (£)	Dairy GM/gallon (£)	Total GM/acre (£)	Farm Net margin/ac (£)
E. Phelan	1020	1200	0.81	731	495
Gp. average	832	940	0.80	518	293

The system:

Growing the crop:

"Drill and Shut the Gate" - as crops go, maize is very easy to grow. Dairy farmers as a rule are not good tillage farmers but most dairymen succeed in growing excellent maize crops with high yields of consistent quality.

Husbandry is as follows:

1. 5,000 gals/acre slurry
2. Plough in immediately
3. Sow early to mid April
4. Spray 1. Mid May. $1^1/_2$ pts/acre Atrazine
   $1^1/_2$ pts/acre Stomp
5. Spray 2. Mid June. $^1/_2$ pt/acre Bromotril
6. Harvest as early as possible, usually late September to mid October. No additive added.

Table 4. Maize costs (£)/acre – 2001

	Rented ground (£)	Owned ground (£)
Rent	50	
Ploughing	20	20
Power harrow	22.5	22.5
Sow	22.5	22.5
Spray	10	10
Seed	50.32	50.32
Fertilizer	80.71	
	(No Slurry)	35
Slurry spreading		16
Chemicals	7	17
Harvesting	80	80
Total cost	**343**	**273**
Area aid		112
Net cost	343	161
Cost/ton DM @ 5.5 t DM/acre	**62**	**29**

Feeding the Crop:

The aim is to start calving on February 1, and to be out on grass by day as soon as weather allows. The cows are fed a complete diet as follows:-

Concentrate (28%)	5 kg	In wagon from 2 pm – 1 am
Molasses	1 kg	
Straw	0.2 kg	
Minerals	0.15 kg	
Grass silage	1 kg	
Maize silage	6 kg	

Table 5. Concentrate formulation

	Maize/grass silage (%)
Hi-Pro Soya	35
Maize distillers	28
Barley	16
Citrus pulp	16
Molasses	5

Cows are left out after am milking and brought in as determined by weather. Because of the small land base, no risk is taken that pastures will be damaged, and for this reason I am not as consistent at leaving cows out as many other farmers. "If the weather is dodgy the cows stay in" - weather-dial is useful for this purpose. This system will remain in place until cows go out by night, which is usually early April.

In general there is adequate grass until early July, or if it rains in June or July then grass supply will be fine until August. As soon as grass supply comes under pressure, maize comes back into the system. Feeding just a few kg DM will hold milk well. However in August or September, up to 6 kg DM cán be fed as maize. At this stage 0.75 kg/DM/day of soya is introduced. This is fed in the parlour, and works well to prevent milk drop due to lack of protein. Cows will now be fed maize silage until they are dried off. The maize is used to supplement grass supply as necessary, with cows being brought in by night from mid to late October, and out by day as long as weather permits or grass runs out

Tips:

Always feed cows after milking to avoid having them congregate at exits of paddocks.

Aim is to reduce labour input by having cows feed themselves. For this reason I have made a long low maize pit beside the milking parlour, with the intention of allowing the cows to self feed the maize.

Conclusions

Maize silage is an important crop as it is the cheapest alternative feed source to grazed grass. It allows the utilization of some of the out-farm land in it's most economic manner within the dairy enterprise.

Each year approximately 80 tons of dry matter is fed as maize.

This costs: **(80 tons maize @ £35/ton DM = £2,800).**

Alternatively, if it were replaced with citrus pulp it would cost?

Citrus Pulp **(80 tons citrus pulp @ £113/ton DM = £9,040)**

This equates to a saving of approx. £6,000. Having the necessary land and using it in its most economic fashion, facilitates leaving cows out early in February and having enough grass to last until April 10. It also allows for keeping grass in the system as long as possible in the autumn. However, in an ideal world where land area was not limiting, there would be no need to grow maize – instead a simpler system would operate, concentrating on growing and utilising what is after all ***"the cheapest feed – grazed grass"***.

Complementary forages for dairy production

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Introduction

Recently there has been a major increase in interest in the production and feeding of alternative forages for dairy cattle during the indoor feeding period. This interest has been driven mainly by the improvement in cow genetics, and producers wanting to increase milk production as cheaply as possible from home produced feed. Furthermore, the cost of producing alternative forages may be reduced if land is eligible for arable aid, and recent costings have shown that the costs of producing maize and whole crop wheat can be similar to grazed grass when arable aid payments are involved. However grass silage is, and will remain the main forage offered to the vast majority of dairy cattle in Northern Ireland during the winter period for the foreseeable future. Given the increasing interest in alternative forages, particularly forage maize, a series of studies have been undertaken at Hillsborough to investigate factors influencing both the growing of forage maize and effects on feeding value when offered to dairy cows.

In the last year the area of maize silage has increased considerably. Recent developments, namely new varieties and the use of plastic mulch, has enabled the consistent production of high feed value maize silage. Research from Hillsborough clearly illustrates, from the mean of 5 years of studies, that, on average, the use of plastic mulch increases crop yield by 2.5 t DM/ha, cob yield by 3.2 t DM/ha, crop dry matter content by 7 % units and crop starch content by 9 % units. However, the response to plastic mulch is greater with later maturing varieties compared to early maturing varieties. To achieve a high forage yield, which is one of the most important factors affecting the cost of production, the crop should be planted early, i.e. mid-April, using medium to late maturing varieties and covered with plastic mulch. When selecting varieties it is important to take into consideration the site on which the crop is to be grown.

Studies from Hillsborough have clearly illustrated that inclusion of high feed value maize silage in the diet increases milk yield and composition, consequently increasing margin over feed costs, relative to high quality grass silages. To obtain optimum levels of animal performance from maize silage:

1. Ensile the crop at about 30% dry matter (Table 1).
2. The extent of the benefit obtained from including maize silage depends on grass silage quality. For poor quality grass silage, responses will be obtained by replacing up to 70 % of the forage component as maize silage. For high quality grass silage, most of the benefit will be obtained from offering maize silage as 40 % of the forage component.
3. As maize silage has lower crude protein concentration relative to grass silage it is necessary to increase the protein content of the concentrate. Formulate the diet so that with cows in early lactation, total diet crude protein concentration is 17-18 % whilst for cows in mid-lactation 16-17 % will suffice.
4. Reduce the starch content of the concentrate to 15-20 % of the dry matter.
5. Including high quality maize silage will enable concentrate feed levels to be reduced by up to 3.3 kg/cow/day to produce a given quantity of milk in a quota situation.

6. Under good grazing management in spring/early summer, buffer feeding maize silage can replace grazed grass in the diet of the dairy cows whilst maintaining animal performance.

Whole crop wheat can be ensiled between 35 and 70 % dry matter. Delaying harvest results in increased yields and starch concentration of the resultant forage. Studies undertaken in the UK using whole crop wheat, ensiled at a dry matter concentration ranging from 30 to 58 %, have shown that inclusion of whole crop wheat increased food intake but had no beneficial effect on milk yield, milk composition or margin over feed costs.

It is concluded that alternative forages should only be included in the diet of dairy cattle if there is evidence to show increased animal performance or better cow health and consequently improved margins over feed.

The data from Hillsborough clearly illustrates that good quality maize silage increases animal performance and margin over feed, whereas whole crop wheat has little effect.

Table 1. The effect of maize maturity at harvest, when offered as 40% of the forage, on animal performance

			Maturity of maize		
		Grass silage	Immature (20% DM)	Mature (29% DM)	Very Mature (38% DM)
Food intake (kg DM/day)					
	Grass silage	10.9	7.3	7.4	7.4
	Maize silage		4.9	4.9	5.0
	Total	16.9	18.2	18.3	18.4
Milk (kg/day)		26.8	27.2	27.8	27.8
Fat (%)		3.98	4.24	4.15	4.02
Protein (%)		3.15	3.23	3.23	3.25

(Keady *et al.*, 2002)

Understanding the N cycle and the pathways of N loss

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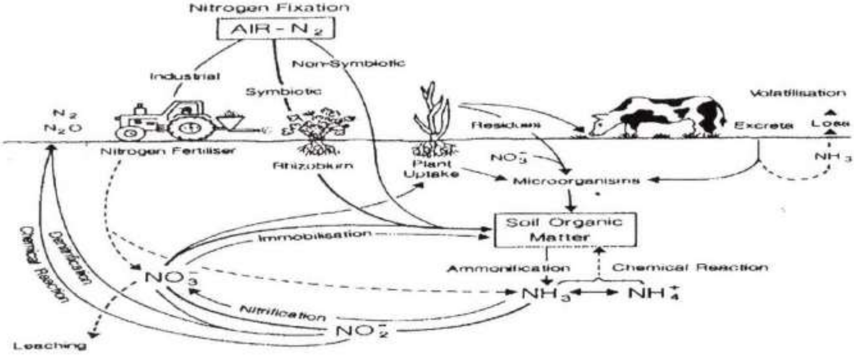
Introduction

Nitrogen (N), the most widely used plant nutrient in fertilisers, is long recognised as a key to improving crop yields and economic returns. That which is utilised, be it fertiliser, manure or soil N comes from the atmosphere and ultimately returns there in gaseous form via the N cycle (Figure 1) maintaining the atmospheric content at a stable 78%.

N Cycle

The earth is habitable due to its constantly changing physical, chemical and biological cycles. The N cycle is one of many cyclic changes on earth, which redistribute elements that are essential for life, e.g., sulphur, carbon, and hydrogen. Much of the interest in the N cycle focuses on the parts of it that human activities influence e.g., the role of soils, plants and atmosphere, yet only about 2% of the world's N is involved in those aspects, almost all of the remainder is present in rocks. In grassland N cycling, there are several aspects of interest, e.g., N fixation, mineralisation, nitrification, assimilation, immobilisation, volatilisation, denitrification and leaching. Consideration of these terms and their role in the movement of N through soils – plants - animals forms the basis of this paper.

Figure 1. Simplified N Cycle



N fixation

This is a biological process whereby symbiotic and non-symbiotic organisms fix atmospheric N gas into organic forms; fertiliser manufacture is the non- biological equivalent. The best-known organisms which symbiotically fix N, are the *Rhizobia* (bacteria), living within the roots of legumes such as peas and clover. Rates of fixation, in pastures containing 35-40% white clover, have been estimated in this country at 90-190 kg N/ha. Non-symbiotic, free-living, bacteria such as *Azotobacter, Clostridium* and blue-green algae, fix N, but to a less important degree.

Mineralisation

Organic N occurs naturally as part of the soil organic matter fraction. It is incorporated in soil from manure, plant residues and biological N fixation, etc. Microbes and soil animals break down, i.e., use organic matter in soil as an energy source and excrete nutrients in excess of requirements e.g., N in the form of ammonium. A very high proportion of the N in surface soils is present in organic forms, and can vary in Irish grassland soils from 5 to 15 t per ha. Assuming a mineralisation (break down) rate of 1.5% of the mean value, approximately 150 kg N/ha/annum are released from organic sources. Trial results support this. Data from 26 sites averaged over 4 years, indicate a N harvest in DM from zero N plots of 219 kg/ha (Ryan, 1976). Release may be much higher - 12 year old swards in the UK released 321 to 420 kg N per ha, due to a build-up of the soil N pool.

Nitrification

The decomposition of organic substances in soil leads to release of N and the formation of ammonium. When oxygen is present, soil microbes transform ammonium to nitrate in a rapid process (nitrification), which is completed in a few days. Nitrification is primarily carried out by bacteria, *Nitrosomonas* spp, which convert ammonium to nitrite and *Nitrobacter* spp, which oxidise nitrite to nitrate. It is the primary route whereby ammonium released from plant residues or added as fertiliser i.e., in urea or calcium ammonium nitrate (CAN) is converted to nitrate. The rate of nitrification increases with increase in soil pH and soil moisture content up to field capacity, reflecting the biological nature of the process.

Assimilation

Plants obtain most of the N required for growth from soil by uptake of soluble, low molecular weight compounds, particularly nitrate and ammonium. When nitrate taken up by plants and microorganisms is assimilated, it is first reduced to ammonium prior to incorporation of its N into amino compounds. The energy for reduction comes from photosynthesis or oxidation of organic carbon. The reduction proceeds via the enzymes nitrate reductase and nitrite reductase.

Immobilisation

Even though ammonium is the preferred form, soil microbes can convert either ammonium or nitrate to satisfy their needs for N. This assimilation of N into organic N constituents of cells and tissues is called immobilisation by the soil biomass. Immobilisation of nitrite and nitrate to organic forms is sometimes due to enzymatic activities associated with plant or microbial N uptake and N utilisation processes. Disappearance of mineralised N is sometimes due to such immobilisation. The soil biomass can compete effectively with plant roots for available N and microbial biomass has the capacity to immobilise N rapidly. The lack of detectable change in soil inorganic N levels when high fertiliser N is added to soils is indicative of a high buffering capacity for N, perhaps through a rapid uptake into plants and into the soil biomass. Therefore, this process may result in accumulation of N over time, with rates varying from 56 to 190 kg N/ha/year. Ploughing of such soils provides quick release of part of the immobilised N.

Volatilisation

Ammonium ions and ammonia in soil water exist in equilibrium with each other. However, soil water ammonia is subject to volatilisation (gaseous loss) to the atmosphere and the amount that occurs is very much dependent upon soil pH and concentration of ammonium in the soil solution. As soil pH increases, the fraction of soil solution ammonium plus soil solution ammonia, in the gaseous ammonia form, increases tenfold for every unit of pH above 6.0, thereby increasing the loss of soil solution ammonia to the atmosphere (Follett, 2001). Volatilisation of ammonia is of most importance on calcareous soils; losses increase with increasing temperature and can be appreciable for neutral soils as they dry out. It is greater in sandy soils and can be high when N wastes such as manure decomposes on the soil surface. Losses can be high from urea applied to grass but losses from soil and fertiliser N are reduced by growing plants. Decomposition of urea by ureases is an important reaction in the ammonification process and the major input of ammonia to the atmosphere is thought to result from animal production through the return of excreta, particularly urine. The amount of N in the dietary intake influences the extent and form of excreted N. There is a strong positive relationship between the N concentration of the herbage at the start of the grazing period and the amount of ammonia (kg/animal/day) lost during the period. The N concentration in the diet affects both the total returns of N in excreta and the distribution between dung and urine. Urine has by far the greatest potential for ammonia loss since 53 to 75% of total urinary N may consist of urea. In urea metabolism, urea is converted, through hydrolysis to ammonium and carbon products. The process consumes hydrogen ions allowing hydroxyl ions to react with ammonium, releasing ammonia gas i.e., $NH_4 + OH = NH_3$ gas + H_2O. Ammonia losses from surface splashplate-applied cattle slurry range 25-75% of applied N after 10 days; losses from this source and housing each amount to 40% of the total (Hyde, pers. com.).

Denitrification

Mineralisation and nitrification processes in soils form ammonium, nitrite and nitrate ions from organic soil N. Nitrate and nitrite can be lost to the atmosphere through denitrification, which is the biological conversion by bacteria of nitrate to the gases, dinitrogen, nitrous oxide, nitric oxide or other gaseous N oxide compounds. Nitrous oxide is a greenhouse gas and is linked to thinning of the ozone layer. Dinitrogen is the product of the complete denitrification process, nitrous oxide results from incomplete denitrification and to a small extent from the nitrification process. Basically, nitrous oxide production in the soil, via denitrification, is the primary route for most losses of gaseous N to the atmosphere. The conditions required for denitrification to occur include: (i) ample carbon substrate; (ii) reduced oxygen availability; (iii) adequate concentration of N oxides, nitrite, nitrate, nitric oxide or nitrous oxide, and (iv) presence of bacteria capable of denitrifying. Topsoils, high in moisture status and well fertilised with N fertiliser or manures, provide ideal conditions for denitrification. Factors, which increase the proportion of nitrous oxide to dinitrogen in denitrification, include decreasing temperature, pH and carbon availability, increasing oxygen and sulfide and low nitrous oxide-reducing enzyme (Betlach and Tiedje 1981).

Runoff/leaching

Research shows that the most important factor in determining the extent of losses through runoff on vulnerable soils, is how quickly the rainstorm which causes runoff, occurs after spreading slurry or fertilisers. If a storm occurs within forty eight hours it is not unusual to record losses of 20 to 40% of the N applied from poorly drained soils i.e., 10 mm of rain may be sufficient to cause runoff from impermeable soils whereas high rainfall of 25 mm in 24 hours may not cause runoff from gravel and sandy soils. If the rain does not come for 1 week there is a dramatic drop in the organic matter and N, potassium concentration in the runoff water. Experiments show that winter rain, collected as runoff, is 17, 30 and 43 % for free draining, imperfectly and impermeable soils (Sherwood, 1984, 1986, 1990). Runoff of ammonium and nitrate has been recorded from N fertilised, grazed grass plots in spring and autumn on moderately heavy and heavy soils (Kurz, pers. com.).

Leaching, the movement of water down the soil profile can be an important source of nitrate loss from soil. Leaching of ammonium is generally not important because it is adsorbed by the soil, except perhaps in sands and soils having low retention capacities. As nitrate is a negatively charged ion, it is repelled by the negatively charged clay and is readily leached below the bottom of the root zone into the deeper layers from which it may eventually reach groundwater. Leaching occurs mainly from October to March, when rainfall exceeds evapo-transpiration and soil water movement is downward. The start – to – end, and amount of drainage varies yearly, which in turn determines the amount of nitrate-N leached. Soil type has a significant effect. Nitrate-N can be expected to move 450, 300 and 200 mm deep with 100 mm effective rainfall (rain minus evapotranspiration) in sandy, loamy and clayey soils respectively. Water quality impact areas for leached N, are wells, ground water supplies, streams and surface water bodies.

Irish research results-grassland

At present there is much interest in nitrate-N loss to water. The knowledge base with regard to nitrate-N loss is very limited but new experiments under way will significantly broaden that base. Published information on leaching in Ireland, divides along the following lines; trials on grass plots with fertiliser or slurry, fertiliser plus slurry, and fertiliser on cultivated soil. A summary of results of leaching to 1 m from grass plots is shown in Table 1.

Table 1. Mean nitrate-N leaching results from cut (*grazed) grass plots.

Soil Drainage	Fertiliser	kg N/ha Applied	mg/l N	Depth (m)	Yrs leached	kg N/ha	Reference
Mod.Free	Pig Slurry	412	3	1	3	13	Sherwood, 1981
Impeded	Pig Slurry	403	2	1	3	8	*ibidem*
Mod.Free	CAN*	51	2	0.9	1	15	Sherwood & Ryan, 1990
Mod.Free	CAN*	408	4	0.9	1	29	*ibidem*
Mod.Free	CAN	40	2	1	5	11	Sherwood, 1986b
Mod.Free	CAN	200	6	1	5	34	*ibidem*
Mod.Free	CAN	300	15	1	5	81	*ibidem*
Mod.Free	CAN	400	22	1	5	119	*ibidem*
Mod.Free	CAN	240	9	1	3	NA	Sherwood, 1988

Table 2. Mean nitrate-N leaching and concentration in drainage water from cut grass in soil columns (lysimeters).

Soil Drainage	type Applied	kg N/ha N	mg/l (m)	Depth leached	Yrs	kg N/ha	Reference
Mod.Free*	CAN+wcslry	422	2	1	2	14	Ryan & Fanning, 1999
Mod.Free*	CAN+scslry	423	1	1	2	7	*ibidem*
Mod.Free*	CAN+wpslry	419	5	1	2	35	*ibidem*
Mod.Free*	CAN+spslry	420	1	1	2	6	*ibidem*
Mod.Free*	CAN+wcslry	250	0.3	1	2	2	*ibidem*
Mod.Free*	CAN+scslry	250	0.3	1	2	2	*ibidem*
Mod.Free*	CAN+wpslry	250	0.3	1	2	2	*ibidem*
Mod.Free*	CAN+spslry	250	0.3	1	2	2	*ibidem*

wcslry = winter cattle slurry; scslry = spring cattle slurry; wpslry = winter pig slurry; spslry = spring pig slurry. *low N reserves in soil.

Apart from two values, nitrate-N concentrations were generally well below the drinking water EU maximum admissible concentration (MAC) of 11.3 mg/litre. The soils with low N reserves had grown barley for 6 years (thus depleting organic N). They then had a 3-month fallow period, following the first grass experiment, resulting in a flush of released N prior to sowing grass for the second experiment. The soils were thus depleted in soil N contributing to the low nitrate-N concentrations measured. Allied with dropping the N input from 420 to 250 kg N/ha brought nitrate-N concentrations in drainage water (at 1 m deep) to very low levels of 0.3 mg/l. Higher concentrations would be expected under grazing conditions. Also it must be remembered that leaching results at depths of 1 m do not represent corresponding concentrations in deeper groundwater.

The effects of CAN fertiliser (300 kg N/ha) plus cattle or pig slurry (120-123 kg N/ha), applied in winter/spring as before, on nitrate–N leaching, at 1 m deep, under grass-cutting conditions, were compared (Ryan and Fanning, 1996; 1999) in another experiment on five soils. After two years the soils were cultivated, fallowed for four months and resown to grass. Results are shown in Tables 3 and 4.

Table 3. Two year mean effects of soil and N application (kg/ha) on nitrate-N leaching (kg/ha) and nitrate-N concentration in grassed soil lysimeters, 1m deep.

Soi	Drainage	Slurry type	N Appl	N Leach	Conc. mg/lN	Slurry type	N Appl	N Leach	Conc. mg/lN
Comer	Poor	wcslry	423	16	3	spslry	420	10	1
Clrch	Free	wcslry	423	54	7	spslry	420	65	8
Elton	Free	wcslry	423	66	10	spslry	420	44	6
Okprk	V.free	wcslry	423	79	10	spslry	420	35	5
Rthgn	Poor	wcslry	423	47	7	spslry	420	38	6
Comer	Poor	wpslry	420	28	4				
Clrch	Free	wpslry	420	87	12				
Elton	Free	wpslry	420	63	9				
Okprk	V.free	wpslry	420	100	13				
Rthgn	Poor	wpslry	420	71	11				

Comer = Castlecomer; Clrch = Clonroche; Okprk = Oakpark; Rthgn = Rathangan.

Table 4. Pooled effects of cultivation, 50 kg fertiliser N/ha, sowing grass (Yr 3) and fertiliser (200 kg/ha) + slurry (50 kg/ha) N applications (kg/ha) in years 4 and 5 on nitrate-N leached (kg/ha) and nitrate-N concentration.

	Mean yr 3			Mean yrs 4 and 5		
	Appl	Leached	mg/lN	Appl	Leached	mg/lN
Comer	CAN 50	177	23	251	1	0.3
Clrch	CAN 50	195	24	251	4	0.8
Elton	CAN 50	286	36	251	4	0.8
Okprk	CAN 50	294	35	251	2	0.4
Rthgn	CAN 50	266	34	251	2	0.5

The drainage water from the Clonroche and Oakpark soils (receiving fertiliser plus winter pig slurry) breached the MAC, while water from the Rathangan soil was borderline. Fertiliser plus winter cattle slurry resulted in high values for the Elton and Oakpark soil water (Table 3). In years 4, 5 reducing the N input severely reduced the loss of N. This was also influenced by a flush of released N which occurred in year 3 from cultivation, 4 months fallow and a small fertiliser input of 50 kg/ha at sowing, giving high nitrate-N concentrations of 23-36 mg/l (Table 4). Mineralisation of soil organic N and absence of a crop to utilise released N would have caused elevated nitrate-N concentrations in the drainage water.

Irish research results-cereals

Cereal crops stop assimilating N around July but soil microbes continue to liberate soil organic N into the autumn, resulting in the accumulation of large amounts of nitrate-N, which may leach to groundwater with the autumn-winter rains. Studies (Ryan and Fanning, 1999; Ryan, Sherwood and Fanning, 2001) at Johnstown Castle in lysimeters show that loss of N, as measured at a depth of 1 m, is high from fallow land declining over time (Table 5).

Table 5. Effect of crop (barley, winter wheat and fallow) and treatment (kg N/ha applied) on mean nitrate-N concentration (mg/l) and loss (leach) of nitrate-N in drainage water.

									Fallow				
Crop	Yrs in tillage	kg N/ha Appl	leach	mg/l N	kg N/ha Appl	leach	mg/l N	kg Appl	N/ha leach	mg/l N	kg Appl	N/ha leach	mg/l N
Barley	1-3	0	86	12	100	50	11	-	-	-	0	171	21
Barley	10	0	13	2	120	32	5	180	36	6	0	76	12
Wheat	12	0	11	3	150	11	3	200	18	6	0	56	16

Table 5 shows high nitrate-N concentrations in the drainage water from the cereal, early on in the rotation, which declines significantly over time so that by year 10 concentrations are very low. Fallow soil releases high amounts of organic N resulting in high nitrate-N in the drainage water to year 12; it was year 14 before the mean value in the fallow treatment declined below 11.3 mg/l (MAC). The 76 kg N/ha lost from the fallow land is the same amount estimated as lost from ploughed land to rivers in the south-east in 1985-86 (Neill, 1989).

Losses in practice

Little is known in Ireland re: losses from farm-size, grazed plots. However, estimates of excretion can be made e.g., a 250 kg steer ingesting 6 kg forage DM containing 3% N will ingest 180 g N/day, retain about 20 g (12%) and excrete the remaining 160g N/day. Excretion as faeces and urine both result in volatile losses of ammonia. About 74% of the total N excreted is in the urine and a single urine spot can have an N concentration corresponding to 600 kg N per ha. Some of the N is released to the atmosphere as volatile ammonia while the N remaining in the excreta and associated plant residues returns to available N pools in the soil. At times of low pasture growth and downward movement of soil water, such returns to the N pools in autumn increase the risk of nitrate leaching (Sherwood and Ryan, 1990; Follett, 2001). In denitrification studies, loss of 4.6% of 362 kg/ha applied N, as nitrous oxide, was measured on a slightly impeded soil over 1 year. Wetter soil would have higher loss for the same N input.

Conclusions

Lysimeter studies have shown that winter application of slurry in addition to high fertiliser N, creates risk of nitrate leaching on some free-draining soils; lower risk is associated with spring slurry applications. In small plots, Mulqueen *et al.* (1999) found very low nitrate leaching from pig slurry application to grass in December on Athenry soils; similar results were obtained from low N inputs to a range of N- depleted soils. Runoff experiments have shown the impact weather conditions can have on nutrient losses to water; only one third of Irish soils are vulnerable. Nutrient loss is important because when waters become too enriched, the aquatic environment can become eutrophic. Leaching losses from well - managed grass are lower than from early rotation barley; continuous cereals leach very little nitrate. Cover crops could reduce winter leaching from uncropped land, which tends to leach easily; the management required to successfully achieve this without harm to succeeding crops requires research. Gaseous N losses Ireland, especially with regard to ammonia, are not well documented; limited information exists on nitrous oxide loss.

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Environmental legislation, current and pending and its implications

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Introduction

The scope of this paper is confined to environmental legislation of immediate concern to farmers. This includes the major EU Directives which Ireland is currently under pressure to implement, notably the Nitrates Directive (91/676/EEC) and to a lesser extent the Waste Directive (91/156/EEC). The on-going implementation of domestic water pollution legislation is also considered including agricultural bye-laws and mandatory nutrient management planning. The Nitrates Directive has generated a particularly vigorous debate in farming circles not least because it seeks to limit the maximum amount of manure from livestock that may be applied to land each year. In order to comply, some intensively stocked farmers may have to reduce stock numbers or alternatively arrange for some manure to be spread off the farm on less intensively stocked land. The paper is primarily focused on this Directive.

Nitrates Directive Overview

The Nitrates Directive is in place since 1991. The objective is to reduce water pollution, caused or induced by nitrates from agricultural sources and to prevent further pollution. Member States are required to identify waters affected by pollution and waters that could be affected by pollution in the absence of corrective action, and to designate these areas as Nitrate Vulnerable Zones (NVZs) on the basis of the monitoring results. Action Programmes containing mandatory manure management measures are required to be implemented in NVZs. In addition, a Code of Good Agricultural Practice (CGAP) has to be established and implemented within NVZs. Alternatively, Member States may decide to adopt a 'whole territory' approach which implies that the CGAP is binding on all agricultural holdings in the state. Member States are obliged to monitor the nitrate concentrations in waters and to assess the impacts of the measures put in place. The designation must be revised every four years, taking into account changes and factors unforeseen at the time of the previous designation.

Nitrate Vulnerable Zones

The 'whole territory' approach was adopted in Austria, Denmark, Finland, Germany, The Netherlands and Luxembourg. This does not automatically imply that the whole territory is exceeding the EU norm of 11.3 mg $N0_3$-N/l in ground and surface waters. The degree of pollution does not explain why a country may choose the 'whole territory' or NVZs, otherwise The Netherlands and Finland would not be in the same group. It seems that these countries wish to maintain a level playing field between farmers in different geographical locations. They also commit themselves to uniform environmental standards and to promoting environmental awareness among all farmers. In Ireland, the whole territory approach would also facilitate national regulations to implement the Waste Directive, also overdue.

In other Member States, regions with significant nutrient surpluses are differentiated as NVZs. A large part of Belgian livestock production, for example, takes place in Flanders and causes severe nutrient surpluses. Several sensitive areas in Flanders have been identified. In other intensive production zones such as Brittany in France and the Po valley in Italy, governments designated NVZs and introduced measures to rectify nutrient imbalances.

Whole territory versus NVZs

Reasoned arguments for and against both options can be made. However, lack of knowledge of possible derogations that may be negotiated on organic N limits is a major drawback in this debate. In addition, economic assessments of either the whole country or NVZ option for the proposed range of organic N limits are not available.

With the 'whole territory' approach, all farmers in the country would be obliged to comply with a national action programme. This would be likely to improve national manure management practices and water quality and provide the basis for negotiating a derogation to retain an organic N limit of 210 kg/ha after the first four years with provision for up to 250 kg/ha organic N in certain circumstances. All farms would be treated the same and there would be certainty that there would be no further widening of the designated area. An important disadvantage of this approach is that it affects farmers in areas where the level of nitrates in water is minimal. Compliance costs for agriculture (particularly in regard to additional manure storage) would be higher, though these could be offset against the cost of compliance with the similar measures (excluding organic N limit) to be applied on a national basis under the EU Waste Directive.

The main disadvantage of the NVZ approach is the likelihood that water quality may not improve in the first four years prompting a reduction in the organic N limit to 170 kg/ha. Given that the proposed NVZs account for the more intensive agricultural areas in the country covering large areas of the east and south of the country this would be a severe blow to future expansion. The NVZ option would generate uncertainty for farmers outside the NVZs in that the four yearly reviews of water quality may require the designation of further areas. This has been the experience in other countries. The advantages of the NVZs are the targeted approach to dealing with nitrate-polluted waters and only farmers in the NVZs would be required to comply with the action programmes.

Action Programmes

Action programmes are key requirements of the Nitrates Directive. They require mandatory restrictions on farming activities in NVZs including balanced nutrient inputs (i.e. the sum of nutrients from organic and mineral fertilizers must not exceed the crop needs) and a maximum application of 170 kg N/ha/year from animal manure (210 kg N/ha/year in the first four years). The Directive allows a Member State to negotiate a derogation from the 170 kg per ha restriction after the first four years, but only where this is justified on the basis of objective criteria, and does not prejudice the achievement of the objectives of the Directive.

Denmark has recently won a derogation for its dairy farmers to apply all the manure produced on their farms on their own lands. This implies that the 170 kg N/ha would no longer be binding as long as the N demand of the crops is significantly higher than the N supplied by the manure. The derogation is limited to existing grassland farmers and the milk quota will limit extensions to other areas. The derogation applies to 5 % of agricultural soils in Denmark and to 6 % of the total N in animal manures. In winning their case the Danes had the following supporting data — over the last 15 years there has been a significant reduction in fertilizer N inputs as well as reductions in the N levels at the root zone. Agriculture had reduced its point sources by 28 %. The nitrate concentrations in rivers draining agricultural areas had dropped by 20 %. Eutrophication of coastal waters had begun to decline. They had data from trials to show that with good management practices there was no difference in N pressures between 170 and 230 kg organic N inputs. They also have a limit of 140 kg organic N/ha for the rest of the country. (O.T. Carton, pers. communication).

An action programme can relate to all NVZs or to each one separately. Portugal, for example, has designated three NVZs and has set up a different action programme for each of these, while Sweden has designated five NVZs in which the same programme is implemented. In the countries with the whole territory approach there is only one action programme which may vary in certain respects across the territory.

Seeking a national derogation

The responsible Government Department has indicated a preference for the 'whole territory' approach to the implementation of the Nitrates Directive. In the event that this approach is adopted, Ireland needs to negotiate a derogation to retain a national 210 kg organic N/ha limit after four years with provision for up to 250 kg/ha N for high stocked farms where in can be demonstrated that this is not in conflict with the water quality objectives of the Directive. Clearly, there would be income implications for intensive grassland farms particularly on the higher stocked farms if an organic N limit of 170 kg/ha were imposed. This would reduce the stocking rate equivalent from 2.5 to 2 LU/ha. There would also be serious cost implications for intensive pig and poultry enterprises in relation to securing spreadlands.

A coherent negotiating strategy will be required based on the overall impact of the national action programme. This will revolve around the scientific input to the development of the action programme, the quality and degree of commitment to implementation and the advice and investment support available to underpin implementation. Reductions in nitrate emissions from Irish agriculture to water will be achieved through improvements in farmyards, manure and fertilizer management rather than by controlling stocking rates. Ironically, the latter is likely to be the easiest to enforce using Area Aid and Herd Register data. Making the case for a derogation represents a significant challenge. Germany recently (March 2002) failed in its attempt to achieve a higher national organic N limit.

In addition to monitoring water quality, a baseline survey of facilities and practices at farm level is required. A repeat survey will be needed after the four-year period to monitor improvement. Water quality responses to changes in nutrient management practices at farm level need to be demonstrated. Success or failure will depend on the recorded changes associated with the action programme as well as the recorded impact on water quality.

Code of Good Agricultural Practices

Codes of Good Agricultural Practices have been introduced in all Member States. These codes regulate manure storage capacity, spreading conditions and timing, spreading technology and the application norms for different crops. In some countries the codes are very detailed and intended as advisory instruments for farmers (e.g. UK). Some include the requirement for mineral accounting (e.g. some regions in Spain), while others only contain the bare minimum of requirements (e.g. Greece). Point sources are a major problem, for example, inadequate or leaking manure storage facilities or uncontrolled silage effluent runoff. In this context, improved technical standards are very efficient in preventing pollution. Storage tanks and equipment can be easily inspected for compliance with existing norms. In France regulations are implemented which require bigger farms to be certified in the same way as industrial plants with an environmental impact assessment. This is similar to the IPC licensing arrangements for certain pig and poultry units in Ireland.

The practicability and cost of the control measures need also to be considered. Extensive on-farm research and courses are used in The Netherlands to make farmers familiar with legislation. In Denmark a considerable effort is required by farmers each year to adjust their fertilizer plans depending on plant growth forecasts. The effectiveness of these measures is closely linked with the control mechanism administered by the government. Some other countries have comparable control systems, but in many, the implementation of the measures is not scrutinized. Although a certain level of control is required to implement the policies, extensive control is costly and time consuming. If, according to the EU 'polluter pays' principle, the costs are to be passed on to farmers, this will be an extra burden on farm incomes.

Infringement Procedure

The infringement procedure gives the Commission powers to take legal action against a Member State that is not respecting its obligations. Infringement procedures are ongoing against almost all Member States except Denmark and Sweden. The infringement procedure contains several possible actions. A 'Letter of Formal Notice' is the first step. In the light of the reply from the Member State, the Commission may decide to address a 'Reasoned Opinion' or second written warning. If the Member State fails to comply with the 'Reasoned Opinion', the Commission may decide to bring the case before the European Court of Justice. Finally, Article 228 of the Treaty gives the Commission power to act against a Member State. In April 2000, 9 countries (Belgium, France, Greece, Germany, Italy, Luxembourg, The Netherlands, Spain and the UK) were facing a charge before the European Court of Justice regarding the implementation of the Nitrates Directive (Environment Daily, 2000). Ireland has now joined this list for failure to implement the Nitrates Directive.

The Nitrates Directive and the CAP rural development plan

At the insistence of the Commission, Ireland's Rural Development Plan included a commitment to implement the Nitrates Directive by the end of 2001. The Commission has indicated that it may suspend the co-financing of the Compensatory Allowances, REPS, Forestry Measure and the Early Retirement Scheme if action on our commitment is further delayed. The Commission has already decided to block Ireland's proposed amendment to the Compensatory Allowances measure. While it was made clear that the amendment itself is acceptable, it appears the Environment Commissioner is not prepared to agree to it until Ireland has taken action to implement the Nitrates Directive. At least 100,000 farmers are claiming aid under one or other of the schemes in the Rural Development package. Eleven years after the Nitrates Directive was published and with legal proceedings pending, Ireland is in a vulnerable position compared to most other Member States given the dependence on EU transfers. The Commission has the means to penalize Ireland without recourse to the European Court of Justice.

Manure Regulations at Farm Level

The Department of the Environment and Local Government has signaled the need for legally binding Regulations to give effect to the Waste Directive and the Water Framework Directive in addition to the Nitrates Directive. The established CGFP is expected to form the basis for these Regulations. The Department has indicated that an unduly onerous regulatory regime is not intended. It is envisaged that the Regulations will allow for flexibility to reflect regional variation due to climate, rainfall and soil conditions. This would provide for differences in slurry storage requirements and non-spreading periods across the country. There is an assurance that farmers will not require licenses or permits to landspread animal manures on their lands, but it is proposed that all farmers will have to register with a Local Authority and provide some basic information on the location, nature and scale of their activities. Additional controls are proposed for inter farm transfer of animal manures.

Waste Regulations for Contractors

The Waste Management (Collection Permit) Regulations (2001) will govern the activities of agricultural contractors involved with the landspreading of animal manures. Implementation of the Regulations for agricultural contractors has been deferred until the 30^{th} June this year (2002). The regulations will place a general obligation on contractors who 'collect waste for the purpose of reward or profit' to obtain a permit. Collection includes the 'transport of waste' and 'acceptance of control of waste'. Contractors will be required to submit records of work carried out by the 28^{th} February each year. The permit fee is €1,200, though there is provision for the licensing authorities to refund or waive all or part of the fee. There is concern that smaller operators may find the new Regulations too onerous to continue and this should be taken into account in regard to the waiving of the permit fee. More rather than less slurry spreading capacity is required and the emergence of more contractors who are prepared to supply slurry spreading services in tandem with silage making operation are especially needed.

Additional Local Authority Powers

The sanctions available to Local Authorities under the Water Pollution Act (1990) have been strengthened to include agricultural bye-laws and compulsory nutrient management planning (NMP). Bye-laws, introduced under Section 21 of the Act, are now in force in parts of five local authority areas (Cavan, Cork, Offaly, Tipperary NR and Westmeath). They have been adopted in all cases to deal with specific problems in specific catchments listed by townland. Six more local authorities have made proposals to bring in bye-laws and a further five are assessing the need for them. So far, bye-law slurry storage requirements vary from 14 weeks in Offaly to 24 weeks in Cavan. In general, where a farmer submits a full nutrient management plan the bye-laws permit a 4 week reduction in the storage requirement. REPS farmers are generally exempt from bye-laws provisions on the basis they are already in compliance. Up to 2,000 farmers are currently affected by this measure.

Under a separate section of the Water Pollution Act (Sec. 21A) local authorities have powers to compel individual farmers to submit nutrient management plans where this approach is considered necessary to prevent or alleviate water pollution. As is the case with bye-laws, a REPS nutrient plan is deemed to meet the requirements of this measure. At least 18 Local Authorities have indicated their intention to introduce mandatory nutrient management planning (NMP) mostly in the short term (2002). The Department of the Environment and Local Government has issued detailed guidelines on the preparation of nutrient management plans to local authorities. The guidelines provide criteria for identifying "hot spots" including sensitive lake and river catchments where resources are to be focused. Three factors are required to be addressed as follows:-

- manure storage and management practices in the farmyard;
- land application of manures and chemical fertilisers;
- controlled use of chemical fertilisers (ie. in line with crop requirements).

It is understood that this measure will be implemented once specialised training of local authority staff, currently in progress, is completed. In contrast to the bye-laws this measure does not have to be voted in by local authority members.

There is significant overlap between these measures and the requirements of the proposed National Regulations under the Nitrates Directive. There is speculation that the latter may remove or reduce the need to enforce the bye-law and mandatory NMP provisions of the Water Pollution Act. This would make sense. Farmers would then have to cope with the record keeping etc. associated with just one set of regulations rather than several separate sets. This would favour the 'whole territory' approach to the implementation of the Nitrates Directive.

Conclusion

It is widely accepted in farming today that agriculture must respect the environment. This is impacting positively on farming methods and practices. It is also clear that more needs to be done. While regulation has a place it is only part of the solution. The vital roles of awareness building, education and investment assistance needs greater acknowledgement. It must be understood that broad-based farmer consent and support for environmental objectives is necessary if regulation is to have the desired effect.

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The future of the Irish Dairy Industry- the IGA submission to the Department of Agriculture

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The Irish Grassland Association was invited by Mr. John Malone, Secretary of the Department of Agriculture and Food at its Dairy Conference in 2001 to make a submission to him and his Department outlining the views of the IGA on the future of the Irish dairy industry.

The Council of the IGA looked on this invitation as a great opportunity to point out some of the problems and possible solutions for our dairy industry going forward.

Although this is outside the role of the Irish Grassland Association (IGA), council members felt that on this one occasion the IGA should comment on the state of the industry and provide some alternative views going forward. As the association is non political and draws its members from all elements of the dairy industry (farmers, advisors, researchers and agri-business personnel), the council felt that the IGA could offer some constructive comment. Within the association it is believed that dairying has the potential to be a leading industry in the Irish economy, but changes must take place if we are going to realize this potential.

After New Zealand, Ireland has the potential to have the best thriving dairy industry in the world - certainly in the Northern Hemisphere we should be the leaders.

- We have a climate ideally suited to growing grass;
- Animals can stay out on grass for 9 to 10 months of the year;
- High emphasis on grazing is an environmentally friendly way of dairy farming, which is highly profitable;
- These advantages must be worked on to provide a thriving dairy industry to benefit farmers and ultimately the Irish economy;
- Progressive dairy farmers are frustrated at present due to the lack of opportunities to expand. The ability to expand is the key driving force for any progressive business;
- Quotas inhibit progress, as other farm enterprises are not returning sufficient income for dairy farmers to change;
- Nationally we need to focus on dairy farming, as it is the only enterprise that can give a good income to the farming community.

There have been significant changes in the economy in the last 10 years. In 1990 agriculture accounted for 10% GDP and 15% of total employment compared to 5% GDP and 9% of employment by 1999.

Industrial wages have increased by over 40% in the last 10 years. This increase has resulted in a large divergence between industrial and agricultural incomes. Inflation averaged at 5.6% for the year 2000 according to the C.S.O. Due to inflation farmers can expect a substantial increase in production costs. Costs such as labour, energy and services are all projected to increase substantially over the next number of years. The F.A.P.R.I. Ireland Partnership has projected that such costs will increase by over 25% in the next 10 years. Also the purchasing power of incomes earned will be significantly diminished due to inflation.

Young people are lured out of farming by the prospect of high paid jobs for less working hours. Further farm labour is difficult and expensive to secure.

The number of children on farms is projected to decline further. The Kennedy William's Report projects that by 2011 there will be little over 12,000 children of school leaving age living on farms between 16 and 23 years of age. This is 58% less than the 1996 estimate. If the potential number of future farmers is decreasing at such a rate, then the actual numbers will inevitably decline, unless there is more scope for young people from non-farming families to enter agriculture.

There has been considerable change in the agricultural policy of the E.U. under the Agenda 2000 Agreement and it seems that all farmers can expect even further changes into the future. By 2010, the price of milk will drop and dairy farmers will get compensation under Agenda 2000. Revenue will be up 6% relative to 2000 levels. However, high rates of inflation mean that farmers will be subjected to price cost squeeze. Strong growth and inflation rates, higher than those experienced in recent years will result in continued increases in production costs. Fixed costs are projected to increase by 15 to 20% thus impacting negatively on farm net margin. ***Farmers who do not respond by increasing efficiency or enlarging operations will be exposed to a price cost squeeze***. Dairy farmers will have to run faster to stand still.

Smaller farms with a quota of 20,000 gallons or less which have a poor historical growth record and cost structure will be unable to expand milk quota at the current fixed restructuring price of €1.57 per gallon. Some 11,000 farmers may find that the future of their farm is not viable and may exit dairy farming. If quotas were eliminated this same group of farmers would find it very difficult to survive. Research has shown that up to one third of producers currently supplying less than 35,000 gallons would find investment unfeasible, given the level of cash surplus remaining. Further it has been shown that where investment was feasible, between 20 and 30% of the current population (depending on the price scenario) would have a disposable income lower than the minimum wage.

Under Agenda 2000 farmers supplying 20,000 gallons or less become non-viable by 2003/2004. The same farmers also become non-viable in a non-quota situation. These facts cannot be ignored.

If there is a large exodus from farming prior to milk quota elimination then quota will be available on the restructuring market. If those farmers who remain in dairy farming can increase their production by acquiring quota then their future following quota elimination may be brighter as they will be in a better starting position and therefore will not need the same magnitude of expansion.

The following are areas where changes can take place.

1. Elimination of Milk Quotas

We see elimination of milk quotas as a priority. Possibly in the past it had its merits but that time has long gone. As already stated the potential that Ireland has to produce milk cheaply from grass must be exploited to its full extent. It is argued that this can only be done in the absence of quotas. This will allow committed dairy farmers an opportunity to grow, and will present the opportunity for young vibrant people to join the dairy industry, something that is not happening at present.

At present there is a drift to an inefficient industry because dairy farms cannot grow and develop. Inflation is rampant in this tiger economy and it will impact negatively on dairy farming. Costs of production will increase while output prices are relatively frozen under the Agenda 2000 Agreement. Farms will be exposed to a price costs squeeze and the purchasing power of incomes will fall due to inflation.

In light of this it should be a national priority that quotas be eliminated. As the accompanying paper shows the largest capital requirement would be for new housing and milking parlors. Capital for housing can be reduced substantially with the use of low cost winter facilities such as stand off pads and keeping cows on grass for longer as we develop our knowledge in this area. The number of cases where additional land is necessary is quiet low. This is a reflection of the large proportion of non-dairy livestock kept on dairy farms. Livestock that in general provides little or no income.

2. Greater movement of milk within present system

Greater movement of milk within the present quota system is needed. It is suggested that the present price for restructuring milk remains for one year and is then reduced to a very low level. Such a policy should be well documented in advance and would have the effect of reducing the value of quota and flushing out those individuals who are holding on to quotas in order to get a high price. This would free up quotas at a faster level. From the beginning of the next quota year milk should not be collected from farms that are not certified. These farmers have been given ample time to certify, and they bring down the standard of milk in general. This policy would bring out more milk, which can then be redistributed, e.g. to young trained farmers, who should be given large quantities of milk say 50,000 gallons minimum and not drip fed 1,000 gallons every year.

Milk should be distributed on a more equitable basis to all quota holders including those over 55,000 gallons. These are the people who drive the industry forward; they should not be discriminated against.

Milk should not be ring fenced into less economic areas, but rather moved into areas where it is more economic to produce it. While politically this policy might not be acceptable, there is no doubt that on an economic basis this is the way forward.

The administration of quota must be changed. The control of quota by dairy companies is not the desired situation as it allows them too much power. Farmers should have the right to move quotas as they wish. Also with dairy companies having control over quotas, it is slowing down the restructuring of the dairy industry.

3. Change in Butterfat Reference level

The Irish butterfat reference level of 3.58 is too low in comparison to other countries in Europe, e.g. the butterfat level in Holland is 4.23%. By 2010 the Irish butterfat level will be at 3.85, which will result in a loss of 121m l of milk in volume terms. This is effectively a penalty for good farming and breeding over the last number of years. Extra butterfat can also be turned into product and sold benefiting the industry as a whole. It would seem ridiculous that from 2002 there will be one common currency, yet quotas are all based on different reference levels. Changes here are necessary if only on the basis of equality within Europe.

4. A and B Quota

Ireland should fight for an A and B quota system, although it is recognized that this may pose difficulties under WTO as stated in the accompanying paper. However, it would be another angle to get more milk production in Ireland. The production of B quota milk would not be a problem for a lot of producers. They are already producing milk at world prices when quota lease and land lease (that is not needed for quota production) is taken out of the milk price. A and B quota would also prepare the Irish dairy farmer for the day when quotas will cease.

Summary on quotas

Milk production is the only farm enterprise that can return a good living in Irish farming terms. We can grow grass, the raw material of milk production cheaply. Into the future, the dairy markets have potential. After New Zealand we can be the most efficient dairy industry in the world, but we need to focus and change in order to be able to achieve this objective.

We can change in the following ways:

- Look for the elimination of quotas; they are suffocating the dairy industry;
- Free up quota within the present system; give milk to those who see a long-term future in the industry;
- Look for a change in butterfat reference level; within the EU there is a common currency why not a common butterfat reference level?
- Look for an A and B quota system; it may not be possible but it will serve notice that Ireland values the dairy industry, and intends to protect and increase it in the future.

If we do not make changes now the dairy industry will regress, young people will continue to leave the industry and inflation will eat into incomes. Steps must be taken now to reward people for their enterprise or the long-term future looks bleak.

*(Statistics from Thia Hennessy, Teagasc - Irish Grassland Association Dairy Conference September 2001)

Industry

The Irish dairy processing industry is a very rigid structure. It has evolved over many years to its present structure of two large PLCs and a range of farmer owned co-ops and many different disciplines. It is a high cost industry, with only a small amount of national milk pool going into added value products. The production profile for milk insures a continuing dependence on commodity products. Commodity products processed through small plants are inefficient. There is little prospect of this changing in the near future. The Irish dairy industry will not change because it is told to do so. History clearly illustrates this fact and it is for this reason that the IGA feels that it would be futile to suggest how the industry should rationalise or restructure. This is not to say that change is not needed!

The IGA urges the Minister to proceed as soon as possible with the proposed study of costs in the industry. It is only when armed with facts that an informed debate can take place and that the reality of the situation becomes clear. Somebody must drive the debate forward. DAF may not be able to fill this role but it can exercise its authority to get things started and also suggest a suitable candidate for this role.

The dependence of commodities and the role of the Irish Dairy Board (IDB) in the marketing of Irish products needs to be looked at. Any study of the industry must include an analysis of the IDB. There are many factors that will impinge on the future viability of Irish dairy farmers, and it would be irresponsible not to try and influence the industry in whatever manner possible. Any factors that may impede restructuring of the industry should be removed. For example, quota administration handled by the co-ops may be an impediment to change, there may be others and any study undertaken must consider all the factors.

Environment

At the outset, the IGA recognises that need to maintain and enhance the environment, and that farmers can no longer engage in practices that are leading to deterioration in water quality.

There is a whole range of issues we that could be discussed, but remarks will be confined to the Implementation of Nitrates Directive 91/676 EEC.

The 3 areas of water quality under this Directive are:

- Surface fresh waters, lakes/rivers
- Ground waters
- Estuaries and coastal waters.

1. Basis for Restrictions

Nitrate vulnerable zones are about to be declared in Ireland. In general terms, when expressed as a percentage of the land area of the country, these are relatively small in area.

However recent suggestions by the EPA and or the Department of the Environment on what constitutes eutrophic in estuarine waters is extremely serious. In fresh water, 50mg of nitrates/l is the level of N, above which there are problems. In estuarine waters it is understood that this level is only 11 mg/l. If this is adopted, it is thought that up 30% of the country could be declared to be in a nitrate vulnerable zone. The basis for this nitrogen level needs to be subjected to rigorous scientific debate.

2. Organic Nitrogen

The Directive states that levels of organic N should not exceed 210 kg N/ha (which is based on 85 kg organic N produced per cow). However if the nitrate problem is not solved in four years the current thinking is that the level of organic N be reduced from 210 to 170 kg organic N/ha. This would cause stocking rates to be reduced to two cows/ha. Intensive farmers would suffer severely under this ruling. At 210 kg N/ha Thia Hennessy, (Teagasc, 19 Sandymount Ave.) has suggested that 14% of farmers would be adversely affected, while if 170kg became the norm some 31% of dairy farmers would be adversely affected.

However, the Directive appears to give considerable leeway to individual countries to modify this figure, if necessary. It is suggested that Ireland has an excellent case for having organic N levels significantly higher than the 170kg/ha. i.e.;

- There is a long growing season in Ireland,
- Grass is a crop with excellent capacity for nitrogen uptake.
- There are no significant quantities of land lying fallow in winter.

In view of the very strict ruling applied to what is termed estuarine pollution, every effort must be made to raise the 170kg N/ha level, and keep it at 210 kg N /ha. Just how definite the 170kg N/ha is should be explored by DAF.

3. Unfairness

There is considerable 'unfairness' in this Directive, in that both the polluter and the non-polluter pay. All in the catchment suffer, even those who are doing things right. Furthermore those 'good' farmers do not get compensation. There is a case to be made for those people that are doing things right be exempt from the ruling, or at least, allowed to keep to the 210kg N/ha.

4. Organic N

All the above organic N recommendations are based on the cow producing 85 kg of organic N per year. There is a danger that this could be altered, which would make the situation even worse. For example if the 85 kg N/cow were increased to 120 kg N/cow, the stocking rate at 210 kg N/ha would be reduced to 1.75 cows/ha. At 170 kg organic N the stocking rate would be reduced to 1.4 cows/ha. This would be a disaster for commercial dairy farming.

5. Blunt Instrument

All these measures imply that reducing the stocking rates will automatically lead to reductions in nitrates in water. Is this necessarily true? At best, it is a blunt instrument. Issues like i). spreading of slurry at incorrect rates, in the wrong place and at wrong time; ii). control of farmyard hygiene; iii). spreading too much nitrogen at the wrong time of year, are all equally, if not more important. Tackling these may rectify the problem quicker and do less damage to the dairy industry.

Summary

Is there a sound scientific basis for the N levels used to determine estuarine pollution? The 170 kg of organic N/ha after 4 years will cause significant hardship for Irish farmers. Can this be changed? Why should good farmers be forced to reduce stock numbers without compensation? Every effort must be made to maintain the 85 kg of organic N per cow, regardless of the type of cow.

Surely, there must be other, less drastic ways, of solving this nitrate problem in water?

Research

It is fundamental that Irish agriculture continues to have the benefit of up todate, profit led, independent and well-financed research. Agriculture is one of the most important export industries and employers in Ireland. Therefore it is vital that all sectors within agriculture benefit from research and development - farmers, researchers and the manufacturing/processing industries.

The IGA emphasize the importance of up to date independent research and development in soil, grass varieties and grassland production. As grass is our cheapest natural resource it is critical that all is done to keep its benefits to the farmer to the fore. In the recent past, other well funded crop production systems, e.g. maize, corn and silage systems are being promoted and funded by their supplying industries and are gaining in popularity with somewhat questionable long term benefits. These crops need well funded on going research into methods of establishment and agronomy, whereas grass regenerates providing a natural feed for all our animal production systems. Grass and grassland production needs the same level of research and funding as the aforementioned crops, but it is vitally important that this research remains independent of industrial funding.

There is an urgent need for new science and research graduates. Acting on this will allow Ireland to retain its competitive advantage as a provider of cheap cleanly produced food for its many export markets. Our "green" image of food production needs to be enhanced.

Education

It is important to acknowledge recent changes in agricultural education and to allow for these changes to take effect. However, it is equally important that agricultural education should be developed and funded to the same extent as other educational sectors, ie CIT, Regional Colleges and Universities. In most colleges, agricultural training and education has been the poor relation with inadequate facilities. There is an urgent need to have all facilities updated to allow an atmosphere of importance and popularity, which will be to the benefit of the student and the industry in general.

Information technology

Information technology (IT) is in its infancy in terms of practical application for farmers. However the farming community will have to embrace this technology and use it to minimise bureaucracy and the paper work involved in day-to-day farming. Farmers will adopt, provided systems are simple and in turn lead to an easier management system. It is also critical that farmers can access relevant information from the DAF to enable them to process headage, forestry, arable aid and area based payments more readily.

Milk pricing revisited: equity, transparency and producer incentives

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Introduction

Milk pricing is at the axis of the relationship between milk processor and milk supplier. Pricing schemes have developed over time reflecting an evolving value relationship between milk processor and producer in response to a changing market environment. The demand for milk at farm level is derived indirectly from the market demand for numerous processed dairy products. Milk payment schemes provide the means by which the price paid for milk at the farm gate is related to the market returns that can be obtained from that milk when processed into final product. The value of milk to the dairy processing industry is a function of its composition and the aggregate profit of the product mix manufactured from the milk. The producer's revenue from supplying milk is a function of the value of milk to the processing industry and the payment scheme used to reward producers (Garrick and Lopez-Villalobos, 1999).

The primary objective of a milk pricing system is that the price paid (received) for milk reflects as accurately as possible the amount and value of products made from it as well as the transport and processing costs incurred. With the exception of liquid milk, the value of milk is directly dependent on its solids content rather than volume. The justification for payment based on constituent composition is therefore inversely related to the importance of the liquid market. In the Republic of Ireland the liquid market is comparatively small, absorbing less than 10 percent of total supplies and there is an overwhelming case for a payment system that encourages and adequately rewards compositional quality.

This paper examines some issues in component milk pricing. Comparisons are drawn with pricing schemes in major milk producing countries. A procedure for estimating market values of milk components is discussed along with the implications of some results obtained. A process of relating price to value with progressive multiple component pricing policies is identified as the way forward.

Criteria for Evaluating Milk Payment Schemes

A milk pricing system can be judged according to its transparency, the extent to which it is equitable to producers and the incentive structure it provides to encourage desirable changes in milk composition.

Equity in Milk Pricing Schemes

The pricing system should be fair to the producer by ensuring that the price paid for milk reflects as accurately as possible the market returns that can be obtained from that milk in terms of processed product. As noted by Keane (1989, p.4) "the basic principle for a payment scheme is that those suppliers with above average solids levels in their milk will generate a higher return from the marketplace and, in strict equity terms, should be entitled to a higher price per gallon/litre." In these terms a payment scheme is inequitable if it results in some producers being paid more than the true value of milk according to its composition while other producers are under-paid for milk of better composition. In addition, while producers are confined by the milk quota system in terms of both volume and butterfat other milk solids are not penalised in this way. Producers should receive fair market value for non-fat milk solids allowing them to increase returns through improvements in milk composition (especially milk protein) over time.

Transparency

A milk pricing system should be transparent in the sense that milk suppliers can easily understand how their milk price has been determined. This should permit producers to assess whether or not they are receiving fair market value for milk according to its solids composition. The system should clearly indicate to producers the relative values of individual milk components within the overall milk price. Improving transparency in milk pricing has implications for the manner in which producer milk statements are constructed (see Keane, 2000). Moreover, producers need to be assured of the reliability of the milk sampling/testing process for determining constituent yields and they must be satisfied that fair and accepted procedures are used in determining values for constituents in the milk price.

Incentives

The milk pricing system has a pivotal role in signalling market values of individual milk components to the producer. The incentive structure provided by the pricing scheme should promote desirable changes in milk composition and provide opportunities for producers to enhance profitability through the production of more valuable milk. While in the past butter-fat was the most important constituent to the processor, changes in the market environment such as increased consumption of low fat products and cheese have meant that the value of protein has risen relative to that for fat. Similarly the expansion in the 'food ingredients' sector has increased demand for milk protein (casein) and to some extent lactose. It is important that the pricing system should adequately reflect changing market requirements and thereby signal these to producers.

Milk Pricing Practice in Ireland

Current milk pricing schemes operated by Irish dairies are essentially 'differential-based' systems. Dairies determine a base price for a reference milk composition (e.g. 3.6% fat and 3.3% protein) and a differential adjustment (addition or deduction) in price per gallon is made for each 0.1% in fat and protein that the individual farmer's milk differs from the base composition. The basic milk pricing equations is:

$$\text{Price/gallon} = BP + [(F\% - FR\%) \times FD] + [(P\% - PR\%) \times PD] \quad \textit{(eq. 1)}$$

Where:

BP is the base price per gallon;
F% is the fat content of the milk;
FR% is the base/reference fat requirement;
FD is the fat differential or incentive paid for fat
P% is the protein content of the milk;
PR% is the base/reference protein requirement;
PD is the protein differential or incentive paid for protein

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While there is consistency in the general pricing system employed by Irish dairies there is considerable variation between dairies in the component differentials (i.e. PD and FD) in the pricing equation. Of twenty dairies listed in a recent milk price comparison (Rea, 2001) the average value for butterfat was 1.12 pence per 0.1% per gallon, however among the dairies this ranged from 0.80 pence to 1.46 pence (Table 1). In the case of protein values, there was even greater variation, with the highest being double the lowest. The average value for protein across the sample of twenty dairies was 1.74 pence per 0.1% per gallon. The average ratio of protein to fat value was about 60:40, however the highest ratio was almost 70:30 while the lowest placed equal values on fat and protein (see Table 1). Moreover, for many of the dairies fat and protein values combined only added to a proportion of the total milk price and a further constant was added to give the total price. The magnitude of this constant varied considerably (Table 1) between dairies with five having a constant amounting to more than 15 per cent of the milk price paid while 10 of the dairies had a constant of less than 5 per cent.

Table 1. Key aspects of pricing schemes for dairies in the Irish Farmers' Journal, milk price league (September 2001)

	Minimum	Average	Maximum
Fat (pence per 0.1%)	0.80	1.12	1.46
Protein (pence per 0.1%)	1.00	1.74	2.04
Ratio protein value: fat value	50:50	61:39	69:31
Constant (% of price)	-4.0	8.8	33.3

International Comparisons

To gain perspective on current pricing policies operated by Irish dairies it is useful to draw comparisons with milk pricing systems in other countries. Milk pricing in Denmark, the Netherlands and New Zealand are considered in the following sections.

Denmark

Under the Danish system milk price is comprised of a number of components: a value for fat, a value for protein, a fixed deduction for milk treatment, a fixed deduction for milk collection, seasonal price differentiation, premia and deductions (Keane, 2000). This pricing system follows a model milk payments scheme produced by the Danish Dairy Board. In determining fat and protein values standard product manufacturing costs are deducted from intervention product revenues for butter and SMP. Milk treatment costs and collection costs are then deducted as a volume related charge. In total this volume related charge under the Danish system has amounted to around 6 pence per gallon (Keane, 2000). The basic price ex-farm derived using this formula is usually much lower than the actual price paid to farmers as substantial supplementary payments on the basis of the financial performance of the co-op are a normal feature of Danish milk pricing.

The Netherlands

Payment for milk in the Netherlands is based on an A+B-C system. Under this system the Dutch include high valuations for fat and protein with a fixed deduction for milk handling and other costs. There are a number of additional premiums including quality premium, tank milk premium, quantity premium, winter milk premium/summer milk levy, supplementary payments at end of year and other payments/retentions (Keane, 2000).

The negative 'C' component of the Dutch milk pricing equation comprises a penalty to discourage added water plus a fixed charge to cover administration and transport costs. Keane (2000) explained that this volume penalty in the Dutch system varies between processors ranging from about 10 percent to 20 percent of the net milk price. Fat and protein valuations are policy decisions of the individual processing companies. Typically, the value of protein is derived from the price of gouda cheese net of processing costs (Keane, 2000). Similar to the Danish system, supplementary payments based on company performance are an important part of the final price paid to producers.

New Zealand

The New Zealand system for payment of milk is essentially kgs of fat multiplied by cents per kg plus kgs of protein multiplied by cents per kg. The protein to fat value ratio is approximately 70:30. The New Zealand Dairy Board (now incorporated within Fonterra Co-operative Group) calculates a single ('pooled') valuation for milk constituents (butterfat and protein) based on expected returns from selling many different dairy products to different international markets net of standard processing costs. This is referred to as the Basic Price and is reviewed quarterly. 'Standard cost models' are used to establish the processing costs associated with the manufacture of virtually every product produced. The model calculations are based on processing milk through efficient New Zealand plants (Bates, 1998). With reference to the Basic Price, dairy companies set a preliminary price, called Advance Rates and this is adjusted quarterly where necessary. In addition, producers may receive supplementary payments based on co-op performance (Keane, 2000).

Issues Emerging from International Comparisons

As shown in Table 1, there is considerable variation in fat and protein differentials applied by Irish dairy processors. Some of this variation can be explained by differences in product mix among companies but even allowing for this the range appears extreme. Moreover, it remains unclear how Irish processors determine their values for fat and protein. This issue appears more transparent in the milk pricing systems for the other countries examined. In these countries, there was a high level of consistency in the milk pricing policies employed with no evidence of the variation in fat and protein values found among Irish processors. This may reflect a greater degree of industry coordination with a central agency providing milk pricing guidelines based on market information. In Denmark, for example, the Danish Dairy Board provides a guideline milk payments system that is almost universally adopted by the industry.

A proportion of Irish dairies include a significant positive constant in their milk pricing schemes. This contrasts sharply with the payment schemes operated in the other countries where a negative term in the pricing equation recognises the cost of handling and removing water in product manufacture. For example, the Danish volume charge is approximately 7 percent of the basic price while in the Netherlands the volume penalty equates to around 15 percent of the base price. Given the small proportion of Irish milk sold as fluid, the payment of a positive constant for volume is hard to justify. Furthermore, the inclusion of a positive constant in Irish payment schemes is an undesirable feature as it reduces the value placed on milk solids and thereby diminishes the incentive for improvement in fat and protein content.

Principles of Multiple Component Pricing

Milk is a flexible raw material as its components can be combined in different proportions to produce many different dairy products. Multiple component pricing (MCP) of milk is defined as the pricing of milk directly on the basis of more than one component: such as fat and protein or fat, protein, lactose and carrier (volume). The primary objective of MCP is that the price paid or received for milk reflects as accurately as possible the amount and value of products that can be made from it (Emmons, *et al.*, 1990a). This is of particular relevance given the variation in milk composition both seasonally and between producers and the fact that yields of products such as butter; skimmed milk powder (SMP) and cheese are directly dependant on the solids composition of milk supplied to the processor. In the strictest sense, the economic value of the solids components of milk should be based on the value (price) of the products in which they are used, less processing and marketing costs and costs of other ingredients (Hillers, *et al.*, 1980).

The task of estimating component values based on their values within the marketable dairy products is a difficult one. Component values vary according to the product mix into which the milk is processed. Different milk products contain different proportions of milk components and have varying market prices and processing costs. For example, milk protein is likely to have a higher economic value when manufactured into a more profitable product like cheese than into a less profitable one such as SMP. A MCP system involves the processor paying directly for milk components as reflected in end products of visible market value (i.e. butter, cheese, etc). The value, or cost, of each component must be closely related to its value, or cost, to the processor. While milk solids constituents have positive values, the value of water (volume) is generally negative as it must be transported, handled and removed in processing. The cost of processing milk, up to the packaging line, increases with increased volume. A MCP system should ensure that the dairy firm pays only what the milk is worth in terms of the amount and value of products produced. Conversely, it should ensure that the producer receives full and fair reward for milk supplied according to its composition and the market return it produces as processed product. Consequently, the milk price under MCP should reflect the values (or costs) of all the key constituents in the milk supplied, i.e.:

- Value of butterfat
- \+ Value of protein
- \+ Value of other solids (lactose and minerals)
- \- Cost of handling/removing fluid carrier (water)

This comprehensive MCP model could be referred to as a 'plus/plus/plus/minus' scheme accurately assigning the positive values of milk solids as well as the cost associated with the fluid carrier, water.

MCP in an Irish Context

While Irish dairies have for many years priced milk on the basis of fat and protein components, the industry has stopped short of implementing a comprehensive MCP system. The main deviations in current Irish milk pricing from the MCP model described previously are:

i) The inclusion of a positive constant for volume in many of the pricing policies. This fails to recognise that volume actually is a cost to the processor.

ii) The omission of solids other than fat and protein from the pricing schemes. Even though fat and protein constitute the most valuable milk components to ignore other solids in payment schemes can result in the milk price failing to reflect fully the true processed value of that milk. For example, lactose is an important component in WMP and SMP and that value should be reflected in the milk price.

iii) Operation of differentials as opposed to more transparent direct valuation of individual components (i.e. cents per kg times number of kgs supplied). Use of a base price per gallon, albeit with quality adjustments, tends to place the focus on price per unit volume. This may confuse producer incentives by reducing the perceived importance of milk solids. In practice it would be more transparent to establish unit values for each component and to price milk directly on the basis of the number of units of each component supplied.

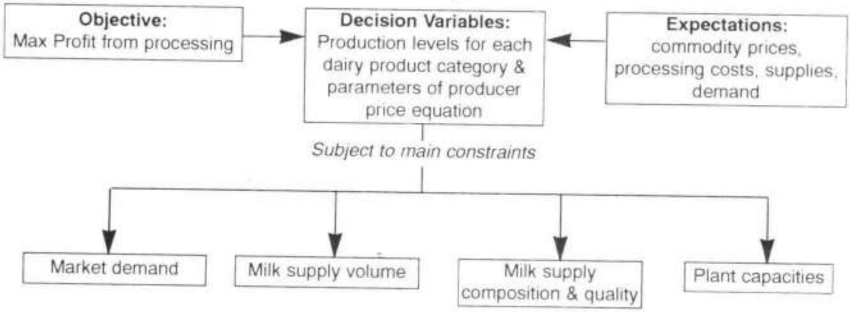
In the remainder of this paper some implications of a comprehensive MCP (plus/plus/plus/minus) system are considered for the Irish dairy industry. Comparisons are drawn with the existing differential payment (DP) schemes currently operated by Irish dairies.

Methodology

Operation of a MCP system requires the development of a reliable approach for the valuation of milk components that can obtain the confidence of milk producers. A wide range of approaches have been identified in the milk pricing literature ranging from partial budgeting or costing models (Caskie, 1992; Brog, 1969; 1970; Hillers *et al.*, 1980; Garrick and Lopez-Villalobos, 1999), through to more sophisticated methods employing differential calculus (Ladd and Dunn, 1979) and linear programming (Bangstra *et al.*, 1988; Breen, 2001). Much of the difficulty in deriving component values arises due to the multi-product nature of many dairy processors. Often a product mix is manufactured comprising various dairy products that contain fat, protein and lactose in many different combinations. In this study a linear programming approach was chosen, as the technique lends itself more readily to decision-making in a multi-product context.

A representative linear programming model of a dairy-processing firm was constructed according to the general structure presented in Figure 1. The model maximised an objective of the processor's net revenue across a multi-period planning horizon that comprised 12 time periods, each period representing one month of the year. The use of a multi-period framework enabled the model to incorporate the effects of the seasonal pattern of milk supplies within the Irish dairy sector. The model included a portfolio of products reflecting the predominant product mix of the Irish dairy industry. These products included fluid milk, butter, casein, whole milk powder (WMP), skimmed milk powder (SMP), cheddar cheese, dried lactose and whey powder.

Figure 1. Schematic Diagram of the Modelling Framework



The decision variables of the model were the levels of each dairy product produced in each month of the quota year. The firm's production decisions were assumed to be influenced by its expectations for product prices, market demand, raw milk supplies as well as production costs for different product lines. Specifically, the quantities of individual products that could be produced in a given month were limited by a series of technical constraints comprising:

- Monthly market demand for each product line according to the firm's market share and supply commitments;
- Processing plant capacity for each product line, e.g. drier plant capacity in the case of milk powders.
- Monthly milk supplies from farmers in the processor's milk pool reflecting aggregate milk quota and seasonal supply pattern of the producers.
- Solids composition of the milk supplied to the processor, which directly influences the volume of products that can be produced.

Manufacturing costs in the model were categorised as either 'fixed' or 'variable.' Fixed costs were assumed to remain constant in total for a given volume of milk regardless of the quantity of product manufactured. These costs included milk collection, reception of milk at the processing plant, administration and general overhead costs. Variable costs were directly related to the quantity of product manufactured. These costs were obtained on a product-by-product basis and included direct labour, fuel/power, added ingredients, packaging, product storage and effluent disposal.

Solution of the model produced two main categories of results. Firstly, the optimum product mix that maximised the market returns from dairy product manufacture subject to the constraints listed above. Secondly, the shadow prices or marginal values for three principal milk solids: fat, protein and lactose. These marginal values, calculated in terms of Irish pounds per kg of each milk component, represent the imputed value to the processor in terms of the net revenue obtained from the last kg of each milk component supplied. The component marginal values estimated by the model form the basis of a MCP equation, which expresses the value of milk as a function of its solids composition. Under the system, producer payment for a given volume of milk would be determined by the equation:

$PR = (VF \times YF) + (VP \times YP) + (VL \times YL) +/- (AP \times Vol) - (CV \times Vol)$ (eq.2)

Where:

PR = Producer revenue (Milk cheque)
VF = Marginal value of fat (£/kg)
YF = Fat yield in milk supplied (kg)
VP = Marginal value of protein (£/kg)
YP = Protein yield in milk supplied (kg)
YL = Lactose yield in milk supplied (kg)
VL = Marginal value of lactose (£/kg)
AP = Additional payments, i.e. quality and seasonal bonuses/deductions (£/gal)
CV = Fixed costs per unit volume (£/gal)

Using the marginal values of the individual milk components multiplied by the corresponding component yield in the milk supplied, it is possible to ascertain the marginal value of a gallon of milk (MVGM) of given composition to the processor. The MVGM plus or minus supplementary payments (e.g. quality bonus/deduction, seasonal incentives) and minus a volume related deduction for collection, assembly and overhead costs would represent the final milk price per gallon that would be paid to a producer under the MCP system.

Model Results

Marginal values of milk components were estimated under six product mix scenarios. These comprised a number of 'specialist' processing channel options and an 'average product mix' scenario reflecting the approximate actual proportions of each product produced by the Irish dairy industry as a whole. The 'specialist' scenarios comprised discrete processing channels for fluid milk, cheese, casein, SMP/butter and WMP and were used to estimate component values according to each of these specific product lines. In each of the five specialist scenarios the focus was on the production of the primary product with secondary products produced as by-products from the remaining milk components. For example, in the specialist fluid milk scenario the focus was on the production of fluid milk, however some butter was also produced from surplus butterfat after standardisation of the milk. Model estimates of values per kg for fat, protein and lactose, under each scenario, are presented in Table 2. Since the results were based on product price and cost data for quota year 1999/00 all figures are given in Irish pounds. Through the MCP equation (Eq. 2) the component values were used to calculate the marginal value to the processor of a gallon of milk according to its composition. This Marginal Value per Gallon of Milk (MVGM) is shown in Table 2 for a milk of composition 3.6 percent fat, 3.3 percent protein and 4.6 percent lactose.

Table 2. Milk component values and marginal value per gallon for milk of 3.6% fat, 3.3% protein and 4.6% lactose by processing Channel.

	Fat (£/kg)	Protein (£/kg)	Lactose (£/kg)	MVGM (p/gal) 3.6% F; 3.3% P; 4.6% L
Average mix	2.48	3.25	0.41	100.83
Fluid channel	2.53	4.74	0.68	130.50
Cheese	2.63	4.27	0.41	119.11
Casein	2.47	4.27	0.41	116.41
SMP/Butter	2.48	1.56	1.56	99.48
WMP	1.84	1.84	1.84	99.05

The highest return for milk was produced under the fluid milk scenario with lowest returns under the milk powders scenarios. Under the 'average product mix' scenario the MVGM for a composition of 3.6 percent fat, 3.3 percent protein and 4.6 percent lactose was almost 101 pence per gallon. This compared to an actual average base price for all dairies in the Irish Farmers Journal Milk Price League of 99.9 pence per gallon in the same period. In converting the MVGM to a net producer price a volume charge in pence per gallon is deducted to cover cost of milk collection, assembly, administration and general overheads. It was estimated that this charge would be approximately 6 pence per gallon of which 3.4 pence related to the cost of milk collection/assembly (Breen, 2001). However, it is noted that current collection charges of Irish processors average less than 1 pence gallon reflecting the fact that the true cost of handling milk volume has not been levied on suppliers.

There was a high degree of consistency in the value for fat under the scenarios reflecting the fact that in most cases its value was determined by the production of butter. The value of protein was more variable according to whether it was used in milk powders or for more profitable products such as cheese and casein. The lactose component had a small value under most processing channels reflecting its modest value as a residual product. However, in the case of milk powders its value was much more significant reflecting its role as a major component of SMP and WMP.

The protein to fat value ratios estimated by the model ranged from 57:43 under the 'average product mix' scenario through to 63:37 for casein and cheese scenarios, 39:61 for the SMP/Butter scenario and 50:50 in the case of the WMP scenario. This concurred with actual protein:fat value ratios of processors, which ranged from 43:57 to 69:31 with an average for all dairies of 60:40 over the same period. Clearly, component values vary according to the product mix produced from the milk and this would suggest that it is not possible to obtain one set of component values that accurately represents the true value of milk for all product channels. Consequently, the best strategy might involve the use of a 'blended' formula where a weighted average of component values is used according to the proportion of milk allocated to each product channel.

Incentive for Improved Composition

An important aspect of a milk-pricing scheme is that it should provide incentive for desirable improvements in milk composition. Milk with higher solids concentration is more valuable to the processor and it is important that this increased value is accurately reflected in the milk price. Results are presented in Table 3 for the increase in milk price (value) due to a 0.2% increase in milk solids per gallon. For comparative purposes actual price incentives provided by dairies are shown in the bottom half of Table 3 based on Milk Price League data for the same time period. The degree of responsiveness of current pricing schemes is inversely related to the magnitude of a constant term in the payment structure. Consequently, the average figures are presented for dairies grouped according to the proportion of milk price accounted for by a constant term in their payment schemes.

Under the MCP model the increase in milk value due to the improved composition was 5.7 pence per gallon under the 'average product mix' scenario. Under the cheese scenario the improved composition added 6.8 pence per gallon to the milk value while under the SMP/butter scenario the improved composition yielded an extra 5.2 pence per gallon. In the case of the actual pricing systems operated by dairies in the same time period the average price reward for the improved composition was lowest (4.4 pence per gallon) for dairies with a positive constant of more than 15 percent of their milk price. On the other hand, the price adjustment for dairies with a positive constant of less than 5 percent was in line with the MCP results for an average product mix but below the MCP results by 1 pence per gallon in the case of the cheese scenario.

Table 3. Producer price incentive for improved solids composition

	Reward for Improved Composition Increase of 0.2% in Fat, 0.2% in Protein and 0.2% in Lactose (pence/gallon)
Multiple Component Pricing Scenarios	
Average Mix	+5.7
Fluid	+7.4
Cheese	+6.8
Casein	+6.7
SMP/Butter +5.2 WMP	+5.2
Current Differential Pricing Systems:	
With constant > 15%	+ 4.4
With constant 5 – 15%	+5.3
With constant < 5%	+5.7

Volume versus Composition

In the case of dairies with a large positive constant in their pricing equations, increased volume is rewarded over improvements in solids concentration. This issue was examined using the MCP model. Two deliveries of milk were evaluated both containing exactly the same quantities (kgs) of each milk component, however, one of the deliveries involved a volume of 1,100 gallons while the other had a volume of 1,000 gallons (see Table 4).

Table 4. Volume and composition of two milk deliveries

	DELIVERY A 1,100 gal @ 3.6% F, 3.3% P, 4.6% L	DELIVERY B 1,000 gal @ 3.96% F, 3.63% P, 5.06% L
Milk (kg)	5,127.50	4,661.37
Fat (kg)	184.59	184.59
Protein (kg)	169.21	169.21
Lactose (kg)	235.87	235.87

In this example the value of both milk pools in terms of processed product should be the same as they contain the same amount of milk solids and therefore will yield the same quantities of product. Moreover, the delivery with lower solids concentration will actually have higher costs in terms of transportation and fluid removal. As indicated in Table 5, the MCP system correctly identified the processed value of both milk deliveries as exactly the same. In contrast, the differential payment systems operated by processors actually paid more for the volume increase than they paid for the increase in solids concentration. This inefficiency in the differential-based systems varied with the prominence of a constant term within the pricing policy. For dairies in the Milk Price League with a constant component of more than 15 percent, the amount paid for the higher volume of milk was on average about £23 more than for the delivery of milk with higher solids concentration. This difference occurred despite the fact that both deliveries would yield the same amount of processed product and the added volume would entail more handling costs.

Table 5. Efficiency of milk pricing systems

	DELIVERY A 1,100 gal @ 3.6% F, 3.3% P, 4.6% L (£)	DELIVERY B 1,000 gallons @ 3.96% F, 3.63% P, 5.06% L (£)	Difference (£)
Current Differential Pricing Systems:			
With constant > 15%	1,096.99	1,073.56	23.43
With constant 5 - 15%	1,108.07	1,097.32	10.75
With constant < 5%	1,096.41	1,093.70	2.71
True Value of Milk (MCP):			
Baseline	1,109.09	1,109.09	0.00
Cheese	1,310.22	1,310.22	0.00
Casein	1,280.56	1,280.56	0.00
SMP	1,094.31	1,094.31	0.00
WMP	1,089.57	1,089.57	0.00

Control over unit costs of processed product

The single largest cost to the dairy processing sector is the milk that is used in the production of its products. Hence, from a processor point of view, an important benefit of MCP is more accurate control of unit costs of milk per kg of final product. A paper by Emmons *et al.* (1990b) has shown that milk differing by as little as 0.1 per cent in fat, protein or lactose could have important effects on the costs of milk per unit of product. These differences in milk costs can in turn have a major effect on profitability of the processing plant. Variation in cost of milk per kg of final product arises where the pricing formula does not accurately reflect differences in product yield as milk composition varies. Thus some milk may be over-valued in terms of the product yield that can be obtained from them, while other milk compositions may be under-valued. In Table 6 the value of two milks differing by 0.1% in milk solids are examined according to the processing channel of the milk. Milk 'A' comprised 1,000 gallons with composition of 3.6 percent fat, 3.3 percent protein and 4.6 percent lactose. Milk 'B' comprised 1,000 gallons with composition of 3.5 percent fat, 3.2 percent protein and 4.5 percent lactose. If manufactured into cheese, Milk 'A' produced net revenue of £1,185 for the 1,000 gallons. Milk 'B' produced a lower product yield due to its lower solids concentration and generated net revenue of £1,151. Hence, the difference in the true value of the two milks for cheese production was £34.

Under the DP formulas employed by processors the difference in value (price) between the two milks was generally less than the true difference in the value of the milks estimated by the MCP model. For example, processors with a constant of more than 15 per cent of their milk price would pay only £22.60 less for the milk with poorer solids composition even though the actual reduction in the net revenue produced by that milk was £34 in the case of the cheese processing channel and £26 in the case of the SMP/Butter channel (Table 6). Effectively, the pricing formula used by these dairies did not fully reflect differences in product yield for different milk compositions. This inefficiency in the pricing system resulted in the cost of milk per unit of final product varying with compositional differences in milk supplied. In the case of dairies with a lower constant value in their milk price the ability of the pricing formula to estimate changes in milk value was better but differences remained for products such as cheese and casein. Under a comprehensive MCP system the price paid to producers should accurately reflect the yield of products obtained; and the cost of milk per unit of product should remain constant as composition varies (Emmons, *et al.*, 1990b). This is a major benefit to processors in ensuring greater control over their largest input cost of raw milk.

Table 6. True values of two milk compositions compared with value under differential pricing schemes employed by dairies

	MILK A Value of 1,000 gallons @ 3.6% F, 3.3% P, 4.6% L (£)	**MILK B** Value of 1,000 gallons @ 3.5%F, 3.2%P, 4.5% L (£)	**Difference** (£)
True Value of Milk (MCP model):			
Cheese	1,185.12	1,151.07	-34.05
Casein	1,158.96	1,125.67	-33.29
SMP/Butter	992.31	966.17	-26.15
Differential Pricing Systems:			
With constant > 15%	997.27	974.67	-22.60
With constant 5 - 15%	1,007.34	980.74	-26.60
With constant < 5%	996.74	968.34	-28.40

Conclusions

Three fundamental principles have been outlined by the International Dairy Federation as guidelines in relation to milk payments systems. A payment scheme:

- should be fair and equitable to suppliers;
- should promote the production of high quality milk;
- should be consistent with developments in milk sampling and testing (IDF, 1979).

Comparison with milk payment schemes in Denmark, the Netherlands and New Zealand identified that Irish milk pricing policies are much more variable in terms of valuation of milk constituents. In addition, the role of a positive constant for volume in many Irish pricing schemes contrasts sharply with practice in the other countries where a volume charge is included in the pricing equation to reflect the costs associated with handling the water component in milk.

A representative processor model was used to estimate component values and the true value of milks according to composition and net returns from processed product. The component values were found to vary by product mix especially in the case of milk protein. However, the average protein:fat value ratio was approximately 60:40, closely in line with the average protein:fat value ratio of Irish dairies over the same period.

Using the estimated component values, a producer milk price was derived using a 'plus/plus/plus/minus' pricing equation according to the amounts of each milk component consigned. For milk of base composition it was found that the milk price estimated by this equation (under the 'average product mix' scenario) compared very favourably with actual average base price paid by Irish dairies over the same period. The comprehensive MCP model was found to be superior to the differential-based systems operated by Irish dairies in a number of respects:

- MCP can provide benefits in terms of equity/fairness by more accurately pricing milk according to its composition and the yield and value of products that can be made from milk supplied. Essentially, the system can ensure that producers are more accurately rewarded for their milk according to its composition and the return that milk produces in the market place. A comprehensive MCP system would prevent some producers being over-paid for milk with poor solids composition while others are under-paid for milk of good solids composition.
- By visually assigning market-based values to solids components as well as the costs associated with handling volume, the transparency of the pricing system is improved. Producer milk price is determined directly from the component values and the quantities of components consigned. The supplier should be able to compare component values assigned by different dairies and thereby make assessments regarding processor performance in the use of that milk. This can benefit the dairy industry as a whole by ensuring that milk is directed to those uses where it has greatest value.

MCP should result in price incentives for improved composition becoming more finely tuned to developments in market returns for dairy products. In most cases the price differentials for an improvement/decrease in milk solids composition were higher under MCP than under the existing pricing systems. Moreover, the system can help to ensure incentive compatibility between processor and supplier. Since the value of milk to the processor is a function of solids composition it is logical that suppliers should be paid directly on the basis of solids also. Payment for milk in this manner should help to align the objectives of the milk supplier and the processor by focusing both parties on the value of milk in terms of solids composition rather than volume.

From a processor point of view, the MCP model was found to have an advantage in reducing variation in the cost of milk per unit of final product. The MCP system is product-yield focussed so the price paid by the processor should reflect accurately the processed value of that milk according to solids composition.

However, it would be wrong to suggest that current pricing policies of Irish dairies are universally inefficient relative to the MCP model. Performance of the differential-based systems of about half of the Irish dairies was very good in rewarding composition according to product yield. However, for about one quarter of the dairies there were important deficiencies in terms of rewarding improvements in milk solids composition. The main reason for this was the inclusion of a positive constant in the milk pricing formula. In some cases this constant was over 30 percent of the milk price. The inclusion of a positive constant reduces the responsiveness of the pricing system to changes in composition, as price differentials for milk components are therefore lower. For dairies with a constant of below 5 percent of the milk price, efficiency in rewarding milk composition was generally much better but the concept of a negative constant to reflect the cost of handling volume (water) remains an issue that the Irish dairy industry must now consider. A movement in this direction would bring milk payment schemes of Irish processors into line with their key competitors and would provide the basis for a pricing formula that accurately reflects the true value of milk to the processor.

Nevertheless, modification of current differential-based systems may not be the complete solution to the challenges facing the industry into the future. The pricing system may have to change further if it is to accurately reward producers, convey the right market information to producers and be equitable amongst producers. To best fulfil these criteria it seems difficult to avoid the conclusion that a MCP system based on the individual component value of the constituents consigned must be adopted.

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How I intend to grow my beef enterprise - a farmers perspective

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Introduction

Beef farming has seen many changes over the past 10 years. The introduction of suckler quotas has seen suckler cow numbers double. However, according to Department of Agriculture statistics, the overall quality of beef being produced in Ireland is disimproving. What can be done to reverse this trend, or how can quality beef producers access niche markets and better prices for their stock? The future of the beef industry in Ireland has to lie in co-operation and partnership from the farm gate, through the factory, onto the supermarket shelf and finally into the shopping basket of the Consumer.

For a vibrant and sustainable beef industry the co-operation between the retailer and the consumer must allow the beef producer to obtain a respectable income and so encourage a continuous injection of fresh young blood - a good recipe for a healthy industry.

This paper outlines the farm development plan of the author.

Farm Details

Hectares owned	84.0
Hectares leased	11.5
Total	95.5

	ha		ha
Grass	**66.5**	**Tillage**	**29**
Grazing	51.5	Winter Wheat	4
Silage (1 cut)	15.0	Spring Wheat	7
		Spring Barley	12
		Set-a-side	2
		Maize	4

Education

On completion of the Leaving Certificate a year was spent in Rockwell Agricultural College, the foundation for a career in agriculture. A FAS welding course, to improve basic welding skills, followed this in 1996. Since completing this course, a lot of time has been spent improving efficiency on the farm. The Teagasc Advanced Certificate in Drystock Management was completed in 2000. This focused on the production of quality beef and on the performance and profitability of the enterprises. A profit monitor was completed for the first time while participating. As part of this exercise, a beef study tour to Belgium and France was included with a second trip to Spain the following year. On completion of the certificate a discussion group was formed, which is proving to be very successful. The discussion group has been named the "U3 Wanderers" – with the goal of trying to produce a U3 carcass.

As a young person why choose a career in agriculture?

- You are your own boss - you decide when and how to do a job
- It provides you with freedom - no commuting, no traffic
- New challenges appear - you decide how best to tackle them
- Fresh blood - new entrants have different ideas and ways of doing a job
- Rewarding

Suckler Herd

The beef enterprise is based on 80 suckler cows, 20 of which are autumn calving. This has been increased from 45 cows five years ago. The breed of cow has also changed from the traditional black whitehead to mainly $^{1}/_{2}$ and fl bred Limousin cows. A small number of Blonde cows have also been tried, however, the majority are too narrow and have led to calving difficulties.

The aim is to use a Simmental bull (purchased at 3 years old) to breed all replacements. At present the Simmental is running with 16, $^{1}/_{2}$ and $^{1}/_{2}$ bred Limousin cows. It is hoped that this breed will bring extra milk, growth, size and most importantly wider pelvic bones to allow ease of calving.

The spring calving cows are mostly in calf to a Charolais bull purchased in 2001. The autumn calvers (which calve outdoors) and the in-calf heifers are in calf to the Limousin bull for ease of calving. Hopefully the Charolais bull will bring increased weight to carcases at slaughter. Table 1 outlines the breeding values of the Charolais and Limousin stock bulls.

Table 1. Stock bull breeding values

	BLUP Figures	
	Charolais	**Limousin**
Muscle	118	117
Skeletal	101	107
Functionality	111	81
Reliability (%)	31	45
Beef Merit (Tully)		123

Beef finishing

Heifers are finished at 20 to 21 months of age for a local butcher, or for Pettits supermarkets. Bullocks are finished at 28 to 29 months of age so as to maximise the carcase weight of the fl bred or greater, continental carcases. Animals are left to grow as long as possible before finishing. As the farm is operating at a physical stocking rate of 2.8 L.U./ha, extensification is not a runner. Allowing animals to remain on the farm longer also avoids the need to purchase extra store cattle to replace the beef cattle and so avoids the risks involved with price fluctuations and the high cost of store cattle.

Prior to November 2000 when age was not an issue, all animals were pushed as close to a 400 kg carcase as possible, for which a premium of 2p/lb was paid. However, now it is the age of an animal that determines the date of sale - surely not a true means of determining the finish or quality of a carcase? In the past 12 months the average carcase weight was 344 and the percentage that graded U3 or 4L and R3 and 4L was 88.

Developments

Since starting to farm in 1994, a major development programme has been undertaken. Slatted accommodation for 85 beef cattle and a slatted cubicle house for cows were built. This also included a feed passage for weanlings. However, the purchase of a computer and a Kingswood Herd Package in 1997 was probably the best investment on the farm. This allowed the herd register to be automatically updated and ensured that all cattle were entered for the 10 and 22-month premium at 0.6 of a LU, which allowed for extra premiums to be claimed in the calendar year. This in turn permitted for extra weanlings to be purchased annually and so pushed output up further.

With the increase in stock numbers, a post driver was made in 1999 and paddock fencing for all animals was installed to allow for rotational grazing. This has ensured the continuous supply of good quality grass all year round, which increases performance at grass. Control of stock is also easier, which is very important nowadays as labour on farms is at a minimum. Paddocks also allow action to be taken earlier if grass supply is running ahead or below demand.

To help maintain the improvement in cattle performance throughout the winter, and to allow for an increased use of homegrown feed, a diet feeder was purchased in March 2002. Prior to 2002, homegrown barley was the cereal fed on the farm. This was ground through a small hammer mill on the farm. However, the labour involved in filling the mill, grinding and then bagging out the meal takes time, and leaves for very dusty working conditions. In 2001, 20 tonnes of alkalage was tried as an alternative feed with good results. In 2002, with the poorer first cut silage quality and maize, which will have a lower starch content than normal, it was felt that alkalage would only increase the fibre content of the diet, which is already high. Instead, 70 tonnes of grain was crimped; 45 tonnes of which was winter wheat and 25 tonnes was spring barley.

Grass silage, maize and crimped grain will form the diet for weanlings, store cattle and finishing beef cattle during the winter of 2002.

At present, a straw-bedded shed for 40 cattle is being constructed, to allow the beef cattle on slats to be finished on straw. It will also allow the shed to be used for cows at calving.

Grassland

Over the last 10 years, 30 ha have been reseeded. An additional 5 ha was reseeded after the 2002 harvest. After seeing and hearing of good results during discussion group visits to other farms, a Sinclair Magill grass seed mix was used. The aim over the next five years will be to re-seed a further 20 ha. The method of reseeding used is to grow three crops of corn and then reseed post harvest. This gives very good yields of corn and allows extra wheat to be grown. Another very important aspect to this approach is that it allows weeds to be controlled, the biggest problem being docks.

Profit Monitor

Completion of the Teagasc Drystock Profit Monitor helps to focus on costs and the direction the farm is heading. Having completed the profit monitor for four years further financial targets can be set. Table 2 shows a summary of both the 1999 and 2001 profit monitors for the beef enterprise on the farm. It also compares the 2001 analysis with an analysis of 10 beef farms in the South East collected by Teagasc for the year 2001.

Table 2. Beef profit monitor per hectare analysis

	M.Doran 1999	M. Doran 2001	Teagasc 10 Farm Average 2001
Output kg/ha	687	738	658
Output excl. premia	938	977	793
Output incl. premia	1318	1542	1463
Variable costs	461	548	481
Gross Margin incl. premia	857	994	982
Fixed costs	555	497	503
Total costs	1016	1045	983
Net profit	€302	€497	€479

Compared to the 1999 analysis and the 10-farm average, the output of beef produced per ha was higher in 2001. This is reflected in the higher output (incl. premia) in terms of €/ha. Variable costs per ha have risen since 1999 but the higher output, due in part to increased costs, off sets this to give a higher gross margin per ha in 2001. The variable costs have also risen due to an increase in prices of most farm inputs since 1999.

Fixed costs have fallen since 1999 and compare favorably to the 10-farm average. Overall the beef enterprise profit per ha has risen since 1999. A large part of this is due to increased premia per ha. This is a reflection of the industry, with an increasing proportion of profit coming from direct payments.

The aim now is to try and increase the amount of subsidy retained as profit to 100%. To achieve this, it is hoped to increase output by a further 25 kg/ha, and reduce variable costs by €35/ha (targeting vetinerary and fertiliser costs). Fixed costs also have room to be reduced, especially depreciation as capital investment in expensive buildings is on the decrease.

Future developments

Tillage

It is planned to reduce the area under tillage. Instead, sheep numbers are to be increased to 150 ewes. The sheep form an important part of the overall production from the farm. Sheep can graze after the cattle without affecting the performance of either. Sheep can also be out-wintered for part of the winter on stubbles and so no additional housing is required. The increased sheep numbers should help increase profitability.

Suckler cows

Suckler cow numbers are also to increase to 100. It is hoped to calve one third of these in the autumn (to ease management) and allow a year round supply of beef to be sold. This is very important if we are to maintain any share of the European beef market. It will eliminate purchasing extra weanlings and the disease risks associated with them. At present, the cost of the better quality weanlings also makes it impossible to purchase such an animal. It is also hoped to improve the quality of the suckler cows by breeding all of the replacements on the farm. Cows of an 'R' grade should also help increase the chances of producing a 'U' grade carcase.

A.I.

A.I. could also play an important role in the improvement of the quality of cattle produced. However, currently the success rate and the lack of a synchronization and A.I. program by A.I. stations limits its use. If synchronization and A.I. programmes were to be provided at a realistic fee for the top quality A.I. bulls in the country, a huge improvement in A.I. usage would be seen. Subsequently the quality of beef produced could be improved.

Mid term review

Any good business has need of a 5 to 10 year plan – 'if you fail to plan you plan to fail'. Under Agenda 2000 the E.U. commission for agriculture entered into a 6-year agreement. This was the foundation for planning in agriculture. At the moment it is very difficult to proceed with development plans with such uncertainty. However, if the present reform proposals were to form a discussion document for the industry to address where EU.agricultural policy is to go post 2006, I would agree to look at the proposals. If however, the commission is to break an agreement already in place mid term, then how can the commission be trusted to introduce another long-term agreement? We have seen no study of the consequences of such a proposal. My belief is that the quality of beef being produced will disimprove under the proposals, as the number of suckler cows will likely reduce, as the cost of carrying such animals could not be justified.

Conclusions

Beef farming has a lot of potential, especially the development of partnership arrangements with factories for farmers producing quality beef suitable for the European market. This market is returning some of the top prices for beef on the world market. The only way for Ireland to compete on the world market for beef is to target these markets. The limits in our scale and the costs of production, combined with environmental and animal welfare regulations, mean we will never be able compete on the world market alone.

We need to maximize the percentage of our animals suitable for the EU market. I hope to do so with a fully enclosed herd, with all animals' slaughtered from the farm on which they were born. Improvements in breeding take time, however, the rewards when reached are worth the effort it takes, and a lot of pride can be taken from the fact that I had an input into them. Too much focus is being placed on claiming subsidies and not enough on the production of quality beef today in Ireland. If we as farmers focus on what we do inside the farm gate we can see an immediate improvement in the percentage of our animals that can access these top priced EU markets and hopefully this will result in an improvement in our profitability.

Outwintering Pads as an accommodation System for beef cattle

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Introduction

During the last two years, outwintering pads (OWP's) have been evaluated as a beef cattle accommodation system at Grange Research Centre. The results to date indicate that relative to traditional slatted floor accommodation, OWP's can have a positive impact on some animal productivity indices. However the system produces large volumes of effluent with a high pollution potential, which must be properly managed to achieve environmental sustainability.

Construction of an OWP

The OWP is constructed by placing a layer of woodchips on top of an artificially drained surface, which is lined underneath to prevent downward movement of effluent into the groundwater. Compacted clay has been used successfully as a liner at Grange for two years. This was done by removing approximately 0.6 m of subsoil and replacing it in 0.2 m layers, and compacting each layer using a 20-ton track digger. However, the soil type at Grange is a clay loam with a high (60-70%) clay and silt content. This facilitated the construction of the impermeable barrier. However, in other circumstances an artificial liner may be necessary. By placing the liner beneath 30 cm of subsoil, between two layers of sand or geotextiles, it will be protected from possible damage. On top of the liner the subsoil was ridged with ridges being 3.5 m apart and 0.2 m high. Along the trough between each ridge a slotted 80 mm ducting pipe was placed beneath 200 kg /m^2 of round stone (approx. 5 cm in diameter). The stone was covered with 50 kg of woodchips /m^2, which was a mixture of timber and bark, known in the sawmills as butt reduced chip or post plant chips.

Animal performance

The first experiment to evaluate the OWP's as a full time accommodation system for finishing continental x Friesian steers was carried out during the winter of 2000/2001. One hundred and twenty six cattle were assigned to one of seven treatment groups: one group was kept indoors on a slatted floor shed at 3 m^2 space allowance per animal. The other six groups were accommodated outdoors on OWP's and allowed a space allowance of 6, 12 or 18 m^2/head. Shelter was provided for 3 of the outdoor groups using a 2 m high netlon windbreaker. The other three groups had no shelter on what was an exposed site, during a winter that was both wetter and colder than normal. All animals were offered silage *ad-libitum* and were supplemented with 5 kg concentrates per head daily. The experiment extended from November 4 to April 4, after which all animals were slaughtered and carcass data obtained.

Animal performance results are shown in Table 1. There was no significant effect of stocking density or provision of shelter on growth rate, carcass traits or feed efficiency among the animals on the OWP. Cattle accommodated on the OWP's had higher liveweight and carcass gains, and better feed conversion efficiency and lower fat scores than those in a slatted floor shed. During the winter of 2001/2002 selected treatments from the above experiment were repeated in a second experiment. The relative advantage in animal growth rate and feed efficiency on the OWP was confirmed.

Animal welfare

Measures of climatic conditions and animal behaviour, immune function, cleanliness, hair length and hoof condition were conducted to determine if outwintering compromised the well being of animals. When indoor and outdoor environments were compared over the experimental period the ambient air temperature was lower outside (3.5 versus 5.0 °C), while relative humidity was higher indoors (90.6 versus 86.0 %). Wind speed was reduced by the provision of shelter and daily rainfall averaged 2.2 mm during the experimental period, with a recorded minimum and maximum daily fall of 0 and 28.4 mm respectively. The climatic energy demand (CED) refers to the amount of heat energy required to sustain normal body temperature. There was no measurable effect of shelter on the CED of animals outwintered. The CED for animals outdoors was higher than for animals accommodated indoors on slats (70.3, 71.1 or 59.2 W/m^2 for animals on sheltered OWP's, exposed OWP's or indoors on slats respectively). On no occasion during the winter did the CED exceed the calculated heat of production (internal heat energy released from the digestion of feed) for any group of animals. This would imply that the animal out-wintered did not use feed solely to maintain body temperature.

Among cattle on OWP's there was no effect of shelter on mean hair length, however housed animals had a shorter mean hair length than those accommodated outdoors (1.11 versus 1.36 cm). There was no effect of outdoor shelter at any space allowance on animal cleanliness. Each incremental decrease in space allowance on OWP's increased the recorded mean dirt score over the experimental period (3.9, 3.3, and 2.7 for 6, 12 18 m^2/head outdoors and 2.8 indoors respectively). There was no effect of space allowance, shelter or housing on time spent lying and eating, blood cell profiles or on the measured indices of immune function. There was no significant effect of shelter, space allowance or housing on the development of interdigital dermatitis or cracks on animal hooves. Indoor animals were more susceptible to white line disease of the lateral front claw and had a greater severity of under-run on front and hind hooves. At the lowest stocking density on the OWP's, a layer of faecal material gathered behind the feed face and was associated with the infrequent removal of surface wood chips. Animals confined on 18 m^2/head therefore had greater incidence of medial and lateral claw erosion on the hind hoof, as their feet were submerged in this material around feeding time. If clean underfoot areas were maintained by more regular removal of the faecal layer this condition should be minimised. Therefore there was no physiological or behavioural evidence to suggest that the animals used required an artificial shelter belt outdoors or that animals were distressed by out-wintering, though transient acute stresses were not evaluated. Animal behaviour studies showed no effect of accommodation environment on aggression. The animals accommodated indoors had a lower number of lying bouts, which has previously been associated with animal discomfort or unease with underfoot conditions. This was supported by a greater number of lying hesitations amongst animals accommodated on the slats rather than on the OWP, again indicative of an animals nervousness and fear of slipping or hurting themselves while attempting to lie down. The under-foot conditions provided by OWP's therefore allowed the animals more security during the standing/lying actions.

Autumn calving sucklers

During the winter of 2001/2002, the Grange autumn calving herd, composed of Charolais X Limousin cows, with Belgian Blue crossed calves, were assigned to one of two housing systems. Half of the cows were accommodated indoors in a slatted floor shed with the calves having access to a straw-bedded creep area. The other half of the cows were accommodated outdoors on the OWP at a stocking rate of 22 m^2/cow and calf, with the calves having access to a sheltered creep area. The cows were fed silage *ad-libitum* and 2 kg concentrate and the calves were offered creep concentrates *ad-libitum*.

The reproductive performance, feed intake and growth rates of the cows and calves are shown in Table 2. The cows and calves on the OWP's had marginally higher feed intake and similar liveweight gain to their counterparts in the slatted floor sheds. However, after turnout to grass the calves that were outwintered had higher growth rates than their housed counterparts. The cows on the OWP had a shorter calving to conception interval and a higher proportion were returned in-calf than for the cows accommodated indoors. This difference was mainly due to low submission rates indoors because of significantly reduced reproductive behavioral activity.

Managing the OWP

The OWP surfaces were inspected daily to quantify surface cleanliness, and were scored for the proportion of clean and dirty areas. If there was less than 2.2 m^2 of dry clean lying area available per animal then the OWP was cleaned off. During cleaning, the top 10 cm approximately of wood chips were removed with a fork loader and the OWP was replenished with clean chips. During the experimental period of 2000/2001 the space allowance treatments of 6, 12 and 18 m^2/head required cleaning on 11, 52 and 110 day intervals, respectively. All the experiments to date have used the OWP as a complete accommodation system where the animals were fed and all the nutrients collected on the OWP. However, in practice many farmers have existing facilities where animals can be fed off the pad such as a slatted floor shed or self-feeding at a silage pit. This will reduce the nutrient load on the OWP and the area required per animal. Typically these systems are stocked at 10-12 m^2 /animal without any requirement for cleaning during the winter.

Conclusion

The main objective of this experiment was to identify any negative effect of outwintering animals on OWP's on animal performance and welfare. The animals accommodated indoors performed as anticipated, however the outwintered animals' grew faster and had leaner carcasses and consumed less energy per kg carcass growth under the prevailing test. The provision of wind shelter or increased space allowance on OWP's had no significant advantage for animal growth or energy efficiency. There was no physiological or behavioural evidence to suggest that this type of animal required wind shelter outdoors or that out-wintering distressed animals. Transient acute stresses were not evaluated. The under foot conditions provided on OWP's allow the animals more security during the standing/lying mechanism. Increasing the stocking density on the OWP's increased the frequency of cleaning the surface area and the dirtiness of the animals. Relative to indoor slatted accommodation, animals accommodated on OWP's had a lower severity of hoof under-run and white line disease. Further studies are required to determine the reason for the increased carcass growth and leanness of the cattle on the OWP's. This is a preliminary report and research is still on-going. A definite specification for the construction of an OWP will need to be drafted in association with the EPA and the Department of Agriculture.

Table 1. Animal performance, carcass characteristics and feed efficiency of finishing steers out-wintered on wood-mulch pads at different stocking densities with or without shelter relative to indoor housing on slats.

Conditions (C)	*Exposed*			*Sheltered*			Indoors (I)		F test			
Space allowance (m^2) (S)	6	12	18	6	12	18	3	s.e.	C	S	C x S	CS v I†
Liveweight gain (g/day)	1165	1174	1216	1174	1136	1229	991	51.4	NS	NS	NS	***
Carcass gain (g/day)	695	700	710	656	657	734	616	26.1	NS	NS	NS	*
Fat score	3.68	3.59	3.74	3.56	3.70	3.66	3.85	0.12	NS	NS	NS	0.12
Fat score/100 kg carcass	1.09	1.06	1.10	1.07	1.10	1.07	1.18	0.03	NS	NS	NS	*
KKCF/carcass (g/kg)	35.3	32.9	36.7	32.4	34.7	34.0	39.7	2.02	NS	NS	NS	*
Conformation	2.89	2.89	2.72	2.71	2.89	2.89	2.67	0.11	NS	NS	NS	NS
Kill-out proportion (g/kg)	539	538	536	529	533	538	540	6.6	NS	NS	NS	NS

†Indoors versus all outdoor treatments

Table 2. Animal performance of autumn calving suckler cows and their calves on OWP's relative to indoor housing in a traditional slatted floor and subsequent performance after turn-out to grass until weaning.

	Outwintered	**Housed**
Cow total DM intake (kgDM/day)	12.1	11.7
Calf winter creep intake (kg)	92	87
Calf liveweight gain (kg/day)	1064	1081
Calving to conception interval (days)	86	122
Proportion in-calf	0.92	0.69
Calf liveweight gain at grass (kg/day)	1224	1109
Calf weaning weight (kg)	317	303
Cow liveweight gain calving to weaning (g/day)	300	260

Important factors in suckler beef production and influence of calving season on income

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Introduction

Suckler beef production is of major importance in Ireland with the cow herd of 1.13 million accounting for 48% of the total cow herd. Incomes from suckling are low with cattle premiums making a major contribution. Assuming a continuation of EU funding in a modified form oriented towards more extensive production the more important factors influencing economic returns in future years are (a) disease/health, (b) beef quality and (c) production costs.

Disease/Health

Bovine Viral Diarrhoea (BVD) and Johne's disease are increasingly becoming major problems in suckler and dairy herds, and are the result of cattle importations. In the absence of national eradication programmes, producers should aim to have their herds free of these diseases. Respiratory disease (caused mainly by IBR, PI3 and RSV) is also a major problem. All of these diseases are likely to cause more problems in Ireland than elsewhere because of the very high level of cattle trading. In addition to testing and possibly vaccination programmes, clearly defined animal management programme are necessary to ensure effective control.

BVD

Possible outcomes of infection include abortion, stillbirth, foetal malformation, weak or apparently healthy offspring. The main source of infection is Persistently Infected (PI) animals that excrete large amounts of infection throughout their lives. PI animals arise from infection before 100 days of pregnancy when the foetus cannot recognise the virus as foreign and therefore does not eliminate it. These PI animals have the virus but develop no antibodies to the virus, and eventually develop mucosal disease (lesions of the gastro-intestinal tract and lymphoid tissues) and die. The severity of the disease in animals infected after birth varies but mortality can be high. The disease can be controlled by avoiding exposure to infection (caused mainly by PI animals which may be recognised due to intermittent scouring, poor health and poor performance) during the first 3 months of pregnancy. Tests are available and could be used to identify PI animals. When eradicating the disease, suspect PI animals should be isolated from the main herd while awaiting test results. When diagnosed, PI animals should be immediately removed from the herd. If a herd is free from the disease serious consideration should be given to providing replacements from within the herd or from herds known to be free.

Johne's Disease

Most cattle are infected with this bacterial disease early in life (usually in the first month) through milk or feed contaminated with faeces. Animals generally do not show signs of the disease until 2 to 6 years of age when the number of bacteria excreted rises dramatically. At this stage symptoms include watery diarrhoea, rapid loss in body condition and eventual death. Sub-clinical infection results in higher rates of mastitis, longer calving intervals and infertility. If the herd is free of Johne's, then preferably provide all replacements from within the herd and any purchased animals should be kept clear of the cow herd and replacements. If the herd has the disease then if possible, replacements should be purchased from a herd (or herds) considered free of Johne's. These should be managed separately from the main herd for at least the first six months of life. In the meantime slurry control in addition to animal isolation is necessary. Tests for diagnoses of the disease have limitations. Further details can be obtained in a document produced recently by the Department of Agriculture and Food.

Respiratory Disease

Bovine respiratory disease is an important cause of morbidity and mortality, particularly in suckled calves following weaning. Fewer cases of respiratory disease are recorded in home-reared than purchased animals. This is due to less exposure to the various organisms causing the disease, which arises due to mixing of animals from different sources and the additional stress associated with marketing. The organisms mainly responsible include Respiratory Syncytial Virus (RSV), Infectious Bovine Rhinotracheitis (IBR) and Para-influenza 3 (PI 3). Vaccines are available and where a problem exists a control programme should be planned with your Veterinary Surgeon.

Beef Quality

Beef carcass quality is important because of its effect on price. In this context good quality carcasses are those of good conformation that are lean. In addition to the various cattle premiums the main source of income from suckling is the calf crop. It is therefore important that the animals (or carcasses) produced from the suckler herd are eligible for the highest priced markets available. The highest priced markets are in mainland EU, for example France where in 2001 steer carcasses grading U3 for conformation were priced at 96c/kg (320 v 224) more than O3 grade (Table 1). The corresponding price difference for bulls in Italy was 64c/kg (279 v 215). In fact the price difference between O3 and U3 was even greater for heifers in these two countries resulting in a greater price difference per animal than with steers and bulls despite a lower carcass weight. Therefore with almost 90% of our beef exported an increasing proportion of which is going to the continental EU market it is important that the animals produced from the suckler herd are suitable for the highest prices in these markets.

Table 1. Effect of carcass conformation score on beef prices (c/kg)

Steers	Grade	Ireland	N. Ireland	UK	France	Italy	Spain	Netherlands
(Bulls)	U3	239	272	276	320	(279)	(249)	(208)
	R3	231	262	268	289	(255)	(235)	(186)
	03	224	246	253	224	(215)	(223)	(190)
Heifers	U3	-	-	-	361	347	271	-
	R3	233	263	266	300	321	266	153
	03	226	247	243	214	196	242	148

Source: Bord Bia for the year 2001

Breed is the main factor influencing conformation and leanness and as continental breeds are superior for these traits the breeding programme must be based on these breeds.

There is considerable variation in muscularity between individual bulls within all breeds. At Grange, young continental cross-suckled bulls have been used to study the relationship between live animal muscularity scores (in addition to ultrasound scanning of the eye muscle) and subsequent carcass traits. Good correlations were obtained between muscular scores at weaning and before slaughter with carcass conformation, meat percent and killing-out rate (Table 2). Therefore, because the heritability for muscularity is high, breeding bulls that are superior for this trait can be selected at an early age.

Table 2. *Correlations between muscular scores at weaning and at slaughter with carcass conformation, meat percent and killing-out rate

	Carcass Conformation		Meat Percent		Killing-out Rate	
Time of scoring	Weaning	Slaughter	Weaning	Slaughter	Weaning	Slaughter
Correlation	0.72	0.82	0.57	0.65	0.66	0.72

*The closer to 1 the better the correlation

Cost of Production

As incomes are low, beef farmers have always been aware of the need to keep costs to a minimum. However, there are always opportunities for further cost reductions particularly where EU payments are associated with more extensive production. Examples of possible cost reductions include:

- retaining animals to slaughter reduces trading costs and incidence of disease;
- improving overall performance resulting in early disposal reduces borrowing for cattle and possibly housing requirements;
- more extensive production (to qualify for premia) results in a shorter winter and therefore lower feed costs and less reseeding.

Some features of beef production

Before discussing systems, a brief outline of the present position regarding the breeds used in suckling, the calving pattern and seasonality of cattle slaughterings is considered useful.

Breeds used in suckling

A desirable feature in suckling is the increased use of continental breeds. Data compiled by Irish Cattle Breeding Federation (ICBF) show that continental sire breeds accounted for 85% (Charolais accounted for 44%) of the 2001 calf crop from the suckler herd (Table 3). Twelve percent of sires were early maturing breeds leaving a further 3% which were mainly other continental breeds. The dam breeds of the 2001 calf crop were about 65% continental breeds and crosses and 35% early maturing breed crosses.

Table 3. Sire breed and cow breed in the suckler herd

	Breed of sire	Breed of dam
Charolais	44	20
Simmental	9	17
Limousin	24	18
Hereford	6	22
Aberdeen Angus	6	13
Belgian Blue	8	4
Other	3	6
Total	100	100

Source: ICBF 2001

Seasonality of calvings

Calving in the suckler and dairy herd is predominantly in spring with 70% of calving in the 4 months February to April and 84% in the first 6 months of the year (Table 4). During the remaining 6 months of the year the highest proportion of calvings in the suckler herd is in July (4.1%) with none of the remaining 5 months exceeding 3% of the total.

Table 4. Seasonal distribution of calf births (%)

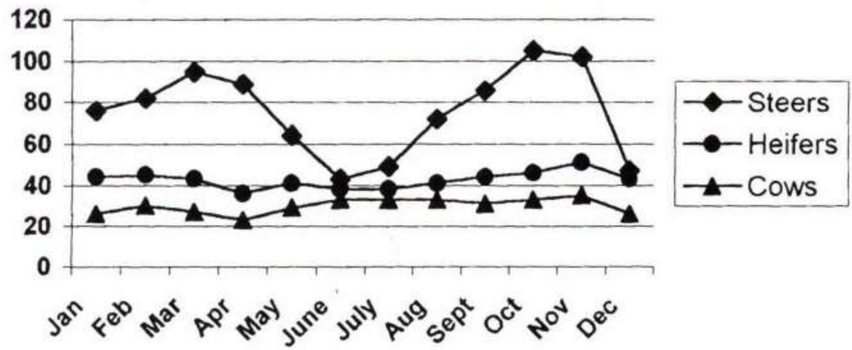
Herd	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Suckler	5.3	9.8	22.2	22.9	15.5	7.8	4.1	2.8	2.4	2.2	2.3	2.7
Dairy	10.0	25.5	25.0	15.2	8.4	3.8	1.8	1.3	2.2	2.5	2.4	2.0
Total	7.6	17.5	23.6	19.1	12.0	5.9	3.0	2.0	2.3	2.4	2.3	2.3

Source: ICBF 2001

Seasonality of Slaughterings

For orderly marketing, a relatively even supply of beef throughout the year is desirable. However, in contrast with most other EU countries, beef production in Ireland, because it is based on grazed grass has a more pronounced seasonality in production, with most slaughterings in Autumn. This poor distribution of slaughterings throughout the year is particularly evident for steers with less variation in heifer and cow slaughterings. Averaged over a 7 year period (1995 to 2001) the monthly steer slaughterings at meat export premises (Figure 1) was 75,740 with peak slaughterings in October (105,000) and November (102,000) and lowest output in June (43,000) July (49,000) and December (47,000). In contrast, monthly heifer slaughterings over the same 7-year period averaged 42,370 per month with a peak of 51,000 in November and a minimum of 36,000 in April. The average monthly figure for cows was 30,000 with a peak of 35,000 in November and a minimum of 23,000 in April.

Figure 1. Mean monthly slaughterings ('000) of steers, heifers and cows over a seven year period (1995 to 2001)



Suckling Systems

Calving season is often considered to have an important bearing on incomes and time of disposal of the progeny for slaughter. Spring (average calving date March 15) and autumn (average calving date November 1) calving are compared based on Grange data from the spring calving herd using Limousin x Friesian and Simmental x (Limousin x Friesian) cows. Sires of the larger continental breeds (Charolais) are used on mature cows and easy calving Limousin sires on heifers. The Grange system has been operated on permanent pasture and would thus be similar to most lowland suckler beef units in the country.

Progeny are taken to slaughter, and a high level of animal performance (Grange spring calving figures) is assumed for both the spring and autumn calving systems. Economic evaluations are carried out using both semi-intensive and REPS (Rural Environment Protection Scheme - eligible for the low level of extensification) systems. Studies at Grange have shown that with good management and similar concentrate inputs similar performance levels can be expected from the REPS and the semi-intensive systems. Details of the comparisons are as follows:

	REPS		Semi-Intensive	
	Spring	Autumn	Spring	Autumn
Calving	March 15	November 1	March 15	November 1
Sale: Heifer (20 mths)	November	June	November	June
Steers (23 Mths)	February	October	February	October
[1]ha/cow unit	1.08	1.08	0.81	0.81
Nitrogen/ha (kg)	90	90	225	225
Silage (tonne/cow unit)	13.4	14.5	13.4	14.5
Conc. (kg/cow unit)	710	770	660	720

[1]Cow and progeny to slaughter and replacements

Both silage and concentrate requirements per cow unit are somewhat higher for autumn than for spring calving. As the autumn calving cow is lactating throughout the winter, silage quality would be more critical. Spring calving cows are fed silage only in winter (except for first calvers which receive 1.5 kg of concentrates after calving) while autumn calvers received 2 kg of concentrates daily during the breeding season (total 190 kg). Standard daily concentrate feeding levels for the spring calving progeny are:

weanlings 1 kg (1.33 kg for REPS as average silage quality is lower);

finishing heifers (2 months) 3 kg and finishing steers 4 kg.

Daily concentrate feeding levels for the autumn born progeny are;

suckled calf in winter 1 kg;

yearlings 1 kg (or 1.33) and finishing steers (2 months) 4 kg.

Target weights for the systems are shown in Tables 5 and 6. In all systems carcass weights of steers and heifers are 395 and 310 kg respectively. Carcass prices are €2.52/kg for steers and heifers sold in spring/summer and €2.35/kg for those disposed of in autumn/early winter. Cull cow prices are €1.85/kg. In the REPS systems the stocking rate was reduced to 1.08 ha per cow unit to have them eligible for the lower level of extensification. Interest is charged on the cow (valued at €635) and half the variable costs. Total fixed (overheads plus depreciation) costs are charged at €244 per cow. The additional premia from REPS and extensification in the REPS systems amount to €206 per cow. There is no charge for labour included in the calculations.

Table 5. Animal weights (kg) for spring calving

	Steers	Heifers
Weaning	316	288
Yearling	404	373
20 Months	570.	565
23 Months	700	-
Carcass	395	310

Table 6. Animal weights (kg) for autumn calving

	Steers	Heifers
Spring: 5 months old	210	200
Autumn: yearling	410	390
Spring: 17 months	500	480
Slaughter	700	565
Carcass	395	310

Receipts per ha were quite similar for the spring and autumn calving systems but due to higher winter feed requirements, costs were higher for the autumn calving system (Table 7). As a result income per ha was €27 (736 v 709) greater for the spring calving REPS system and €21 (642 v 621) greater for the semi-intensive system than for the corresponding autumn calving system. Although stocking rate and beef output was one-third higher for the semi-intensive system, income was greater for the REPS system indicating the importance of the extra premiums (REPS and extensification) to income. It is noticeable that in the absence of all premia, incomes per ha ranged from €26 to €99. Thus, at low cattle prices when fixed costs are charged at a standard rate per cow resulting in an extra €75 per ha for the intensive system compared to REPS there is no effect of stocking density on income per ha. Total costs per kg carcass gain are higher for autumn than for spring calving (Table 8). Costs per kg carcass gain are marginally greater for the semi-intensive than for the REPS systems as land which is not charged replaces fertiliser and some other costs. Placing a rental charge on land would have a major effect on incomes particularly in the REPS system where stocking rate is low. Total premiums per kg carcass produced are 1.67 and 1.17 for the REPS and semi-intensive systems respectively.

Table 7. Incomes (€) per ha. from suckling systems

	REPS System		Semi-intensive System	
Time of calving	Spring	Autumn	Spring	Autumn
ha/cow unit	1.08	1.08	0.81	0.81
1. Animal sales	901	894	1201	1192
2. Premia	637	637	595	595
3. [a]Total receipts	1538	1531	1796	1787
4. Variable costs	501	520	748	760
5. Interest and overhead costs	301	302	405	406
6. Total costs (4+5)	802	822	1153	1166
Gross margin (3-4)	1037	1011	1048	1027
Income (3-6)	736	709	642	621
Income (excluding premia)	99	72	48	26

[a]REPS system eligible for the lower level of extensification and receive €117/ha in REPS payments

Table 8. Total costs and total premiums per kg carcass weight gain

	REPS System		Semi-intensive System	
	Spring	Autumn	Spring	Autumn
Costs (€)	2.10	2.15	2.27	2.29
Premiums (€)	1.67	1.67	1.17	1.17

Although not taken into account in the economic analysis, housing requirements are greater for the autumn than for spring calving due to the high requirements for the cow/calf unit (about 6 m^2) compared to about 3 m^2 for the cow alone (space vacated by finishing steers assumed to be adequate for the young spring born calf) using slatted accommodation. Reproductive performance is also likely to be better in the spring calving than in the autumn calving system. An examination of the results shows that the factors that have the greatest effect on income are cattle prices, animal performance (fertility, mortality and daily weight gains) and cattle premium.

Summary

- It is important to avoid diseases such as BVD and Johne's in the herd.
- To be eligible for highest prices, aim to produce carcasses of good conformation that are lean.
- Minimise production costs while improving performance.

- The suckler herd is increasingly based on continental breeds and crosses but there is scope for improvements in muscularity.
- Calving is predominantly in spring with 70% of calvings in the 4 months February to May.
- Cattle slaughterings (steers in particular) are unevenly distributed throughout the year with over 100,000 (average of 7 years 1995 to 2001) steers slaughtered in both October and November, which is double that in June, July and December.
- Spring calving is more desirable than autumn calving due to

  Higher income;

  Lower cow, winter feed costs;

  Lower housing requirements;

  Likely better reproductive performance;

  Better distribution of slaughterings where producing 2 year old steer beef.

  Delaying sale of steers in spring calving would improve slaughtering distribution while a delay with autumn calving would increase housing costs.

References

Irish Cattle Breeding Federation. Irish Cattle Breeding Statistics 2002, 24 pages.

Financial returns from cattle systems

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Introduction

The Teagasc National Farm Survey for 2,000 puts average Family Farm Income on cattle farms at €7600 for cattle rearing (mainly suckling) systems and €7750 for 'Cattle Other' units. For farms over 50 hectares the equivalent figures are €21200 and €21500. The percentage of profit arising from direct payments is 120 % for 'cattle rearing' and 124 % for 'cattle other' across all farm sizes and drops only slightly to 114 % and 109 % for farms of over 50 ha in the respective production systems. These figures confirm what is widely accepted, that cattle farming incomes are (a) low, and (b) hugely dependent on direct payments.

There is however a very wide range of financial performance across cattle farms even within similar systems and size groupings. Using gross margin (output including premia less variable costs) as a measure of efficiency illustrates the point. Gross margin per hectare on all cattle farms averaged €564 per ha, but the bottom 25% produced a gross margin of only €250 per ha as against a figure of almost €900 per ha for the most efficient quartile. Figures from Teagasc Demonstration Farms and Profit Monitor data also indicate a very significant variation in margins within rather than between cattle systems. Some interesting questions arising from these various sources of information are:

- What are the principal contributing factors to higher or lower gross margins per unit area, and specifically what role do Direct Payments play? In the current premium system what is the "ideal" level of stocking to maximise profit in the various systems?
- What are the principle production costs per hectare or per kg of animal liveweight on farms?
- How does the overall margin available for production of suckler beef break down between the weanling, producer and the grower/finisher?
- How would the proposed Mid-Term Review affect cattle farming economics?

Factors Contributing to Higher Gross Margin on Top Farms

Considering the overall importance of direct payments to cattle farming incomes, it is very surprising to note that only 10 % to 15 % of the difference in gross margin between top and bottom farms in the NFS can be attributed to premium receipts. The biggest contributors by far are technical issues like animal performance and quality, overall production efficiency, trading skills and cost control. Stocking rate, controlled by premium regulations, is less significant than in pre-premium days.

Table 1. Cattle margins - top vs bottom farms

Single suckling (soil group 2)	Bottom 25%	Top 25%	Advantage
Gross margin €/ha	292	797	505
Premia €/ha	276	408	132
75% Of Advantage to Top Producers Derives From Technical Performance			
Mixed production (best soils)	Bottom 25%	Top 25%	Advantage
Gross Margin €/ha	248	879	631
Premia €/ha	254	317	63
90% Of Advantage to Top Producers Derives From Technical Performance			

Source: Teagasc National Farm Survey 2,000

Ideal stocking level?

Table 2 outlines the total premium receipts in suckling to beef and weanling to beef systems operating to the upper (tighter) limit of stocking density for basic premia, low rate extensification or high rate extensification.

The most noteworthy points in this table are;

1. The higher levels of premium "take" in trading versus breeding systems regardless of extensification level.
2. The effect on total "take" of finishing steers at 28 rather than 24 months where extensification is claimed.
3. High rate extensification is very justifiable in trading systems but possibly less so on breeding farms where land quality is good.

Breeding farms selling weanlings or stores with premia attached can optimise income without claiming maximum premia through the increased market value of "unpunched" or "single-punched" cattle. This of course means that the purchaser is actually buying the premium right along with the beef producing potential of the animal. Following the same rationale the higher levels of premia in trading as opposed to breeding systems do not automatically lead to higher farm profits. It is an accepted logic within Irish cattle farming that premia have to be purchased and paid for with the qualifying animal. It is impossible to estimate the cost of this entitlement purchase but a figure of 50 % to 70 % of the payment is often mooted. A recent review of competitiveness questions whether this trading of entitlements has actually imposed a new cost on the industry (The Competitiveness of Irish Agriculture, Prof. G. Boyle, 2000).

Table 2. Premium receipts (€) on 40 ha at differing extensification rates

System	No Extn	€40	€80
Suckling to Beef Steers @ 24 mts, Hfrs @ 20 Mts	21,774	23,954	19,304
Suckling to Beef Steers @ 28 mts, Hfrs @ 20 Mts	21,774	20,445	18,052
Weanling to Beef Steers @ 24 mts, Hfrs @ 20 Mts No. of Heifers in Brackets	28,409 (55)	30,659 (30)	33,011 (6)
Weanling to Beef Steers @ 28 mts, No Heifers	27,599	27,599	25,399

Production costs in cattle farming

Cattle production costs within the NFS are considered in terms of variable (direct) costs and fixed costs. The principle outcomes are;

1. Costs are high (as expected), and account for more than trading output. For year 2,000 on cattle rearing farms of over 50 hectares, direct costs amounted to €226 per hectare and fixed costs to €255.
2. Both direct and fixed costs account for approximately one-third of total output value including direct payments.
3. Feed is the principle direct cost and when feed, fertiliser and contractor charges are combined they account for over 80% of direct costs.
4. In fixed costs the largest single item is machinery coming in at 28% with land rental also featuring strongly at 22% of total fixed costs.

Teagasc demonstration farms in 2000 had direct costs of €0.75 per kilo of liveweight produced, and fixed costs of just over €0.90. This equates to approximately €3.20 per kg of carscase. The Boyle review of competitiveness in beef production highlights a deterioration in our situation *vis a vis* some of our EU competitors in recent years. Our cash cost index is now above the average of a basket of states (UK, Germany, France, Ireland) at 113 %, whereas in 1993 we stood at just 82 %. Only the UK has a higher cost structure than Ireland, whether considered as a percentage of total output or per unit production (100 kg liveweight).

Comparison between Systems

NFS data show comparatively little overall difference in profitability between 'cattle rearing' and 'cattle other' systems. A look at theoretical output, cost and profit figures for well managed suckler to weaning and weanling to beef units would suggest that in the quality suckler beef sector the breeder is currently faring better than the feeder/finisher. Applying standard costings and outputs to efficient production systems in each case allows for the calculation of an overall profit for producing beef from a herd of 30 suckler cows. Distributing this profit evenly on a per hectare basis between the breeding and the finishing farms allows for estimination of an 'equitable' weanling value. Assuming a beef price of €2.50 per kg this figure works out at approximately €1.85 for males and €1.45 for females (Table 3). Actual prices in recent years have been well in excess of these levels, particularly for male weanlings. This is again related to the trading of premium entitlements and the high value placed on them, rather than the meat producing potential of the animal. This suggests that the weanling producer has been winning out in most years in the battle for the limited profit available.

Table 3a. Suckler farm - 30 cows producing weanlings in autumn

Calves reared per 100 cows bulled	90
Weaning (sale) weight males (kg)	300
Weaning (sale) weight females (kg)	270
Replacement rate (%)	15
Stocking rate (ac/cow)	1.4
Ha employed	17
Premia	Suckler cow
Extensification	Low rate

Table 3b. Feeder farm bringing progeny to finish

	Males	Females
Start Weight (kg)	300	270
Days on farm	570	365
Sale date	March Year 2	October Year 1
Carcass weight (kg)	380	290
Stocking rate ha/head	0.6 (For Premia)	0.30
Ha employed	8.5	4
Premia	2 SBP, slaughter	Slaughter, heifer top-up
Extensification	Low Rate	

Table 3c. Financial - start to finish (30 cows - progeny to beef) €

Farm	Suckler Cows	Weanlings	Finisher Heifers Yr 2	Steers Yr 2	Total
Sales @ €2.50			9425	13300	22725
Premia 2002	6705	2,095		2095	10895
Slaughter Premia	355		1360	1115	2830
Extensification	1205	540		540	2285
Total premia	8265			7745	16010
Replacement	-1525				-1525
Total output					37210
Variable costs	6225		2,600	5250	14075
Fixed costs (€315/ha)	5335		3935		9270
Total costs	11560		11785		23345
Overall profit				13,865 (€470/ha)	

Table 3d. "Equitable" price for weanlings

Beef Price	Weanling sales required (equal profit/ac)	Females (270 kg)	Males (300 kg)
€2.50 /kg	€12800	€390	€554

Effect of mid-term review

As understood at the moment, the proposed mid-term review of Agenda 2000 would de-couple direct supports from animal production and apply approximately the same level of payment for each farm on an area basis. It is suggested that there will be some level of farming activity required in order to draw down this premium but it may be minimal. There are no direct market support changes involved in the review, so any price evolution over time will be the result of supply and demand rather than policy change. Obviously policy in the area of world trade would have an impact but that is outside of the current review. For the practising cattle farmer some of the effects that could be expected to follow are:

- Total premium take should remain constant, although the modulation proposal may result in some redistribution over time.
- Farming activity beyond a minimal level will be dependant on trading returns, selling price, buying price and production costs.

- In breeding to finish systems, equal premium payments and similar market pricing should produce similar overall financial output. Whether this will be the case will depend on farmer decision making regarding cattle numbers and age at sale, which will be more discretionary in a new regime.
- In trading systems, whether buying or selling calves, weanlings or stores there will be a new valuation system, which should logically depend solely on the economic beef producing potential of the animal.

Same systems - new scenario

In Table 3 above, at the 'equitable' weanling price, neither the breeder nor the finisher could produce a profit in the absence of direct payments. The actual outcome is that 97 % of premia would be retained as profit on the weanling unit and 76% on the finishing farm. So what happens after de-coupling? One line of logic suggests that both systems would cease to operate since neither is profitable outside of premia, which would be paid almost independently of production in the new system. This, though, is not the full story. The profit margins above allow for fixed costs, most of which would not disappear with the livestock. In the absence of production, therefore, part of premium receipts would be absorbed by existing fixed costs. An alternative logic proposes that an enterprise that leaves a margin over variable costs and interest payments and contributes to meeting fixed cost commitments will improve the profitability of the overall business.

Table 4 looks at the same two farming operations from this new perspective. Attempting to allocate the available gross margin over breeding and finishing farms on an area basis, the overall result is a drop in the value of the output from the breeder farm and obviously an improvement in the situation of the finisher. This comes about because the finisher no longer has to buy premium entitlement and, if he behaves logically will only purchase cattle at a price that leaves at least a margin over direct costs and interest. The magnitude of the change on these figures is not huge, but as stated earlier, real prices for young stock are considerably higher than the 'equitable' figure calculated here. More realism may or may not evolve in a new situation.

A more interesting facet is the change in relative values of male and female weanlings. The value of heifers holds up well for two reasons, (a) they were not reaping high premium payments anyway and (b) the production costs associated with them in this system are low with most of the liveweight gain achieved on grass. Male weanling values are seriously reduced for the opposite reasons, high dependence on premia and high finishing costs in this spring born two-year old beef system.

Cattle production systems in Ireland are closely aligned with the premium regime in force. Steers are not finished under 22 months so that they qualify for second stage SBP. Equally, turning two year old cattle back to grass can impact negatively on extensification payments. Removing this straitjacket will allow for more flexibility and possibly reduced costs on farms. Trials in Grange show that high quality suckler beef can be produced from grass in autumn at 18 to 20 months.

The example does illustrate that high winter feed costs will be an even bigger burden in the proposed new scenario. Attempts to reduce the burden such as finishing more cattle in the autumn or storing animals for finishing on spring grass will be facilitated by the new payments system. One very immediate result could be the return of seasonality as a feature of the Irish beef industry. Certainly long finishing periods indoors on expensive diets will be difficult to justify without the benefit of headage based premium payments unless there is an old-style seasonal price rise. This may be one of the first obvious side effects of the policy review.

Table 4. Financial - start to finish (30 cows - progeny to beef) €
Revised for decoupled payments

	Suckler Cows	Finisher Heifers Yr 2	Finisher Steers Yr 2	Total
Sales @ €2.50		9425	13300	22725
Replacement	-1525			-1525
Total output				21200
Costs				
Total variable costs	6225	2600	5250	14075
Overall contribution (FC and Profit)			7125 (€240/ha)	

Table 4a. 'Equitable' price for weanlings
Revised for decoupled payments

Beef Price	Weanling Sales Required (equal contrib/ha)	Females (270 kg)	Males (300 kg)
€2.50 /kg	€11,830	€451	€430

Conclusions

Profitability in cattle systems is low and highly premium dependent. There is a huge range from top to bottom in terms of profit per unit area and this is related greatly to technical performance rather than to superiority at premium optimisation. Costs are high and relative to international figures have disimproved in the last decade. Feed cost, and in particular winter-feed, is the single largest cost element in cattle farming. The current premium system does not always predispose to lowest cost production with its age and area restrictions and regulations.

From the viewpoint of an individual farmer the proposed review of Agenda 2000 would have obvious implications for the trading values of male animals in particular, with premium eligibility no longer of importance. If premium payments are to be largely de-coupled from animals high costs will only be justifiable on a trading basis, this could well result in a return to highly seasonal beef supply and price differentials. Even assuming that average prices remain generally similar to current levels in the new situation, there will be huge changes at farm level in terms of flexibility and scope for management decision making. Less stock and more output from grass to reduce direct costs or more animals and higher production to pull down fixed costs per unit output? Either way, the emphasis will be even more on costs.

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