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The Effect of Genotype and Feeding System on the Performance of Holstein Friesian Cows at Pasture

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The rate of genetic improvement in Ireland up until the mid-80's was low (approx. 0.5% per year) compared to North America where genetic merit for milk production was increasing by 1.5% per year (Funk, 1993). Since 1985 the rate of genetic improvement increased markedly to about 1.5% per year in 1992 (Coffey, 1992). This high rate of genetic progress has mostly been achieved through the importation of North American and European genetics. The relative merit of these sires has been obtained from the performance of their progeny in systems of milk production which differ greatly from those operated in Ireland.

The term "high genetic index" (HGI) in this paper is used to describe a cow, which as a result of selection, is generally predisposed to produce significantly more milk than a cow of lower merit status. Studies from New Zealand have shown that cows of high 'genetic index' at pasture, produce more milk (20 to 40%), consume more herbage (5 to 20%), were more efficient convertors of food into milk (10 to 15%) than lower merit cows (Holmes, 1988). However, these 'high' genetic index cows would be considered 'low' when compared to present-day genetics. Recent results from Langhill (Veerkamp *et al.*, 1994) have shown that increasing genetic index results in major increases in feed efficiency, reflecting increases in milk yield with cows fed indoors on silage/concentrate diets. There is little information available on the performance of present-day HGI dairy cows on seasonal calving, grass-based systems of milk production.

Implication of increased cow genetic merit (CGI)

Table 1 shows how improved management and breeding has contributed to

Table 1
Evaluation of the Moorepark Milk Production Technology

	Moorepark 1983 Pre-quotas	Moorepark 1996 MGI•	Moorepark 1996 HGI*
Milk yield (kg/cow)	5076	6585	7640
Stocking rate (cow/ha)	2.90	2.60	2.47
Nitrogen (kg/ha)	380	380	380
Grazed grass (t. DM/cow)	3.30	3.69	3.88
Silage (t DM/cow)	1.40	1.56	1.65
Conc. (t DM/cow)	0.63	0.63	0.63
Total intake (t DM/cow)	5.3	5.9	6.2

•MGI = Medium Genetic Index
*HGI = High Genetic Index

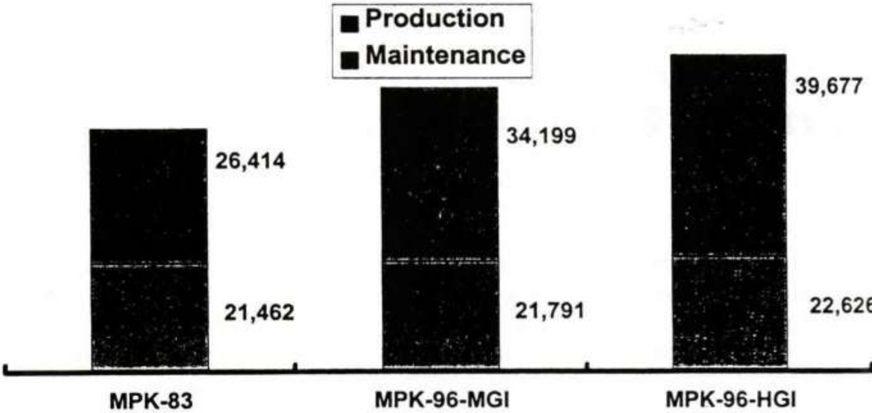

Figure 1. Effect of increased milk production on feed efficiency (Relative ME requirement in Mj for Maintenance and Production)

increased output per cow and per hectare since 1983 in controlled full lactation experiments at Moorepark. 'Moorepark 1983' refers to the performance being achieved at the introduction of EU milk quotas in 1983. 'Moorepark 1996 MGI' and 'Moorepark 1996 HGI' refer to the performances being achieved over the last two years with cows with present-day medium genetic index (MGI) and very high genetic index (HGI) in similar feeding systems. This has led to an increase of 50% and 28% in milk yield per cow and per hectare, respectively. It is not possible to differentiate precisely how much of this increase came from genetic improvement and how much came from management plus feeding. Figure 1 shows the effect of this increased performance on overall feed efficiency. With the Moorepark cow of 1983, 44% of its total feed requirement was required for maintenance, while with the HGI cows of 1996, only 36% of its feed requirement was required for maintenance. This has resulted in an increase in feed efficiency of 16%. There is no evidence that CGI has any influence on partial efficiency of ME use for milk production (Grainger *et al.*, 1985). Therefore, the extra energy requirement for milk yield must come from increased intake and/or greater mobilisation of body reserves, especially in early lactation. Recent studies have shown (Veerkamp et al., 1994) that cows of HGI produce significantly higher milk yield than cows of lower genetic index (LGI) with only small differences in intake of energy. A breeding programme based solely on increased milk yield and angularity (or dairyness) without consideration of feed intake may result in an animal which depends on large mobilisation of body tissue in early lactation (negative energy balance) to support high milk yields. Such a breeding programme may not be suitable in seasonal spring-calving systems which depend to a large extent on grazed grass as a feed, due to the possibility of increases in metabolic disorders and reduced fertility performance.

Moorepark comparison

In the autumn of 1994, two contrasting genetic groups of in-calf heifers were assembled at Moorepark. The pedigree index of the two groups is shown in Table 2. The pedigree indices of the HGI group were 13 kg of fat and 14 kg of protein higher than the MGI group. It should be noted that average RBI (95) for first lactation animals in 1995 nationally was 104 (IDRC).

Table 2
The pedigree index of the other two genotypes being compared

Genotype	RBI 95	Milk (kg)	Fat (kg)	Protein (kg)	Fat (%)	Protein (%)
HGI	134	620	23	20.5	-0.02	0.00
MGI	117	120	10	7.1	+0.09	+0.05

Three different feeding systems were compared with each genotype. The Moorepark feeding system (System A) incorporates high stocking rate (2.54 cows/ha), high nitrogen input (400 kg N/ha) and a planned concentrate input of 500 kg/cow (Dillon *et al.*, 1995). System B had a similar stocking rate and nitrogen input to System A, but twice the level of concentrate. System C had a similar level of concentrate and nitrogen to System A but with unrestricted levels of high quality grass throughout the year. To maintain system C, achieving second-cut silage was not a priority. The feeding systems were applied from mid-April to end of November. A total of 48 HGI and 48 MGI animals were used. Excess grass was harvested as wrapped baled silage to maintain grass quality. Grass was considered to be in excess when pre-grazing yields were >2000 kg DM/ha. In 1996, a total of 3.2 ha in system A, 3.8 ha in system B, and 4.8 ha in system C were harvested in this manner.

Performance in 1995

Tables 3 and 4 show the average performance of the two genotypes across the three feeding systems (adjusted for calving date) in 1995 and 1996. In 1995, when all animals were in their 1st lactation, the HGI heifers produced

Table 3
Effect of cow genetic index on milk production (1995)

	MGI	HGI	Difference (H-M)
	Total	Total	Total
Milk (kg/cow)	5,496	6,441	+945
(Gallons/cow)	1,174	1,376	+202
Fat %	4.06	3.75	-0.31
Protein %	3.53	3.44	-0.09
Fat (kg)	222	241	+19
Protein (kg)	193	222	+29
Lactation length (days)	296	303	+7

significantly more milk per cow (+945 kg) of a lower fat content (-0.31%) and slightly lower protein content (-0.09%). The yield of fat and protein was significantly higher for the HGI heifers. The grass-growing season of 1995 was very erratic with very poor growth rates in the August/September period due to the large moisture deficit. Concentrate supplementation therefore was much higher than planned. The actual concentrate feeding levels were 863, 1449 and 859 kg concentrates/cow for the feeding systems A, B, and C, respectively. There was no interaction between feeding system and CGI, i.e. both groups of heifers responded similarly to each feeding system. The average response to concentrate feeding was 0.80 kg milk/kg of extra concentrate fed in feeding system B.

Performance in 1996

Table 4 shows the milk production for both genotypes (averaged across the three feeding systems). In Figure 2, the milk production profile for both genotypes is shown.

Table 4

Effect of cow genetic index on milk production (1996)

	MGI Total	HGI Total	Difference (H-M) Total
Milk (kg/cow)	6,860	7,764	+904
(Gallons/cow)	1,465	1,659	+194
Fat %	4.02	3.89	-0.13
Protein %	3.43	3.41	-0.02
Fat (kg)	274	302	+28
Protein (kg)	235	264	+29
Lactation length (days)	305	303	-2

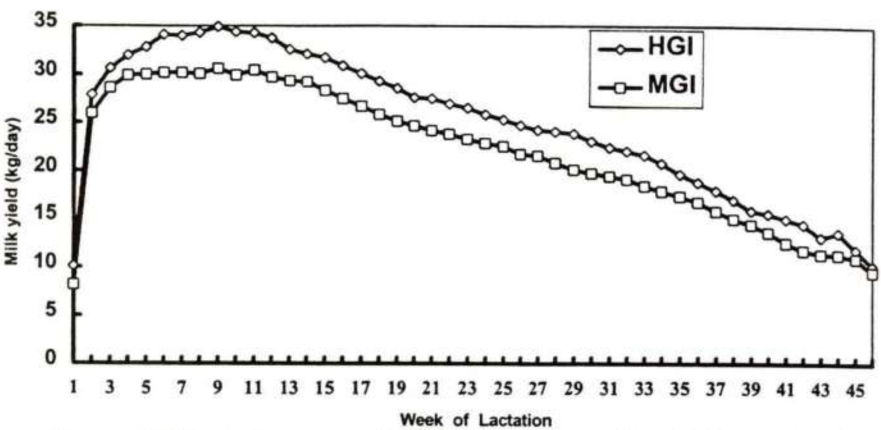

Figure 2. Effect of cow genetic index on mean milk yield by week of lactation (1996).

The HGI cows produced significantly higher yields of milk (+904 kg), fat (28 kg) and protein (29 kg) of slightly lower fat content (-0.13) and with similar protein content. The average daily milk production for the MGI and HGI cows was 22.5 kg (4.8 gals) and 25.6 kg (5.5 gals) per cow over the lactation. Peak milk production was obtained in early May at 35 kg/cow/day (7.5 gals) and 31 kg/cow/day (6.6 gals) for the HGI and MGI cows, respectively. Lactation lengths were similar for both genotypes.

Tables 5, 6 and 7 show the milk production (adjusted for calving date) for both genotypes on each feeding system. The concentrate feeding levels were 695, 1340 and 695 kg concentrate/cow for feeding systems A, B and C, respectively, over the entire lactation in 1996. Concentrate supplementation exceeded the target level in 1996 due to delayed turnout resulting from poor grass growth rates. Cows were turned out to pasture by day on April 1 and by day and night on April 10. There was no interaction between CGI and feeding system, although the difference in fat and protein yield between genotype was greatest in feeding system B (+64 kg). The average response was 1.12 and 0.92 kg milk/kg extra concentrate fed for the HGI and MGI cows, respectively, of solids-corrected milk. The best responses were obtained in the autumn period and the lowest responses were recorded in early spring. The milk yield response to feeding system C was 190 kg (41 gals) of solids-corrected milk over the total lactation. The largest responses were again obtained in the autumn when supplemented with high quality grass silage while the Moorepark feeding system were on grass-only.

Table 5

Effect of cow genetic index on milk production - Feeding System A

	MGI Total	HGI Total	Difference (H-M)
Milk (kg/cow)	6,576	7,632	+1,056
(Gallons/cow)	1,405	1,630	+225
Fat %	4.11	3.76	-0.35
Protein %	3.39	3.37	-0.02
Fat (kg)	266	286	+20
Protein (kg)	222	257	+35
Lactation length (days)	302	300	-2

Table 6

Effect of cow genetic index on milk production - Feeding System B

	MGI Total	HGI Total	Difference (H-M)
Milk (kg/cow)	7,221	8,142	+921
(Gallons/cow)	1,543	1,739	+196
Fat%	3.96	3.97	+0.01
Protein %	3.45	3.41	-0.04
Fat (kg)	285	321	+36
Protein (kg)	249	277	+28
Lactation length (days)	309	307	-2

Table 7

Effect of cow genetic index on milk production - Feeding System C

	MGI Total	HGI Total	Difference Total
Milk (kg/cow)	6,786	7,518	+732
(Gallons/cow)	1,450	1,606	+156
Fat%	4.03	3.96	-0.07
Protein %	3.45	3.45	0.00
Fat (kg)	272	298	+26
Protein (kg)	233	259	+26
Lactation length (days)	305	303	-2

Grazing management and intake

Table 8 shows the intake estimates taken in both 1995 and 1996. Individual animal intake was measured on 4 occasions during lactation in 1995 (May to November) using the n-alkane technique of Mayes *et al.* (1986), as modified by Dillon and Stakelum (1989). Over the four intake measurement periods, concentrate supplementation levels of feeding systems A, B and C averaged 1.0, 3.5 and 1.0 kg/day, respectively. During the 3 measurement periods in 1996 (June to September), feeding systems A and C were on grass only while feeding system B was supplemented with 3.0 kg of concentrates daily. For both years, the HGI group had higher intakes (5% in 1995 and 8% in 1996). In 1996, the daily allowance of herbage (>4 cm) to achieve these intakes were 24, 21 and 27 for feeding systems A, B, and C, respectively. Supplementation with concentrates at pasture significantly increased total dry matter intake (TDMI) in both years with small reductions in grass dry matter intakes (GDMI). Previous studies (with lower milk producing cows) have shown that when cows are supplemented with concentrates at pasture, large substitution rates can occur.

Previous results from Moorepark (Stakelum *et al.*, 1988) suggest that at daily intakes of 10, 12, 14, 16 and 17 kg of grass dry matter/cow, substitution rates

Table 8

Effect of cow genetic index and feeding system on grass (GDMI) and total (TDMI) intake (kg DM/cow/day)

	Feeding system					
	A		B		C	
	HGI	MGI	HGI	MGI	HGI	MGI
CDMI[1]	14.2	13.4	13.9	13.5	15.1	14.1
TDMI[1]	15.1	14.3	16.9	16.6	16.0	15.0
GDMI[2]	20.3	18.6	19.6	18.3	20.7	19.2
TDMI[2]	20.3	18.6	22.2	20.9	20.7	19.2

1 = 1st lactation

2 = 2nd lactation

Table 9
Effect of cow genetic index on liveweight

	1st lactation (1995) HGI	MGI	2nd lactation (1996) HGI	MGI
Pre-calving	592	585	650	634
Week 1 of lactation	522	518	572	563
Week 9 of lactation	491	490	536	538
End of lactation	549	560	631	649
Pre-calving	650	634	707	701

of 0.20, 0.32, 0.44, 0.55 and 0.62 kg/kg of concentrate, respectively, will result. The reduction in grass intake per kg of concentrate offered in study in 1996 was 0.2. The consequence of this is the very good milk yield response to the concentrate which was achieved. The increase in intake with feeding system C averaged 0.5 kg/day when compared to feeding system A.

During the dry period of 1996, individual intakes were measured on 20 HGI and 20 MGI cows. The genotypes were balanced on expected calving date and received high quality silage (75 DMD) *ad-lib*. The HGI cows had significantly ($P<0.01$) higher DM intakes at 13.2 and 12.1 kg/cow/day for the HGI and MGI cows, respectively.

Liveweight and condition score

Table 9 shows the liveweight at critical stages of lactation for both genotypes, while Figure 3 shows the effect of genotypes by week of lactation. Over the total lactation, the HGI cows gained less liveweight during the lactation (27 kg in 1995; 59 kg in 1996) compared to the MGI (42 kg in 1995; 86 kg in 1996). This was as a result of either losing more liveweight in early lactation and/or

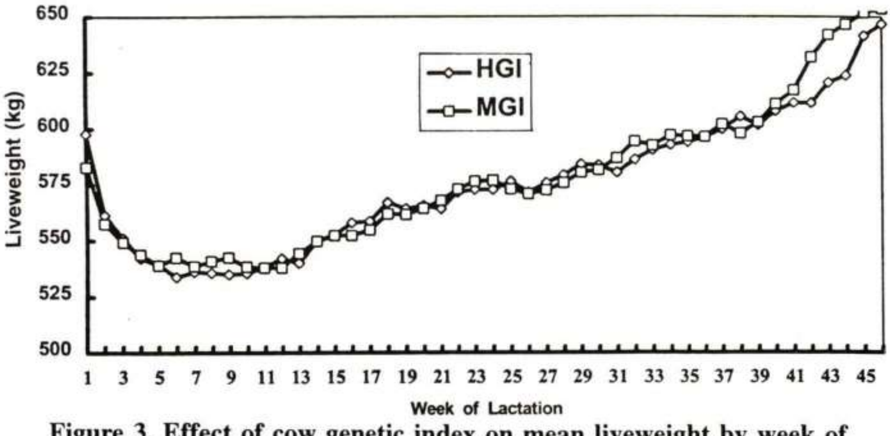

Figure 3. Effect of cow genetic index on mean liveweight by week of lactation (1996).

gaining lower liveweight in the second half of lactation. The opposite was the situation during the dry period when the average liveweight gain was 1.20 and 0.90 for the HGI and MGI cows, respectively. This high level of liveweight gain during the dry period was achieved on *ad-libitum* high quality silage (75 DMD). Feeding system had no effect on liveweight at any stage of lactation.

Table 10 shows the condition score at similar stages of lactation to that of liveweight in Table 9. Condition score changes follow liveweight changes during lactation. The condition score of the HGI cows was lower at all stages of lactation when compared to the MGI cows, while again feeding system had no effect.

Table 10
Effect of cow genetic index on condition score

	1st lactation (1995)		2nd lactation (1996)	
	HGI	MGI	HGI	MGI
Pre-calving	2.79	3.25	3.04	3.38
Week 9 of lactation	2.35	2.77	2.44	2.92
End of lactation	2.52	2.97	2.75	3.35
Pre-calving	3.04	3.38	3.11	3.65

Fertility performance

Table 11 shows the effect of cow genetic index on fertility performance for 1996 and 1997. The breeding seasons were confined to 13 weeks in both years. There was no effect of cow genetic index on submission rate, calving-to-service-interval, or calving-to-conception-interval. However, the HGI cows had a greater number of services per conception, lower pregnancy rates to 1st and 2nd service with subsequently higher infertile rates. There was no indication that feeding system had any effect on any of the fertility parameters measured.

Table 11
Effect of cow genetic index on fertility performance

		HGI		MGI	
		1996	1997	1996	1997
Calving to 1st service interval	(days)	71	69	73	68
Calving to conception interval	(days)	87	85	92	85
Cows served in 1st 3 weeks	(%)	88	88	85	100
Services per conception	(all cows)	2.02	2.14	1.79	1.79
Pregnancy rate:	1st service	38	44	54	52
	2nd service	43	30	59	57
Infertile rate	(%)	21	25	6	6

Discussion

(1) There was no indication of an interaction between CGI and the feeding system evaluated in this study. However, there was an indication that the

response to concentrates was higher with the HGI cows in 1996 (1.12 and 0.9 kg milk/kg of extra concentrate fed with the HGI and MGI cows, respectively). It is also important to emphasize the narrow range of the genotypes used in this study. The two years results also indicate that the difference in milk production between the two genotypes is very similar to that which can be predicted from the pedigree index.

(2) There is a clear indication in this study that selection of cows for higher milk production leads to higher feed intake as a consequence of the genetic correlation between these traits. To accommodate a cow with an RBI (95) of 135, as compared to that of 100, it is estimated that stocking rate would have to be reduced by between 15 and 20%, if most of the extra milk production is to be obtained from grazed grass and silage. With reduced stocking rate in place then, it will depend on grazing management skills of the farmers to be able to consistently maintain a sward of high quality. Cows, regardless of their genetic merit, require good management practices to be adhered to if they are to perform to their potential. This is especially so as the herd's CGI increases.

(3) The milk yield response to feeding extra concentrates at pasture was much higher than that reported previously with lower milk-producing cows. Hoden *et al.* (1991) reported higher milk yield responses from higher-producing cows. The higher milk yield responses are supported with the lower substitution rates of concentrates for grass and no effect of feeding system on liveweight change. The milk yield response to allocation of extra grass (system C) was small (190 kg). These results are supported with the small increase in GDMI achieved. However, feeding system A (which is the Control) was managed on a daily basis to provide sufficient high quality grass with a post-grazing height of 5 to 6 cm.

(4) The reduced fertility performance of the HGI cows is of concern and will require further investigation. However, evidence is accumulating to suggest that milk production will mainly reduce reproductive performance when the intake of energy is insufficient to meet current milk output and this results in prolonged negative energy balance (NEB) in early lactation. The severity and duration of NEB may vary, depending on body condition score at calving, production level, ration formulation and environmental factors. Studies to define more precisely the effect of increasing milk yield in early lactation on reproductive performance, especially in Holsteins, are required. Oestrus detection rates and pregnancy rates for American Holsteins of less than 50% are accepted widely in the USA (Macmillan *et al.,* 1996).

Conclusions

The objective of this study was to evaluate the performance of HGI and MGI cows on three grassland based feeding systems. The results clearly show that cows of HGI produce higher yields of milk and milk constituents. There was no significant CGI x feeding system interaction observed for any of the measurements taken, indicating that HGI dairy cows do not respond differently to feeding system when compared to MGI cows (across the range of diets examined). It is also evident that HGI cows have higher grass DM intake and total DM intake. The study also indicates that HGI cows have a higher rate of liveweight loss in the post-calving period, and that HGI cows have a lower live-weight gain during lactation, suggesting greater body tissue mobilisation. They also exhibit higher rates of gain during the dry period. The HGI cows clearly maintain a lower condition score at all stages of lactation suggesting a high correlation between selection for CGI and this trait. Feeding system had a significant effect on yield of milk and milk constituents, DM intake, and had no effect on milk composition. Feeding system had no effect on live-weight, condition score, live-weight change, and condition score change. In the present study, milk yield response to additional concentrate fed was much larger than that reported previously. Both genotypes in the present study are of higher genetic index than those in previous studies. The present study may suggest that increasing CGI has a detrimental effect on fertility performance, although further research is required in this area.

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Phosphorus Recommendations for Grassland

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Introduction

Competitive agriculture depends on the efficient production of high quality food in a clean and healthy environment. Nutrient inputs, including phosphorus (P) are essential to optimise production. Irish farmers are currently spending over £300 million annually on inorganic fertiliser of which approximately 20% is spent on P. Recent research suggests that P inputs into agriculture have been too high in recent years in some situations (Tunney, 1990). International reports suggest that there is considerable potential for P losses from agriculture into water bodies (Sharpley and Rekolainen (1997), Lennox, Foy, Smith and Jordan (1997), Sibbesen & Sharpley (1997). In 1996, the P recommendations for grassland were reviewed and revised.

Phosphorus is an essential element for plant and animal life. In agricultural systems P is needed for seed and root formation, and the accumulation and release of energy during cellular metabolism (Finkl and Simonson, 1979). In animals, P is required for bone formation and a deficiency can cause osteomalacea. 'Pica' or depraved appetite has been noted in cattle when there is a deficiency of P in the diet. Low dietary P may also be associated with poor fertility and apparent dysfunction of the ovaries causing inhibition, depression or irregularity of oestrus.

In the 1950s soils were generally extremely deficient in P, resulting in low yields of grass and crops and in some areas aphosphorosis in livestock. Farmers have, over the past three to four decades, rectified this situation by the constant application of phosphatic fertilisers. Now as we approach the end of the 1990s, there appears to be excessive P being used in some parts of the agricultural production system and this is contributing to eutrophication of rivers and lakes.

The sources of P loss and the pathways of P loss are the subject of considerable controversy. There are three main sources of P losses:-

1) Seepage of soiled water from farmyards appears to be the main culprit and there is little doubt that if farmyard design and maintenance were improved, there would be less P pollution of our waterways. The EPA have suggested that up to 50% of agricultural pollution is due to seepage from farmyards.
2) Slurry spreading in itself will not lead to run-off of P. It is spreading slurry at the wrong rates, or in the wrong place, or at the wrong times that lead to slurry finding its way into drains, rivers and streams. Spreading slurry at reasonable rates during the grass growing season in places where there is no risk of runoff into rivers/lakes will ensure no loss of P.
3) Elevated soil P levels. There is evidence that increasing soil P levels can lead to increased P runoff in areas where run-off to water-bodies is possible (Kurtz et al., 1998).

This paper deals with agronomic rather than environmental issues. The objective is to present the background and justification.

Soil testing

There are many soil testing methods used internationally across Europe to measure available soil P. The method used at Johnstown Castle is the Morgan's test. One study of various soil tests showed that Morgan's extractant compared favourably with the limited range of others studied and was superior to a modified Olsen Extractant (Brereton, 1970). The R^2 for the Morgans extractant for a select group of sites that contained *Lolium perenne* and other sown species was 43.5%. It was 17% over a wider range of sites. The results from the study did not provide the basis for replacing Morgan extractant with any of the alternative methods tested. Data from a plot experiment on ryegrass (Humphreys, 1996) and from field experiments on 77 sugar beet soils (Herlihy, 1986) also indicated the superiority of the Morgans extractant vis a vis other test methods like conventional Olsen extractant. For sugar beet, Morgan P accounted for 34% of the variation in fertiliser P requirement, Mehlich-2 for 35%, Olsen for 26% and 0.01 m $CaCl_2$ for 16%.

There is no doubt that the Morgan P test has limitations. Furthermore, in interpreting the results of the tests, no account is taken of differing soil types (apart from peats). Nonetheless, it would appear that it is as good as any other extract and will continue to be used. A new series of trials on 8 different soil types at different levels of soil P was initiated at Johnstown in 1997. This investigation will form the basis of either changing to a different extractant or to adding modifications to Morgan's extractant to cope with differing soil types. In order to cope with the shortcomings of the Morgans, a test with relatively wide Index bands are used to cope with as wide a range of variations as possible.

Soil indices

When soils are analysed for nutrient status at Johnstown Castle, an index system is used to categorise them into differing soil P levels. This index system is presented in Table 1. Agriculture productivity is very low at Index 1. The productive species like perennial ryegrass do not thrive in this Index and the stock carrying capacity of land is this Index is very poor. If stock numbers are to be increased, phosphorus must be applied at high rates in order to get a full yield and to improve the soil P status. At Index 4, soil P levels are very high and there is no agronomic response to further phosphorus fertiliser. The aim of agricultural productivity should be to have soils at Index 2 or Index 3. These issues are discussed in more detail under the recommendations section.

Table 1

Soil test ranges for P index system

Index	Mineral Soil	Peat	
1	0 - 3.0 mg P/L	0 - 10 mg/L	Response:- Definite
2	3.1- 6.0 mg P/L	11- 20 mg/L	Response:- Likely
3	6.1 - 10.0 mg P/L	21- 30 mg/L	Response:- Unlikely
4	>10	>30	Response:- None

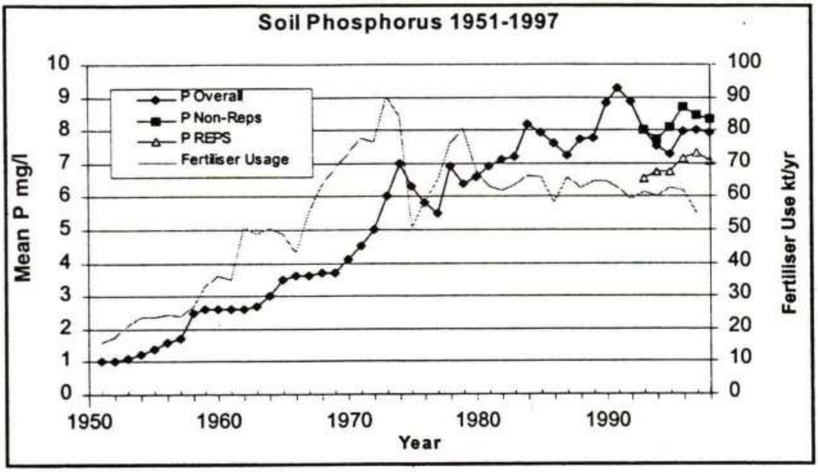

Fig. 1 - Soil phosphorus levels and fertiliser usage 1959-1997.

National trends in P levels in soils

As already noted, Irish soils were grossly deficient in P (<1 mg/l) in the 1940s and 1950s when systematic soil testing began. During the period 1950 to 1991 the average P levels increased over ten fold to 9.3 mg/l (Fig. 1). Since 1991 the levels have dropped a little and appear to have stabilised around 8 mg/l. The average P content of samples received at the soil laboratory may not precisely represent the P status of the country for a number of reasons. It is not known whether there is an undue preponderance of samples from the more progressive farmers who might tend to use more fertiliser. Alternatively, the majority of the samples could have been taken from less fertile farms in greater need of P which would tend to bias the result downwards. A random sample of soils was taken in 1981 (Brogan, Kelly and O'Keeffe, 1981) and when this was compared with the average samples received at the laboratory it showed that advisory samples were 11% higher in P than the random sample. REPS farmers who are generally less intensive, have been shown to have more samples at lower soil P levels than the average of the Non-REPS farmers. After 1993, large numbers of samples have been received from REPS farmers and the recent mean P values in Figure 1, which include many REPS samples, may be somewhat low for this reason.

The distribution of P levels in soil samples for grassland received at the laboratory from September 1996 to August 1997 is shown in Table 2. Of the

Table 2

Soil P status 1996-1997 for grassland, % of soil samples in each category

Index 1	21
Index 2	35
Index 3	23
Index 4	20

samples received, 20% had P levels in Index 4 and 21% had soil P levels in Index 1. It is quite clear that soils low in P should be fertilised if yields are not to be severely restricted and there is no justification for further P while soils are in Index 4.

A county by county break-down of the soil fertility status of the country is given in Table 3. This is based on soil analyses of samples received at the laboratory between July 1993 and June 1996. The mean P level varies from a high of 11.5 mg/l in County Carlow to a low of 4.6 mg/l in County Donegal. Maps showing the P fertility distribution across the country have been published by Coulter *et al.*, 1996.

Table 3

The P content of soils analysed at Johnstown Castle from July 1993 to June 1996 (Coulter et al., 1996)

County	Number of samples	P ppm	Percentage of samples with Phosphorus content (mg/l) 0-3	3.1-6	6.1-10	>10 mg/L
Clare	1440	7.23	23.1	35.5	20.6	20.9
Dublin	698	10.67	16.0	28.4	23.1	32.5
Carlow	1894	11.54	11.9	25.1	23.0	39.9
Donegal	1257	4.64	36.8	41.6	16.2	5.3
Meath	3428	7.13	21.4	36.0	24.4	18.2
Longford	1117	7.96	16.3	34.3	24.5	24.9
Galway	3168	8.59	17.2	29.6	25.4	27.7
Westmeath	1917	6.21	29.2	36.6	19.9	14.3
Kildare	2582	8.41	22.0	31.9	19.9	26.2
Monaghan	1135	9.07	16.2	34.4	24.6	24.8
Kerry	2550	9.00	17.7	31.0	22.8	28.5
Laois	2895	9.62	18.6	28.9	21.5	31.0
Mayo	1919	6.92	23.6	32.7	24.6	19.2
Kilkenny	3808	7.23	22.2	34.7	23.1	20.0
Cork	15321	9.73	11.0	28.6	28.0	32.5
Tipperary	7716	8.48	15.4	32.7	24.9	27.0
Leitrim	88	5.35	37.5	39.8	12.5	10.2
Roscommon	1306	7.22	24.0	35.1	21.7	19.1
Sligo	1566	6.23	32.5	34.6	18.6	14.3
Waterford	2528	8.47	15.0	34.3	27.8	23.0
Louth	2244	8.75	21.9	31.1	21.7	25.2
Cavan	683	6.61	19.8	40.3	22.5	17.4
Wicklow	2280	6.59	26.0	35.5	21.4	17.1
Wexford	4648	6.98	20.2	37.5	24.4	17.9
Offaly	1818	8.54	20.2	31.1	21.0	27.7
Limerick	3683	7.40	18.7	35.2	25.5	20.6
Overall	73689	8.30	18.3	32.5	24.2	25.0

Phosphorus recommendations for silage

To achieve optimum silage yield the soil P status should be adequate and a maintenance P dressing should be applied to replace the P that is being removed in the crop. Research at Johnstown Castle shows that full grass production under

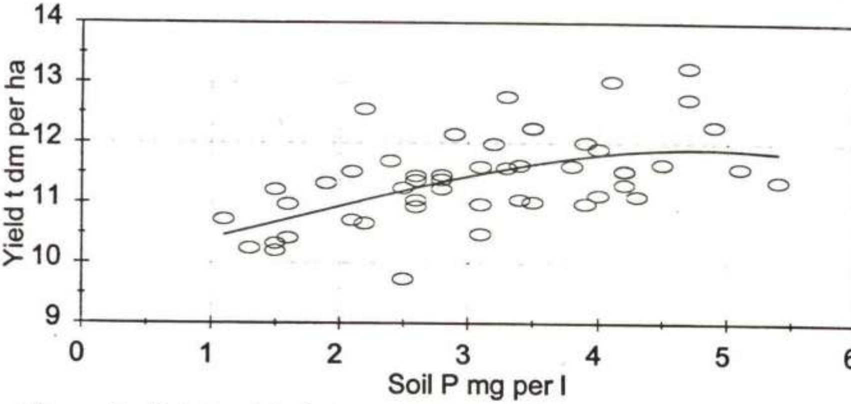

Figure 2 - Relationship between total herbage dry matter yields(3 cuts) for Clonroche in 1995 and the corresponding soil test P for each plot (equation of the line is: $y = 10 + 0.33x + 0.11x^2 - 0.02x^3$, $R^2=0.32$).

cutting conditions can be obtained at Morgan soil test P levels between 4 and 6 (mg P/l) (soil Index 2), provided maintenance P dressings are applied.

Target yields for first and second cut silage are 6 and 4 tonnes dry matter per hectare (t DM/ha), respectively. The P removals for these crops at 0.3% P in the herbage DM were calculated for a soil at Index 2 (3.1 - 6.0 mg P/l) (Table 4).

Table 4

Grass yields and P removals in first and second cut silage at 0.3% P in the herbage

Silage	Grass Yield (t DM/ha)	P removal (kg/ha) at 0.3% P
First Cut	6	18
Second Cut	4	12
Total	10	30

Tunney et al., 1996

Therefore, for a one cut silage system 18 kg P/ha are required to replace the P removal (maintenance) and 30 kg P/ha are required for a two cut system, where slurry is not recycled.

Calculating maintenance P for silage land

It is recommended that slurry from animals fed on silage should be recycled, in proportion to silage yields, to the land where the silage was cut. Table 5 summarises the average amount of N, P, K available in slurry. Where animals are fed 0.5 tonnes of barley based concentrates (or concentrates supplemented with minerals) per livestock unit the recycled slurry will satisfy most of the P requirements of silage land because the animals that consume the silage and concentrates remove only about 30% or less of the P present. Therefore, an annual application of 5.4 and 9 kg/ha of fertilizer P should be adequate for a one and two cut silage system, respectively, as the annual maintenance dressing for soils at Index 2. This does not include P removed in aftermath grazing.

Table 5

Average nutrients available in animal manures (kg/t).

	%DM	N Spring	N Summer	P	K
Cattle Slurry	6.9	0.9	0	0.6	4.3
Pig Slurry	3.2	2.3	0.5	0.9	2.6
Poultry Slurry	24.0	7.1	1.4	5.1	5.7

P guidelines for silage land

In the guidelines in Tables 6 and 7, Soil Index 2 (3.1 - 6.0 mg p/l) is considered adequate for grass cutting and subsequent grazing. For early grass in silage areas we recommend a soil P level of Index 3 (6.1 - 1 0 mg P/l). To ensure optimum silage yields over a range of soil types the P level should ideally be at or above the mid point of Index 2. Therefore, an additional increment of 5 kg P/ha should be used for Index 2 when the soil P level is between 3.1 and 4 mg/l. Table 6 summarises the chemical P fertilizer recommendation for silage land where all slurry is recycled to optimize the P supply. Additional P will be required where no concentrates are fed and less P will be required where more than 0.5 tonnes per LU is fed.

Table 6

Fertilizer P guidelines (kg P/ha) for silage swards where 0.5 t* concentrates are fed and slurry is recycled (cut 1 from 50% of farm and cut 2 from 25% of that area) (Tunney *et al.*, 1996).

Soil P Index	a) Spring silage (1 cut)	b) Spring and summer (2 cuts)	c) Summer silage (1 cut)
1	20	20	25
2	10	10	15
3	0	0	0
4	0	0	0

*Reduce these recommendations by 2 kg/ha for every 0.1 t/LU/yr increase above 0.5 t/LU/year of concentrates fed. Equally, increase by 2 kg/ha for each 0.1 t decrease below 0.5 t.

The fertilizer P for silage land where slurry is not recycled is shown in Table 6.

To allow for variation in soils and soil test results, an insurance factor of 30% more than removals is included in the final recommendations at Index 2 shown in Table 6. For the same reason a small P fertilizer input, of the same order, is also recommended at Index 3 where slurry is not recycled (Table 7).

Farm Management Survey

The farm management data for 1995 were used as the basis for a fertiliser use survey (Murphy, Culleton, Roche & Power, 1997). The farms were selected

Table 7

Fertilizer P guidelines (kg P/ha) for silage swards where slurry is not recycled (Tunney *et al.*, 1996)

Soil P Index	a) Spring Silage (1 cut)	b) Spring and Summer (2 cuts)	c) Summer Silage (1 cut)
1	40	50	35
2	30	40	25
3	8	10	7
4	0	0	0

by the Central Statistics Office on the basis of farm size and farming systems. The survey was carried out on 1226 farms and every country was represented. The mean P usage for silage and the influences of various farming systems are outlined in Table 8.

Table 8

The effects of farming systems on N P K use for silage

	P Usage (kg/ha)		
	Mean	S.E.	No. of Farms
Dairy	20	0.7	235
Dairy & Other	23	1.1	210
Cattle Rearing	18	1.2	109
Cattle Finishing	21	0.9	218
Sheep	20	1.2	142
Tillage	17	1.9	50
Pigs & Poultry	6	2.2	8
Mean	20	0.4	972

The mean P usage for silage was 20 kg/ha. If slurry was not recycled onto silage land then P usage was close to recommended levels. However, it must be assumed that on most farms the slurry was recycled and in this situation, P applications to silage were significantly higher than is agronomically necessary. What appears to be happening on many farms is that the slurry is applied in the normal way and a further 3-4 bags of 0-7-30 are also applied. The point to be made is that account should be taken of the nutrient value of the slurry. Fertiliser should only be used to top up the shortfall in requirements that remains when the slurry is applied.

When slurry is recycled the amounts of P required are small. For first cut silage, assuming normal fertility, fertiliser compounds like 20:2½:5 are very useful. They can supply all the N, P and K required. For second cuts, products like 25:2 ½ :10 can be quite useful.

In silage areas where, for one reason or another, slurry is not recycled, 0:7:30 is still one of the key fertilisers to be used. In the longer term, the amount of silage land that does not receive slurry will be getting less and less, and the necessity for products like 0:7:30 - will presumably also diminish.

Phosphorus usage for grazing

P build-up in soils

The phosphorus (P) recommendations for grazing are more complex than for silage. For grazing, the objective is to fertilize pastures to produce a grass supply that meets the demands of the imposed stocking rate (SR) throughout the grazing season. At high SR, optimum grass production is required from pastures compared with lower stocking rates where grass production targets will be lower. In general, farmers manipulate the grass supply with nitrogen (N) fertilizer. However, P plays an important role in determining the annual pattern and total grass yields from grazed grass. Therefore, optimizing fertilizer P inputs is an important variable in maximizing the production efficiency of any animal production system based on grazed grass.

When soil P levels are in Index 1, there is little scope for improvements in productivity. The productive grasses like perennial ryegrass simply do not survive at this level of soil P, while grasses like *Agrostis* thrive in these impoverished situations. If stock numbers are to be increased, it is imperative the soil P levels be improved significantly.

Conway, McLoughlin and Murphy (1972) demonstrated this very clearly in a study using old permanent pastures for sheep and cattle production systems in Ballintubber, Co. Roscommon. It was shown that when P was applied to an impoverished soil over a four year period and improved management strategies implemented that the stocking rate of cattle and sheep could be increased resulting in a four fold increase in liveweight gain between the first and the fourth year. There was a major change in botanical composition in the sward over the same period (Table 9).

Table 9
Output parameters in Ballintubber trial (Conway *et al.*, 1972)

	1963	1966
P levels	1-2 mgA	?
Fertiliser inputs (8% P)	4 cwt/acre	4 cwt/acre
Agrostis spp %	49.8	11.8
Rough Stalked Meadow Grass	2.2	53.3
Liveweight gain/acre	213	810

Culleton (1989) reported similar findings in trials in Co. Wexford with beef cattle, where output increased dramatically as the perennial ryegrass content improved (Table 10).

Table 10
Output parameters in Johnstown Castle trial (Culleton, 1989)

	1986	1987	1988
P levels in soil (mg/l)	2.5	3	4.5
P application rates (kg/ha)	50	40	40
Liveweight gains/ha	849	1091	1118

A long term grazing trial (Cowlands trial) at Johnstown demonstrated this change in botanical composition from a different point of view. A beef grazing trial was commenced in 1968, when 0, 15 and 30 kg P/ha were applied to a soil at a P level of 6 mg/L. At the commencement of the trial the sward was dominated by perennial ryegrass. In the zero P treatment the botanical composition deteriorated as the P levels dropped. In 1997 the P levels in the zero P plots were 2.0 (mg/l) and the plots were dominated by *Agrostis* species. Swards in the higher P treatments are still dominated by perennial ryegrass.

It can be concluded that if reasonable productivity is to be achieved, it is imperative that P be applied in sufficient quantities to move the soil out of Index 1.

Work at Johnstown Castle suggests that at Index 2 the perennial ryegrass can be maintained in the sward and reasonable levels of productivity can be achieved. At stocking rates significantly below the stock carrying capacity of the land there will be sufficient grass produced at Index 2. However if there are aspirations to further increase stocking rates, P should be applied at rates that will move the soil out of Index 2 into Index 3.

The Cowlands trial showed that a soil P Index of 3 (6.1 - 10.0 mg P/l) is required for optimum production of grazed grass. Therefore, when farmers require all the grass that the system has the potential to produce, Index 3 is the target soil fertility level. Recent and current grazing trials at Taranaki Agricultural Research Station in New Zealand also support this conclusion. This contrasts with the results from cutting trials where Index 2 is adequate. The reasons for the differences between the results of the grazing and cutting trials cannot, as yet, be explained. However, tentative explanations are as follows:- the uneven distribution of dung pats as well as lower efficiency of P returns in the dung pats from grazing compared with uniform distribution of fertilizer P in the cutting trials. Other possible reasons are the necessity for extra P to ensure that there is out-of-season grass in grazing systems; the high tiller density with subsequent increased rooting of grazing systems as opposed to silage systems; the higher frequency of defoliation gives rise to increased root activity and hence higher P requirements; higher P offtakes in grazing systems. The dietary requirements of dairy cows is another factor that must be taken into account and this is covered in the section on P levels in herbage.

There is some evidence in the literature which suggests that soil with Morgan's P levels of < 4 mg/l will restrict grass growth in spring. Murphy (1977) showed that P applied in autumn/early spring gave 200 kg DM/ha more grass in late March than when no P was applied at soil P levels of 4 mg/l. A new trial has been initiated to verify this effect. Preliminary results indicate there was a significant grass DM response in March and April at a soil P level of 2 mg/l. There was a significant response to 45 kg P /ha in April at soil P of 4 mg/l. There were no differences at higher soil P levels. These results are supported by New Zealand work which showed a seasonal response at low Olsen's P (5 -15 mgA) compared with no response at higher P soil levels (Roberts, 1987). When early grass is required for grazing be it in silage or in grazing ground Index 3 is the target soil fertility level.

The quantities of P required to change soil P levels by 1 mg/l is difficult to predict, as it depends on soil type and soil P level. It can take from 10 to more than 100 kg P/ha to move the available P by one point depending on the soil. In light sandy soils, P levels can be reduced rapidly, while in heavier soils it can take up to and maybe more than 100 kg of P removed to drop the P by one point. It is further complicated by the level of P already in the soil. Available soil P of 20 mg/l can be lowered to 19 by the removal of approximately 10-30 kg P/ha. It could take the removal of greater than 100 kg P/ha to move the available P level from 5 to 4 mg/l.

If approximate calculations are to be made, a figure of say 40 kg P to change the Morgan's P by one point can be used e.g. to go from Morgan's P 11 to 10 will need a net removal from the soil of 40 kg P. At a stocking rate 2.5 LU/ha, this will take approximately 3-4 years.

Phosphorus can be applied with equal effectiveness in autumn, in spring or in smaller amounts at frequent applications throughout the year. At Index 1 where there are responses to P, autumn application is beneficial. Phosphorus in cold conditions is less available to plant roots and if early grass is required, there needs to be a relatively rich supply of P. At Index 3, there is no advantage to autumn as opposed to early spring application.

P maintenance in soils

The soil P levels should be adequate to support the required level of grass production. Once the desirable soil P level is attained a maintenance dressing of P should be applied to replace the P that is being removed in animal product and other unavoidable losses. Bertilsson and Forsberg (1997) indicated that when an adequate level of soil fertility is attained, optimum yields can be maintained by replacing the P that is removed from the farm system. Therefore, P is required to replace the nutrients exported off the farm in animal product, P fixed by the soil and other losses from roadways.

Phosphorus recommendations for grazing

Teagasc P fertilizer recommendations for grazing are based on two principles

1) Soil P must be built up to desirable soil P levels, as rapidly and as economically as possible.
2) Once this level has been achieved, soil P levels are maintained by replacing what is removed or lost from the farm system.

As already stated, Index 1 represents a state of impoverishment and if serious farming is to be conducted, it is imperative that soil P levels be built-up. Table 11 summarises the guidelines for P build-up to either Index 2 or Index 3.

Table 11
Phosphorus required for build-up (kg/ha/year)

Soil P	Target Index for Soil P	
Index	Desired Index 2	Desired Index 3
1	20	20
2	0	10
3	0	0

As already stated, Index 3 is the desired soil P level for farming at or near the stock carrying capacity of the soil. This level ensures optimum yields, satisfactory grass growth at both ends of the season and ensures that there is adequate P in the herbage to meet the dietary requirements of cows in most situations. Once this P status is achieved, P offtakes should be balanced by P fertiliser.

A cow results in the removal of approximately 5 kg P per grazing season. Therefore, the amount of P removed is determined by stocking rate. Table 12 outlines the removals at a range of stocking rates. A number of assumptions were made in calculating these offtakes and these are summarised in Appendix 1.

Table 12
Soil phosphorus maintenance requirements (kg/ha)

	Stocking Rate LU/ha			
System	1.0-1.5	1.6-2.0	2.1-2.5	>2.5
Dairying	6	9	13	16

The 5 kg/cow removals were made on the basis of a milk yield of 5000 L/cow. Table 13 shows the offtakes for a range of milk yields and stocking rates. Changes in milk yield of 1000 L/cow would mean a change of 2.3 kg P/ha in the recommendations.

Table 13
Offtakes of P (kg/ha/yr) at various stocking rates and milk yields (Culleton *et al.*, 1996)

Milk Yield	Stocking Rate LU/ha				
l/cow/yr	1.0	1.5	2.0	2.5	3.0
3,000	3.4	4.9	6.4	7.8	9.3
4,000	4.4	6.3	8.2	10.2	12.1
5,000	5.3	7.7	10.1	12.5	14.9
6,000	6.3	9.1	12.0	14.9	17.8
7,000	7.2	10.5	13.9	17.2	20.6
8,000	8.1	12.0	15.8	19.6	23.4
9,000	9.1	13.4	17.7	21.9	26.2
10,000	10.0	14.8	19.5	24.3	29.1

There are situations where Index 3 P levels are not required. Irish soils have been classified in terms of their stock carrying capacity (Lee and Diamond, 1972) and many farmers are stocked below the potential of the soils. It is quite reasonable that Index 2 P level is quite sufficient in this situation. The amounts of P required to maintain the soil P test at Index 2 will be somewhat greater than those removed by stock, as there will be some long-term immobilisation of P by the soil. Table 14 outlines the considerations that can be taken into account when deciding whether to opt for Index 2 or 3.

Table 14
Choosing the target soil index

Target Index 2	Target Index 3
(1) Stocking rate <75% of the stock carrying capacity	(1) Stocking capacity at or near stock carrying carrying capacity
(2) Set stocked paddocks	(2) Rotationally grazed.
(3) Out of season grazing not required.	(3) Out of season grazing or grazing required before closing for spring silage.

In REPS, Index 3 is required for stocking rates at or near the limits allowed for REPS rates because of the restrictions in N use and the need for a good grass/clover sward for summer grazing.

A summary of the guidelines for P when Index 3 is the target is summarised in Table 15.

Table 15
P guidelines for grazing

Soil	Stocking Rate (LU/ha)			
Index	1.0 - 1.5	1.6 - 2.0	2.1 - 2.6	>2.5
1	26	29	33	36
2	6	19	23	26
3	0	9	13	16
4	0	0	0	0

Phosphorus recommendations for grazing are complex. There are still considerable gaps in our knowledge. It is quite possible that as new information becomes available from the Johnstown Castle dairy trial and from new trials on the responses to P over a range of soil types and fertility, the recommendations will be modified.

Nonetheless, these recommendations, which are based on stocking rates, targeted soil fertility levels and offtakes, are significantly more focused than previous recommendations. They are also more precise and it should be pointed out that when these recommendations are followed, it is vital to monitor the P status in the soil. Soil testing should be used not only to monitor the amounts of fertilizer needed to ensure optimum yields but also to ensure that satisfactory soil P levels are maintained. In the light of reduced fertiliser recommendations, it is vital that the soil be tested. It is essential that the following protocol for soil testing is followed correctly.

Protocol for soil sampling

1. Map out discrete areas of the farm that are uniform in soil type, slope, drainage and cropping history.
2. Take a composite sample consisting of 20 individual cores in each designated area.

3. Cores should be taken to a depth of 10 cm.
4. The cores should be taken in "W" shape across the sampling area.
5. Avoid unusual spots like old fences, ditches, water troughs and gateways.
6. Avoid dung and urine patches, avoid where fertiliser was stored or spilled.
7. Do not sample a field for P and K until 6 months after last application of fertiliser. Do not sample a field for lime requirement until 2 years after lime application.
8. Sample at the same time of year on each sampling occasion.
9. Sample every 3 years in intensive farming.
10. Sample every 4-5 years in more extensive farming.
11. Fill in the Soil Identification form completely (including details on texture).
12. Enter map grid number of each soil sample identification form.
13. To get a recommendation, as well as nutrient status statement, include information on crop to be harvested and stocking rates.

Fertiliser use survey

The fertiliser use survey also examined the use of P on grazing areas and the results are summarised in Table 16. The table shows clearly that the dairying sector are the most intensive users of P, while cattle rearing farmers use in the order of 9 kg P/ha. The farmers with pigs and poultry obviously use their manures as they use only 4 kg/ha of fertiliser P. As stocking rates increased, the usage of P also increased. However, when comparing the usage to the recommendations, it is clear that at all stocking rates recorded, the usage is somewhat above recommendations. This is especially true at the more extensive stocking rates.

Table 16
N P K usage on the estimated grazing areas

Farm system	P (kg/ha) Mean	*s.e.*	Mean Size of area	Number of farms
Dairy	14	*0.6*	21	237
Dairy + Other	13	*0.6*	29	212
Cattle rearing	9	*0.9*	15	142
Cattle finishing	11	*0.6*	20	287
Sheep	10	*0.9*	24	206
Tillage	9	*1.2*	18	84
Pigs & Poultry	4	*1.8*	38	9
Stocking Rate				
0-1 LU/ha	7	*0.6*	20	287
1-1.5 LU/ha	12	*0.5*	23	439
1.5-2 LU/ha	13	*0.5*	24	379
2-2.5 LU/ha	17	*1.8*	20	72
Mean	11	*0.3*	22	118

Table 17 outlines the sources of fertiliser P that were used by the farmers in the survey.

Table 17
Sources of P for grazing

Compounds	Phosphorus % from each source
0:10:20	12
0:7:30	5
10:10:20	16
18:6:12	31
10:25:22 NI	6
High N compounds	26
Others	4

For Index 2 or 3 soils fertilisers like 18:6:12, 0:10:20, 10:10:20, 27:2½:5 are all still very useful. For extensive dry stocking farming a new fertiliser is being manufactured this year which should be very useful, in that the amount of P has been reduced a little, while the amounts of K has remained the same. The formulation of this new product is 18:4:12. It is likely that this product will be useful in many farms that are currently spreading a little too much P each year. This product will be especially useful in extensive beef farming provided the grass is kept in the vegetative stage.

There is a movement towards using high N products, thereby spreading small amounts of P and K during the grazing season when the crop needs them. This is a trend that is likely to continue and it has the added advantage that this type of fertiliser can be environmentally friendly in that only relatively small amounts of P are being applied at any one time and the risk of runoff is therefore being reduced.

Herbage P levels

One of the major concerns in this P debate is the level of P in herbage. A P trial is currently being conducted in the dairy at Johnstown Castle. The objective of the trial is to determine the minimum soil P level at which dairying can be carried out efficiently. The long term target is to have 3 herds of 21 cows each grazing soils with differing P levels. Herd 1 will be grazed and fed silage from soils with a P level of 2-4 mg/l. Herds 2 and 3 will be managed similarly on soils with P levels of 6-8 and 11-12 (mg/l), respectively. At that stage, similar maintenance dressings of P will be applied to all treatments.

In 1996 Herd 1 land had soils around 4.7 and this received no P fertiliser. Herd 2 land had soil P levels of 8.5 and received maintenance dressings of 13 kg P/ha. Herd 3 land had P levels of 10-12 mg/l and received 20 kg P/ha.

The P in herbage was recorded pre-grazing, throughout the growing season. The results are summarised in Table 18. While 1997 data are not complete, preliminary results suggest that the P levels in herbage are not dissimilar to 1996.

Table 18
Phosphorus percent of D.M. in herbage pre-grazing at various times during the year

	11/4	29/4	24/5	21/6	18/7	27/8	18/9	15/10	Mean for whole year
Soil P 4.7	.37	.33	.34	.40	.36	.39	.30	.50	.37
Soil P 8.5	.34	.39	.42	.35	.30	.40	.32	.46	.37
Soil P 12.0	.43	.51	.43	.39	.32	.38	.31	.50	.41

In general terms, on well grazed grassland percentage P remained at reasonable levels on a range of soil P levels between approximately 5 and 10 mg/l.

On silage land the results were somewhat different and in general P concentrations in silage were lower than in the grazing sward (Table 19). This may result from a dilution effect i.e. as the grass yields increase, the P concentration declines.

Table 19
Phosphorus, % of DM in silage

Morgan P mg/L	1st Cut	2nd Cut
4.5	.26	.23
8.5	.27	.24
12.0	.33	.25
L.S.D. (P = 0.05)	.04	.03

At the higher soil and fertiliser P levels, the P concentrations in first cut silage were higher than when the soil P levels were low. The second cut silage had lower P levels than the first cut.

Fleming and Murphy (1968) conducted a series of cutting trials in the late 1960s. When no phosphorus was applied to ryegrass cut 9 times during the year, P levels remained around 0.3%. When 21 kg P/ha was applied %P started in spring at 0.6% and dropped to 0.5% in late summer. In silage swards P level fell to approximately 0.25% in late May/early June.

Table 20 summarises the percentage P in herbage from the Cowlands trial. There were 3 phosphorus treatments, PO, P15 and P30 kg/ha applied annually at two stocking rates, 1800 and 2400 kg liveweight at turnout in spring. This shows the P concentration was reasonably high in all treatments and at all stocking rates. There were no real differences in P levels between stocking rates. Herbage P levels in the control plots (PO) were quite high but were not as high as the P levels in the P15 and P30 plots.

Table 20
P % in herbage dry matter in the Cowlands trial

	High stocking rate			Low stocking rate		
	P0	P15	P30	PO	P15	P30
All Samples	.33	.46	.53	.33	.45	.49
Pre Grazing	.35	.46	.54	.37	.45	.52

These results suggest that percentage phosphorus in grazed herbage is in the order of 0.37-0.45% provided the grass is well managed and kept in the leafy vegetative stage. The P concentration can be kept at this level over a range of soil P levels ranging from 5 to 10 mg/l. In general terms, these levels are adequate to meet the dietary requirements of lactating cows. For very high yields it may be necessary to supplement with additional P if there is a shortfall in intake of P.

Future phosphorus research

1. There is little doubt that the soil P test is not adequate for all soil types and all situations. It is primarily useful in giving guidelines as to the P status of the soil. A new trial started in 1997 on thirty sites around the country will hopefully shed new light on responses to P, as well as bringing new information about Morgan's P test and other possible new soil P tests.
2. Quantification of pathways of P loss from agriculture to water. The production of an easy to use methodology of assessing the risk of P loss to the environment is required. Factors to be considered are soil types, soil P level slope, rainfall, drainage systems and proximity to water. The contribution of farmyards and slurry needs to be clarified. Some areas are more vulnerable to P loss than others. Knowledge of these vulnerable zones and how to define them could greatly help in devising strategies to reduce P losses.
3. More detailed work on soil chemistry is required. We need to know more about the fate of fertiliser P when it is applied to soils, we need to know more about how it reacts with the organic and inorganic matter in the soil, we need to know more on the role of pH, the timing and rate of application, and the interaction with nitrogen and other elements.
4. Role of organic phosphorus in contributing to pasture production and the study of the factors which affect the mineralisation of organic P throughout the season in different soils.
5. Role of livestock units in determining offtakes needs to be elucidated further.

Conclusions

The phosphorus recommendations in this paper are based on the best information available. There is a considerable amount of work being conducted on P at national and international level and there is a possibility that there will be further revisions in the management of soil P levels in the future. There is evidence for reduction in soil P levels while still ensuring optimum growth. Two points must be made. Firstly, it will be difficult to reduce soil P levels any further without significant improvements in soil testing methodology. Secondly, it must be remembered that grass is an intermediate product; it is the nutritional requirements of the ruminant that is paramount. Any future changes in P recommendations must ensure that the P in the grazed grass is sufficient to meet the dietary requirements of the cows.

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APPENDIX 1

Assumptions Made in Calculating Offakes in Dairy System

1) P content of milk = 0.9 g/kg.
2) Cull cows.
   1 kg liveweight = 8.0 g P
   Replacement rate = 20%
   Mean weight = 500 kg
   Mean weight of replacement heifers = 500 kg
3) Calves are sold off in dairying at a mean weight of 50 kg and the P content is 8 g/kg liveweight. Some 20% of the weight of the foetus at birth is gained during the grazing season.
4) There is a loss of P in dung while cows are not in the paddocks. This has been calculated at 1.8 kg/cow/yr (Morton, 1984). However, much of this loss occurs in the milk parlours and yards and this is either recycled directly to some field as soiled water or it is washed into the slurry storage areas. Thus the P lost to the system is that contained in the dung which is deposited on farm roadways. This can be lost to rivers, streams and lakes when rain washes it off the roadways. This is calculated as 0.18 kg/cow (3 hours off the paddocks per day during the grazing season, at intake of 16 kg DM/day = 1.8 kg P/cow, 10% of that time on roadways).
5) The amount of P fixation and soil P release is difficult to quantify. At maintenance P levels in Index 3, for the purposes of these calculations, we have assumed zero fixation. An arbitrary allowance of 2 kg/ha P over and above maintenance is allowed at Index 2.
6) The removals of P take into account that enough silage is made to give adequate feed during the winter months.
7) All calculations are based on a spring calving herd. The requirements would be lower for an autumn calving herd.

Grassland Management – The Effect on Herd Performance

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Current changes in agricultural policy and future expected changes will continue to remove the relatively high level of protection engaged by the EU countries. Market forces are likely to determine producers returns much more in the future. With lower milk price and the possibility of increased milk production (no - quotas) Irish dairy farmers will have to become more efficient producers of milk. Grazing grass in situ at a reasonable level of utilisation will remain the simplest and most efficient method of milk production. With good grazing management we can have a long grazing season with high quality feed available at low cost. A research programme was set up in Moorepark in the Autumn of 1995 to investigate if increased measurement at farm level could influence the performance being obtained from grazed grass. The farms selected were intensive dairy farms which were already achieving above average performance. The increased performance would result in improved financial returns. The measurements that would have most influence on performance were:

(1) **Pasture cover**
(2) **Post-grazing sward height**
(3) **Pasture quality**
(4) **Cow condition score**

Other measurements which were already being monitored on these farms included milk yield, milk composition, cow fertility performance, concentrate input and silage quality and yield. Thirteen dairy herds were initially selected for this project. All herds were visited twice monthly from March to September and once monthly for the remainder of the year. All four measurements were taken on each visit. The grazing management practises of these farms have now being monitored for two and a half years. The questions being asked in the project are: (1) What major deficiencies in terms of grazing management have been identified on these farms? (2) Has the use of more measurements been a benefit in correcting these deficiencies? (3) What are the recommendations arising from these measurements?

(1) Pasture cover

Pasture cover is defined as the total supply of available grass (>4cm) on all the paddocks which are available for grazing. Paddocks closed for silage are not included. Four main areas were identified where a knowledge of pasture cover was of significant benefit.

(a) Closing cover in late November/early December. Figure 1 shows closing average farm covers for six Spring calving herds over the last 3 years (1995-

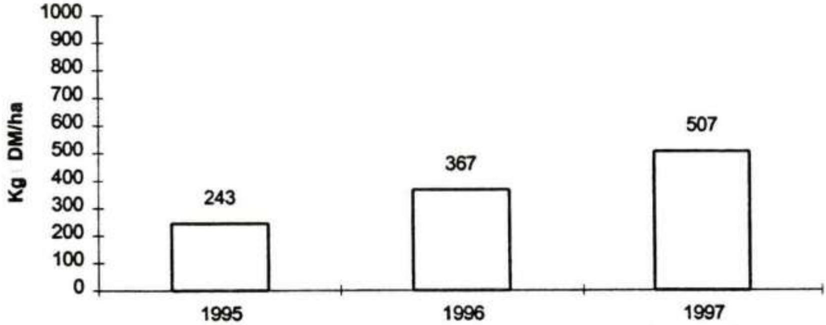

Fig. 1 - Average pasture cover at closing in Autumn for six Spring Calving Herds 1995 - 1997.

1997). The figure clearly shows large increases in closing cover over the past 3 years. The benefit seen at farm level of an increased closing cover is a much increased Spring grass supply. Increasing opening Spring cover demands a higher level of utilisation by earlier turnout and making more grass available during the first cycle. The results also showed that grazing very large covers (>2800 kg DM/ha) in the last grazing rotation was detrimental for perennial ryegrass survival and grass supply the following Spring.

Therefore the main findings concerning pasture closing cover were:

(i) Farm grass cover should be >350 kg DM/ha with a range in paddock cover of 200 - 800 kg DM/ha.

(ii) The farm should be closed in rotation, with the first paddock closed between the 10th - 15th of October.

(iii) By the end of the first week of November 60% of the farm should be closed and all grazing should cease by late November.

(iv) Large covers >2000kg DM/ha should be avoided on the last grazing rotation.

(b) Opening pasture cover in the Spring

The benefit of grazed grass as part of the diet in early lactation with Spring

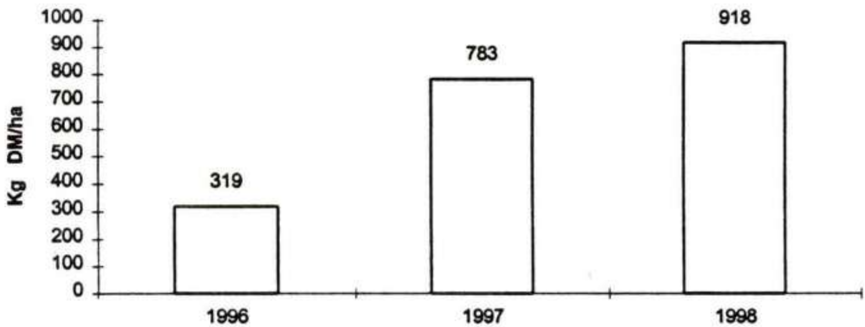

Fig. 2 - Average pasture cover at turnout for six Spring Calving herds 1996-1998.

calving dairy cows has long been identified. It is not possible to suggest one turnout date for all dairy farms. This will very much depend on grass supply, stocking rate, calving pattern, soil type and the implication of other enterprises on the farm. It also has implications on target Mean Calving Date. The project has identified that a knowledge of pasture cover can be used to make maximum use of grazed grass from mid February to late April. Figure 2 shows the average turnout cover on six Spring calving herds for the last 3 years.

It is evident from the data that considerable improvement has taken place on these farms with regard to pasture cover at turnout in late February/early March. Figure 3 shows how turnout with very low pasture cover can actually reduce the amount of grass utilised over the Spring. Whereas if turnout takes place at the proper cover the grass available can be maximised in the cow's diet. However over the past two Springs the former has been the situation on some dairy farms where turnout was too late and optimised use of Spring grass was not achieved.

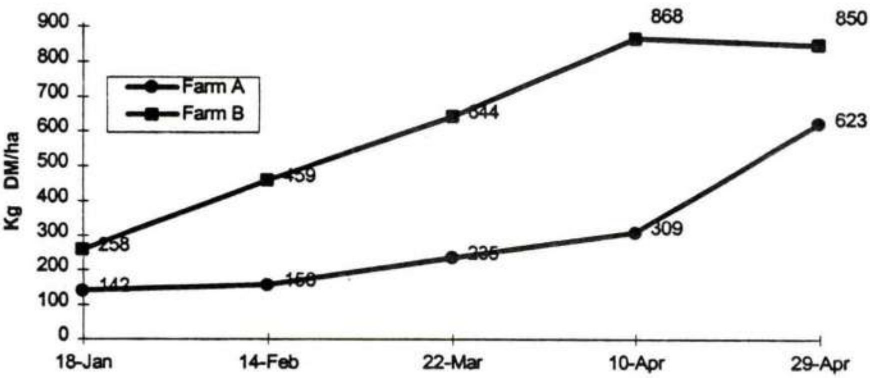

Fig. 3 - The effect of two levels of pasture cover at turnout on subsequent Spring cover.

Tables 1 and 2 show feed budgets for two contrasting farms. For the purpose of comparison the two farms were 100 cow herds with similar calving patterns. Farm 1 has access to 40 ha (100 acres) of grazing area, while Farm 2 has access to 22 ha (54 acres). Both farms have a turnout cover of 600 kg DM/ha. The farms have different turnout dates and turnout only occurs when the cows can be allowed 6 kg DM/cow. Both of these farms have a target cover of 800 kg DM/ha on the grazing area in mid April at similar stocking rates. Because of the larger grazing area, a lot more grass can be allocated to the cows in Farm 1, Farm 2 cannot turnout as early or allow the same level of grass because of the grazing area constraint. From turnout until mid April Farm 1 is able to allow a total of 1.0 t grass/DM/cow, while Farm 2 can only allow 0.62 t grass/DM/ cow. This shows the benefit of using pasture cover measurement to exploit the extra grass which is available because of the lower stocking rate and earlier turnout.

Table 1
Feed budget from turnout late February until mid April (Farm 1)

Date	No. of cows	Grass allowance	Stocking rate (cows/ha)	Demand per ha	Predicted growth	Depletion	Days	Decline	Expected cover
									600
21/2	52	6	1.3	8	14	6	7	43	*643*
28/2	59	8	1.5	12	17	5	7	36	*680*
6/3	62	12	1.6	19	20	1	7	10	*690*
13/3	66	14	1.7	23	25	2	7	13	*703*
20/3	73	16	1.8	29	35	6	7	41	*744*
27/3	79	18	2.0	35	45	10	7	67	*810*
3/4	84	20	2.1	42	60	18	7	126	*936*
10/4	92	20	4.5	90	75	-15	7	-105	*831*
17/4	100	20	4.5	90	85	-5	7	-35	*796*

Table 2
Feed budget from turnout early March until mid April (Farm 2)

Date	No. of cows	Grass allowance	Stocking rate (cows/ha)	Demand per ha	Predicted growth	Depletion	Days	Decline	Expected cover
									600
6/3	62	6	2.8	17	20	3	7	22	*622*
13/3	66	8	3.0	24	25	1	7	7	*629*
20/3	73	10	3.3	33	35	2	7	14	*643*
27/3	79	12	3.6	43	45	2	7	13	*656*
3/4	84	14	3.8	53	60	7	7	48	*704*
10/4	92	16	4.2	67	75	8	7	55	*758*
17/4	100	18	4.5	81	85	4	7	28	*786*

The main finding regarding turnout date and budgeting of the feed:

(i) Turnout should begin with a pasture cover of 550-600 kg DM/ha at 2.75 cows/ha, lower turnout covers are possible at lower stocking rates.

(ii) The available feed should then be budgeted, and the first rotation should finish between the 10th-20th April (the day grass supply equals grass demand). This date can vary from year to year. The precise date to finish the round can only be found by careful monitoring of pasture supply.

(iii) Pasture cover target on the 20th April should be 750 - 800 kg DM/ha at a stocking rate of 4.5 cows/ha on the grazing area

(c) Identification of surpluses and deficits

The results from the study have shown that cow performance can be influenced by early identification of a surplus or a deficit grass supply with the use of pasture cover measurement. An extremely steep wedge pattern of grass supply (going from 350 to 3000kg DM/ha) indicates an oversupply of grass. Grazing large covers during the main grazing season (>2500 kg DM/ha) will often result in reduced milk production or necessitate topping large residuals. In the lead up to a period of a grass shortage pre-cutting some paddocks would facilitate better utilisation of large pre-grazing yields especially in dry weather conditions. The reaction on most dairy farms to large pre-grazing yields of grass was to remove the surplus grass as silage. If silage harvesting was delayed then it resulted in (a) reduced pasture cover (b) increased stocking rate on the grazing area. Farmers that delayed harvesting these surplus paddocks generally had a grass shortage in the next rotation. Using pasture cover in conjunction with grass DM available per cow and a forecast of future grass growth rates over the following 7 to 10 days will allow better management decisions to be made.

If grass growth rates are below normal and/or stocking rate too high a less pronounced wedge shaped grass supply pattern will result. Cows will be going into paddocks with low covers (<1500 kg DM/ha). Running covers down to very low levels will result in even more reduced grass growth rates at farm level and will generally result in the under feeding of the cows. Pasture cover measurements will identify a future problem with grass supply before pre-grazing yield will. Therefore the use of pasture cover measurement will allow management decisions to be put in place at an earlier stage i.e. stocking rate can be adjusted or supplements can be introduced.

The main findings regarding identification of surplus/deficits are:

(i) Pasture cover should be maintained at 900 -950 kg DM/ha or 200 kg DM/cow on the grazing area during the main grazing season.

(ii) If pasture cover increases to greater than 1000 kg DM/ha from mid April to mid July the surplus grass should be removed as silage. The surplus paddocks should be harvested as silage at day 21 to 25 in the rotation.

(iii) With a decreasing pasture cover, the herd should be supplemented or the grazing area should be increased by including some silage paddocks. This should be introduced early enough so as not to let the pasture cover drop below 700 kg DM/ha.

(d) Obtaining high performance

Figure 4 shows the average daily allowance of grass for 6 Spring calving

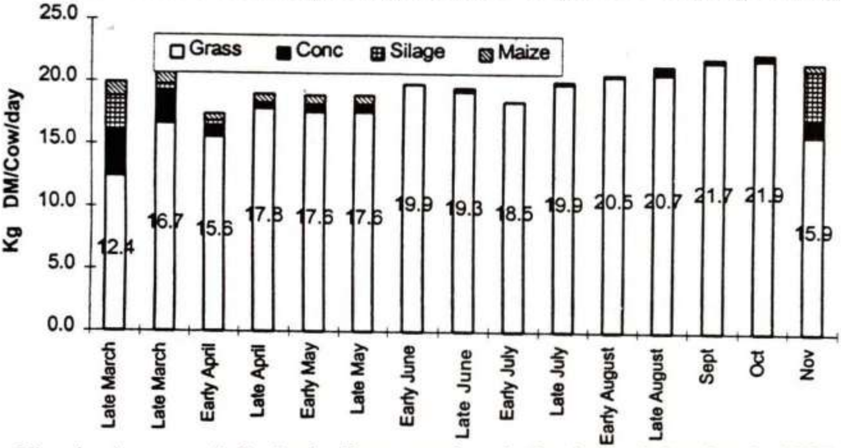

Fig. 4 - Average daily feed allowance for six Spring calving herds 1997.

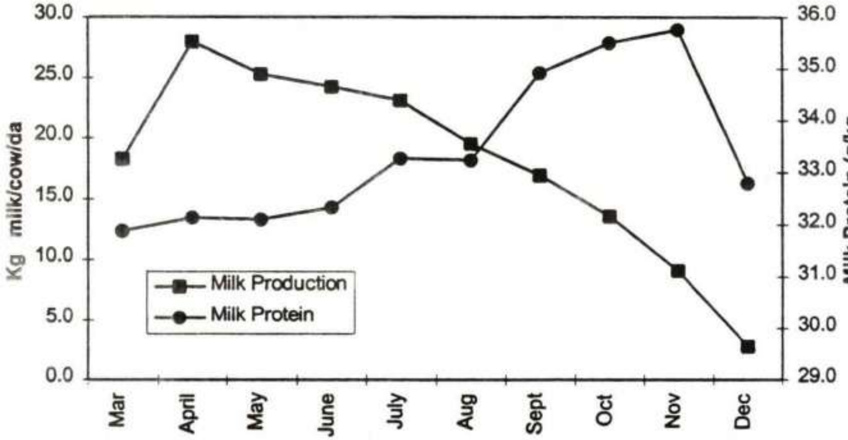

Fig. 5 - Average milk yield and milk protein production for six Spring calving herds 1997

herds over the grazing season of 1997. The data indicate that the lowest allowance of grass occurred in the late April to early June period. This is the period of peak milk production and also coincides with the breeding season. Figure 5 shows the milk production profile for the six Spring calving herds. In 1997, average milk production in kg milk/cow/day was 28.0, 25.3, 24.2, 23.1, 19.5, 16.9 for the months of April, May, June, July, August and September respectively. The average reduction in milk yield from April to May (2.7kg milk/cow), May to June (1.1kg milk/cow), June to July (1.1kg milk/cow), July to August (3.6kg milk/cow), August to September (2.6kg milk/cow), September to October (3.3kg milk/cow), October to November (4.5kg milk/cow). The mean calving date for these herds was March 1st. Therefore peak milk production should occur in May. The milk production data show a large milk yield reduction in May. This reflects inadequate feeding which can be seen in Figure 4 with the low grass allowance and the use of very little supplement. The factor that will create the largest pressure on grass supply in this period is the stocking rate on the grazing area. Stocking rates of 5 cows/ha or greater are too high unless large levels of supplement are being fed. Some farms on the study carried very high stocking rates during this period and very little supplements were fed. Table 3 shows the daily allowance of grass and the availability of grass per cow (kgs DM/cow = Pasture cover/stocking rate) at varying stocking rate using average Moorepark grass growth rates (1990-1996) from April 22 to May 27.

Table 3

Effect of stocking rate on daily grass allowance and DM available per cow

Stocking rate (cows/ha)	6.0	5.5	5.0	4.5	4.0
Grass allowance (kg DM/cow)	15.3	16.7	18.4	20.4	23
DM available (kg/cow)	150	164	180	200	225

The major findings with regard to obtaining high performance from grazed grass:

(i) A stocking rate of 4.5 cows/ha from mid April to early June is sufficient to maintain the correct balance of pasture supply and grass allowance to adequately feed cows at pasture.

(ii) Very high stocking rates (>5 cows/ha) from mid April to June will result in inadequate grass supply and result in underfeeding of cows unless large levels of supplement are fed.

(2) Post-grazing sward height

The degree to which any paddock is grazed is a function of grass availability versus herd requirement. Table 4 outlines the post-grazing height that results from different grazing intensities. If a paddock is grazed to a post-grazing height of 4cm, then the grass intake of the herd will be very much reduced. If on the other hand a pasture is grazed to a post-grazing height of 8cm, intake will be high but a large level of grass will be wasted. On some farms post-grazing height ranged from 4.5 to 5.5cm for a large part of the grazing season.

Table 4
Post-grazing severity score

Grazing score	Grazing height	Description
1	<4.5	grossly over-grazed
2	4.5 - 5.5	over-grazed
3	5.5 - 6.5	good grazing
4	6.5 - 7.5	under-grazed
5	>7.5	grossly under-grazed

Figure 6 shows the post-grazing height and corresponding grass allowance over the year for one of the Spring calving herds on the study. In this case, there was an inadequate grass allowance and a low grazing intensity. Low post-grazing height could be the results of two situations at farm level.

(i) Low pasture cover as a result of below normal grass growth rates or too high a stocking rate.

(ii) Even with adequate pasture cover daily allocation of grass may not be adequate.

Both of these two situations were recorded at farm level. Low post-grazing height as a result of low pasture cover generally occurred in the mid April to June period. This was mainly as a result of too high a stocking density (5 to 5.5 cows/ha) where the farmer attempted to maintain a 21 day rotation with very little supplementation. It also occurs during the main grazing season in periods of below normal grass growing conditions where no adjustment in stocking rate occurred and no supplements were fed. Low post-grazing heights with adequate pasture cover also occurred. This took place generally where grass was being allocated on a 12 hour basis (after each milking) at farm level. A 24 hour allocation may be more conducive to achieving higher intakes of

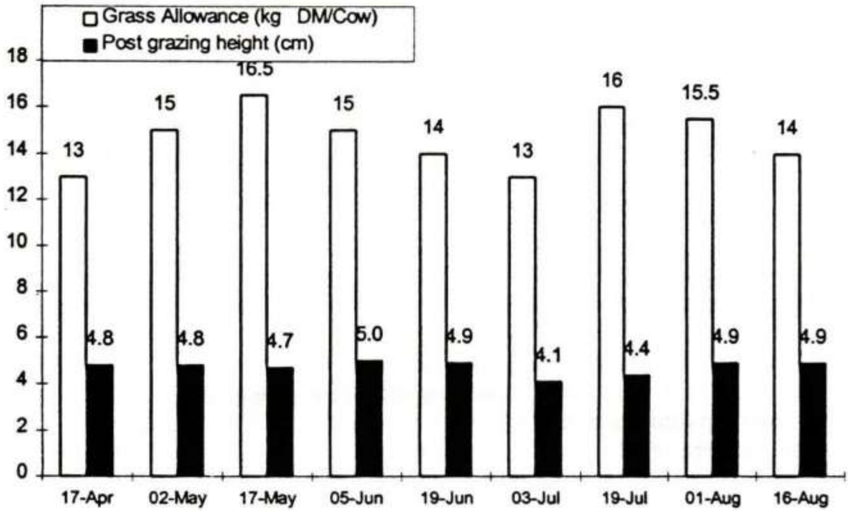

Fig. 6 - Low grass allowance and corresponding post-grazing height.

grass. At farm level there was over emphasis placed on achieving extremely high grass utilisation.

The main findings on the monitoring of post-grazing sward heights were:

(i) Very low post-grazing height was much more evident on the farms studied rather than high post-grazing heights.

(ii) The main reason for very low post-grazing height was very high stocking rates with low pasture cover.

(iii) Very low post-grazing height also occurred with adequate pasture cover where over emphasis was placed on achieving high utilisation to the detriment of cow performance.

(3) Pasture quality

The measurement of pasture quality which was used in this study was the measurement of the proportion of green leaf available in the sward (>4cm). Moorepark studies have shown a direct relationship between proportion of green leaf and digestibility. For optimum milk production the proportion of green leaf should be >65% of DM available. Most farms achieved very high quality pastures over the grazing season. However there were a number of situations at farm level where the proportion of the sward decreased below 65% green leaf. These were:

(i) Where rotation length was in excess of 25 days in mid May/June, 30 days in July/August and 40 days in September.

(ii) In periods of below normal grass growth rates and in semi-drought conditions where large amounts of stem development were evident.

(iii) In pastures which contained less than 50% ryegrass. These pastures had generally lower pasture quality throughout the grazing season. The greatest

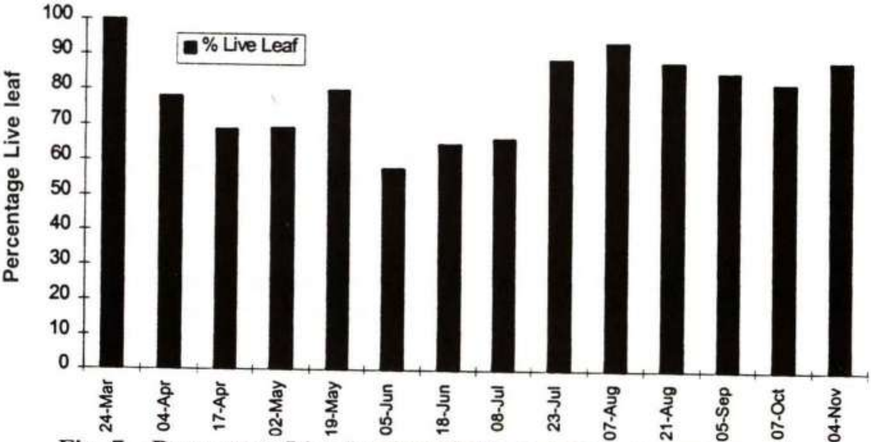

Fig. 7 - Percentage Live Leaf available in poor ryegrass swards

deterioration in quality took place in mid season on these pastures. Figure 7 shows the percentage of green leaf in the grass offered to one of the Spring calving herds.

The main findings with regard to pasture quality were:

(i) Most farms maintained very high pasture quality over the grazing season. This was achieved by not leaving large residuals after the previous grazing and using pasture topping, if required.

(ii) The main reason for reduced pasture quality was an extended rotation length for the time of year.

(4) Cow condition score

Body fat reserves are important for the dairy cow. Immediately after calving, the cow's capacity to consume energy in feed does not keep pace with the amount of energy being used for milk production. This is even more important in very high producing cows. Therefore, the cow must draw on body reserves to make up the difference. A cow with good body reserves may be in a better position to support milk production and may have better subsequent fertility performance. There are three periods in the year when condition score is important.

(a) Drying off/end of lactation, (b) At calving, (c) Start of breeding season

(a) It is important to monitor condition score towards the end of lactation. Condition score can be easily modified at this stage by either adjusting the length of the dry period or the level of feeding during this period. Average herd condition score at the end of lactation should be around 3.

(b) Condition score at calving is important and will influence the level of supplementation during early lactation. The target herd condition score at calving is 3.5. In early lactation, when energy intake is less than current requirement for milk production, condition score manipulation may be difficult.

(c) It is important that cows are in good condition at the start of the breeding season and that this is maintained throughout the breeding season. A target condition score of 2.9 at the start of the breeding season with Spring calving dairy cows should be the aim. Table 5 shows the average condition score for two Spring calving herds of similar genetic merit in the herds monitored. Table 6 shows the fertility performance for the same two herds. While it is not possible from this study to make a definite cause/effect relationship, it does indicate that there is a large difference in fertility performance as well as herd condition scores between both herds.

Table 5
The average condition score profile of two Spring calving herds

Farm	Pre-calving	Start of breeding	Drying off
Herd A	3.0	2.6	2.8
Herd B	3.5	3.1	3.5
Difference	0.5	0.5	0.7

Table 6
The fertility performance of Spring calving herds

Fertility performance		Herd A	Herd B
Cows served in 1st 3 weeks (%)		81	86
Calving to 1st service interval (days)		79	75
Services per conception		2.4	1.5
Pregnancy rate:	1st service (%)	42	61
	2nd service (%)	38	67
	3rd service (%)	37	100
Infertile rate (%)		13.2	3.6

Conclusion

This paper clearly outlines the large benefit obtained at farm level from an increased use of measurement. Measurements will allow dairy farmers to achieve much higher levels of performance from grazed grass. They also allow research findings to be more readily adopted at farm level. With the increased use and focus on discussion groups as a method of technology transfer, these measurements are essential and should be an integral part of the discussions.

Dairy Cattle Breeding in Ireland - The Way Forward

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In this paper I will cover:

• The **Irish Cattle Breeding Federation's** mission, membership and method of operation. The Federation has been established to lead the way forward.

• **Co-operation** is one of the fundamental elements required for successful cattle breeding. Co-operation between farmers, cattle breeders, AI services, milk recording organisations, breed associations and animal evaluation units is essential if the potential benefits of cattle breeding are to be fully exploited.

• An integrated **database** breeding information is an essential component of a successful dairy breeding program. The establishment of a computerised database is one of the Irish Cattle Breeding Federation's major priorities.

• The technical aspects of **cattle breeding** will ultimately determine the speed with which improved genetics contribute to the profitability of dairy farming in Ireland. Breeding objectives, animal evaluations, progeny testing, semen technology and embryo technology all make important contributions to the rate of genetic gain. These issues and the way they affect rates of genetic gain are well understood.

• Cattle breeding is one of many inputs into milk production. It must compete with other uses of farmer's increasingly scarce money. For this reason **Customer Focus** will become an important aspect of the provision of cattle breeding services in Ireland.

• Dairy farmers are facing on on-going cost/price squeeze. The number of dairy cattle is declining. For these reasons the **efficiency** with which cattle breeding services are provided will play a significant role in determining their future in Ireland.

Mission

The Irish Cattle Breeding Federation has been established by its members with the mission of: **Leading the development of cattle breeding in a way which will best serve the national commercial livestock sector.** Note that this mission is focused on the commercial livestock sector. The commercial sector are those farmers for whom milk and meat production is a business. It also requires the Irish Cattle Breeding Federation to provide leadership in the ongoing development of cattle breeding.

The Irish Cattle Breeding Federation is registered as a Co-operative and its membership includes:

8 Artificial Insemination Societies, 13 (9 major) Milk Recording Societies, 12 Cattle Breed Societies, Irish Farmers Association, Irish Creamery Milk Suppliers Association and the Irish Meat Association. These organizations have decided to establish the Irish Cattle Breeding Federation as a way of ensuring

an orderly, technologically advanced and efficient progression of cattle breeding services in Ireland.

A small headquarters for the Irish Cattle Breeding Federation has been established in Bandon which is operated by South Western Services. This decision was made after considering a large number of alternatives. The main considerations were: the need to avoid further overheads on cattle breeding, availability of suitable accommodation, availability of support services and the avoidance of conflicts of interest with the organization providing the accommodation.

Structure

The Irish Cattle Breeding Federation has an interim Board chaired by Mr. John Malone, the Secretary of the Department of Agriculture. Two advisory committees provide the Board with specific advice on matters relating to Beef Cattle and Dairy Cattle breeding. The Irish Cattle Breeding Federation will be utilizing staff and resources from within its member organizations and employing outside expertise on a contract basis. In the longer term there will be a requirement for further Irish Cattle Breeding Federation staff.

Funding

Funding of the Irish Cattle Breeding Federation is initially being provided by contributions from the member organizations, EU structural funds and by the Department of Agriculture. In the longer term, funding will increasingly be from the provision of services to the cattle breeding industry. The challenge for Irish Cattle Breeding Federation and its member organisations is to develop services which cattle breeders will value and happily pay for the full cost of provision. The Department currently contributes some £1 million to cattle breeding in the form of animal evaluation, quality assurance and beef breeding services. In due course the Irish Cattle Breeding Federation will either take over these services or establish alternatives which better meet the needs of the cattle breeding industry.

Co-operation

The reasons why dairy cattle breeding, in contrast to pig and poultry breeding, remains a co-operative based industry include:

• The value of a commercial animal, relative to the cost of recording production is high - of the order of 100:1 in Ireland. This means that it is comparatively easy to keep for commercial cows the records needed for breeding purposes.

• The records required for breeding purposes are also useful for other purposes such as disease control, quality assurance and subsidies. Thus the cost of keeping the records needed for breeding purposes is further reduced.

• Artificial insemination provides an inexpensive mechanism for distributing superior genetics to commercial herds. This means that at least within a country, commercial milk producers are able to access the best sires at the same time as specialized breeders.

• International trade in animal genetics is well established based on shared information. Breeders around the world have access to the best sires and to a slightly less extent dams, in all countries at about the same time. This makes it very difficult for a single organization to gain a significant genetic advance over the co-operative organizations.

The future of Irish dairy cattle breeding will thus be based on co-operation between farmers, breeders, AI organizations, researchers, breed associations both within Ireland and internationally.

Database

Successful dairy cattle breeding requires access to data on the ancestry and performance of large numbers of cows. A national computerised database is the best way of providing this information while avoiding duplication of effort, minimizing errors and facilitating the sharing of data with other legitimate users. The key database concepts are:

• There is only a single copy of the "truth". This means that all changes to data - new data corrections to existing data - are made in only one place.

• All legitimate users of the data have access to the single copy. This ensures that all users of the data are able to obtain the correct information.

Cattle breeding databases with these characteristics have been established in a number of countries. The two I am most familiar with are in New Zealand and Holland. In both cases single databases are meeting the needs of cattle breeding while also meeting needs associated with disease control and quality assurance. The Irish Cattle Breeding Federation is planning to establish such a database for cattle breeding purposes in Ireland. Three options for establishing the database are to be evaluated:

• To build one from first principles. The main advantage of this approach is that it guarantees a database customised to Irish conditions.

• To purchase an existing database from another country with similar cattle breeding requirements to Ireland and to modify it to meet Irish needs. This is potentially a more rapid way of obtaining the database.

• To contract the provision of database services to another country with a suitable database

These options will be evaluated and a decision made on the best way to proceed for Ireland.

Animal evaluation

Animal evaluation systems combine data on ancestry with animal performance data to estimate the genetic merit of individual animals. The Irish Cattle Breeding Federation has decided to give immediate priority to addressing issues of the time required for the calculation of breeding values, frequency of breeding value calculation and the number of animals evaluated. The objectives of the review are to:

• Resolve data quality issues which cause delays in the calculation of breeding values.

• Reduce the time taken for the calculations to 4 weeks including time for data to be sent to and received from INTERBULL.

• Provide evaluations twice per year.

• Increase the number of animals for which breeding values are readily available above the current figure of 50% of milking cows in milk recorded herds.

• Implement an improved system within twelve months.

An example of what can be achieved is provided by the new system which was recently implemented in New Zealand.

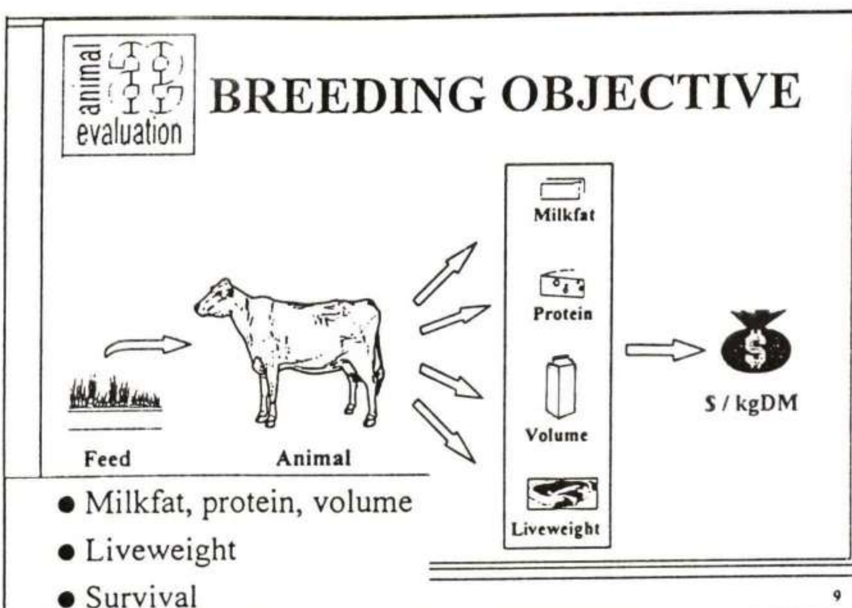
The NZ animal evaluation system comprises two main elements. Every day the breeding values are updated for all females with new milk recording results. Every three weeks the breeding values for all animals are updated. Twice a year the latest INTERBULL results are incorporated into the NZ evaluations.

One of the consequences of the continual updating of breeding values is that it has become possible for newly proven bulls to be used widely on liquid semen prior to their first crop of daughters completing a first lactation. There are substantial genetic implications associated with the shorter generation intervals thus achieved

Breeding scheme design is one of the most fruitful aspects of cattle breeding research. It provides a rational basis for making major decisions on aspects of cattle breeding. The Irish Cattle Breeding Federation will be initiating research work to ensure its breeding decisions have a sound scientific basis.

Breeding objective

The technical aspects of cattle breeding centre on breeding objectives, animal evaluation and breeding scheme design. Breeding objectives define the goal



of cattle breeding. The Irish Cattle Breeding Federation, with its focus on the commercial producers, is considering a review of cattle breeding objectives for Ireland. The purpose of focusing on breeding objectives is that they provide a rational basis for deciding which traits are worth measuring as well as the establishment of criteria to be used in selecting bulls for use in artificial insemination. An example of the outcome from such a review is provided by the recent work completed in New Zealand.

The breeding objective for NZ cattle is to *"maximise the net farm income per kg of dry matter"*. The main considerations are the income from milk - fat protein, lactose, water and minerals - income from meat balanced against the feed requirements for production, replacements and maintenance. In this way a "Breeding Worth" has been established as the main selection criteria for NZ cattle of all breeds. A novel aspect of this index is that it allows comparisons across breeds.

By including "survival" as a trait in the index, account can be taken of any trait which affects the time an animal lasts in the commercial herd.

Customer focus

Customer focus is a way of summarizing an organization's approach to the development and provision of services. As cattle breeding in Ireland moves towards industry control there is a real need to focus on the needs of customers who, in the case of dairy breeding, are dairy farmers.

Commercial dairy farmers breed cows to produce milk that is eventually consumed by a wide range of customers. The main issue for dairy breeding is one of providing farmers with cattle that enable increased efficiency of milk production and/or improved returns from milk and meat sales. With genetics playing such an important role in determining milk composition and characteristic there are opportunities for increasing returns by altering milk composition. As the new genetic technologies develop it is likely that further opportunities will emerge in the future, that is, by focusing on the needs of the customers for milk we may be able to increase farmer income.

Equally important is the relationship between the Irish Cattle Breeding Federation and its members organisations with dairy farmers. We must focus on providing services to farmers which are profitable to the average as well as the individual. These services need to be valued by farmers to the extent that they are happy to pay for them.

Some of the implications of a customer focused approach to servicing are:

- Services would be developed to meet the needs of farmers.
- The role of farmers in determining the direction of cattle breeding will increase.
- Government will have a reducing influence on cattle breeding services.

Customer focus is thus integral to the working of the Irish Cattle Breeding Federation.

Efficiency

There are opportunities for greater efficiency in cattle breeding in Ireland. Efficiencies can be obtained by:

• Increasing the scale of operation so that fixed overhead costs can be spread over a greater volume of business. Just as larger farms enjoy economies of scale so do cattle breeding organizations. As a general rule it is more efficient to have one organisation than two performing the same functions and covering the same number of customers. Cattle breeding has significant overheads associated with databases, progeny testing, research and product development. With larger customer bases and greater volumes of business it is easier to carry these overheads.

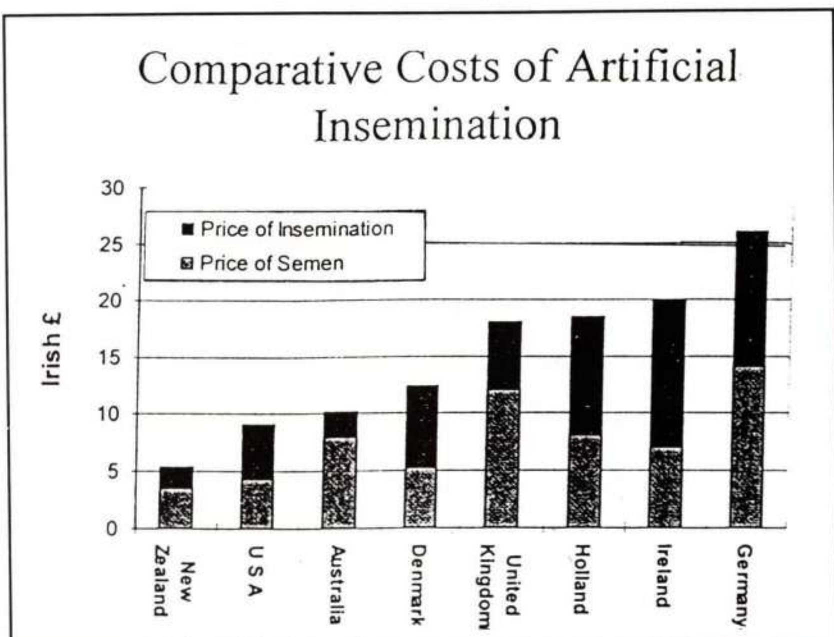
• It is essential that duplication be removed. Examples of duplication within Irish cattle breeding, the removal of which would result in cost reductions include the two linear assessment systems and the databases created by CIMRA (Central Irish Milk Recording Authority) and the Department of Agriculture.

• All of the work being undertaken needs to be adding value. A close look at all costs needs to be undertaken to ensure they add value. For example, in New Zealand 4 or 5 tests per lactation is considered adequate for breeding purposes. What value is added by the extra 4 or 5 tests per herd in Ireland?

• The rapid developments in information technology provide opportunities to use automation to reduce costs. Equally there are developments in semen technology which enable greater use of high index bulls.

A focus on efficiency is one of the priorities for Irish cattle breeding in the future. Here are a couple of illustrations of the extent to which New Zealand was successful in achieving increased efficiency.

The first example comes from artificial insemination. This comparison shows



the average cost to farmers of artificial insemination per pregnancy in several countries including Ireland.

The results are expressed in Irish £ and are based on figures collected over the last two years. While herd size can explain some of the difference, economies of scale, removal of duplication and use of appropriate technology also explains a large part.

Table 1
Cost of milk recording in NZ - system used by 70%

	Cost of milk recording per cow per year in Irish £.				
	Number of tests per season				
Herd	**4**	**6**	**8**	**10**	**12**
50	4.58	5.22	5.86	6.50	7.14
100	2.84	3.16	3.48	3.80	4.12
150	2.26	2.47	2.69	2.90	3.11
200	**1.97**	**2.13**	**2.29**	**2.45**	**2.61**
250	1.80	1.92	2.05	2.18	2.31
300	1.68	1.79	1.89	2.00	2.11
350	1.60	1.69	1.78	1.87	1.96

The second example comes from Milk Recording. Table 1 shows in Irish £ (converted at £0.40 to $NZ 1.00) the current charges for milk recording on the most commonly used system in NZ. The highlighted row is the average herd size in New Zealand. Note that charges per cow per year vary according to herd size and number ot tests. The average paid per farmer is much lower than in Ireland. The herds are larger, the system utilizes farmer labour for sample collection and a wide range of options are available.

The Irish Cattle Breeding Federation is initiating a project to find less expensive milk recording options for Ireland. The project will focus on reducing the costs associated with determining milk volume and sample collection. If a less expensive system can be found and demonstrated to be practical you can expect to see it introduced in Ireland in the future.

In conclusion:

The Irish Cattle breeding industry has committed itself to a process of improvement with some of the immediate goals being to:

- Increase the collaboration between organisations.
- Implement a cattle breeding database which will be shared by the cattle breeding organisations.
- Improvements to the animal evaluation systems.
- An increased customer focus.
- Greater efficiency.

Genetic Selection for Higher Milk Yield: Opportunities to Use Energy Balance, Feed Intake and Liveweight[1].

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Introduction

Most dairy cattle breeding schemes world-wide have had a dramatic effect on the productivity of cows in many countries in the last few decades. However, there has always been concern about the suitability of these breeding schemes to produce cows that perform on a grass-based diet. To date, however, there is convincing evidence (from experimental herds, e.g. Langhill and Moorepark, and from larger population studies e.g. Cromie *et al.* 1997) that high genetic merit animals outperform their low genetic merit counterparts in most feeding systems, at least in terms of production. More of a problem for grass orientated systems is that high genetic merit animals have, on average, poorer fertility across feeding systems (Figure 1). The question of whether these effects on fertility are exacerbated on grass based systems or low concentrate systems is yet unanswered. The challenge is clearly to select high producing animals that maintain their fertility in all feeding systems. That enough of these animals are around is shown in Figure 1, and hence there is scope for genetic selection to improve both fertility and yield.

The potential role that energy balance might play hereby, are currently under investigation at ID-DLO in Lelystad. The aim of this paper is to outline some

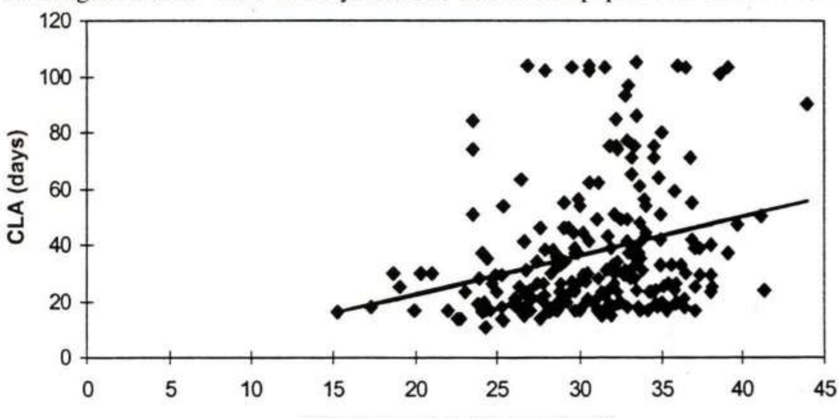

Figure 1 - Relationship between milk yield and days till first heat (measured using progesterone) (Veerkamp *et al.* 1997).

1. Holland Genetics is acknowledged for their contribution to this work.

recent information on the heritability of energy balance and how it interacts with selection for milk production, feed intake and liveweight.

Heritability

That the amount of food eaten by a cow, bodyweight, energy balance and condition score are not only affected by the feeding systems but are heritable also, is less well understood. Heritability estimates from our data in Lelystad demonstrate this again (Table 1). Heritabilities for all traits are close to 0.5, which means that about 50% of differences between cows can be explained by their genetic background. Hence, using genetic selection alone, cows can become heavier or lighter or, more importantly, cows can be selected to have a more or less negative energy balance during early lactation.

Table 1
Heritability for milk yield, liveweight, dry matter intake and energy balance, and heritable association (i.e. genetic correlation) between these traits.

		Genetic correlations		
	Heritability	Milk production	Liveweight	DMI
Milk production	0.48			
Liveweight	0.54	0.31		
Dry matter intake	0.62	0.48	0.75	
Energy balance	0.51	-0.46	0.29	0.55

('t Gen experimental farm, Oldenbroek *et al.* 1997)

Genetic associations between traits

Also important are the genetic correlations between traits, which can range from -1 to +1. This is because the correlations indicate the association between traits and how they respond together to genetic selection. For example, from Table 1 it can be seen that selection for milk production alone results in a higher dry matter intake (because the correlation is 0.48) and a more negative energy balance because the correlation is -0.46.

Another important conclusion that can be drawn is that selection on anyone of the traits in Table 1 will affect changes in almost all of the other traits (because all correlations are different from 0). This makes genetic selection to improve feed efficiency more complex. This is because what might be perceived to be gained by accounting for one of the traits, might in fact be lost because the others are changed in a negative way. A clear example is that selection for a lighter cow might give a perceived advantage (because the lower maintenance costs associated with smaller cows), but selection for a lower liveweight will result in a more negative energy balance also (Table 1).

Energy balance

In Table 1 it can be seen that selection for a higher milk yield results in a more negative energy balance also (correlation -0.46). Or, on a given diet, high

Table 2:

Milk production and live weight during the first 100 days of lactation, for three groups of heifers differing in genetic merit in the same management system

Group	High	Medium	Low
Milk yield (kg/day)	33.6	29.8	26.7
Fat (g/day)	1359	1179	1113
Protein (g/day)	1116	991	918
Weight (kg, day 10)	551	528	514
Weight (kg, day 100)	544	540	531
Weight (kg, mean over 100 days)	535	525	516
Weight change (kg, day 100 - day 10)	-7	11	18

('t Gen experimental farm, Oldenbroek *et al.* 1997)

genetic merit cows are more willing to go in a negative energy balance to produce milk. This is not surprising: the energy for extra milk production has to come from either eating more food or mobilising more body tissue. The cow that eats most and is still prepared to be in the most negative energy balance will be most productive in terms of yield.

'T Gen results

The heritability and the genetic association between traits have been discussed above. The effects of these genetic associations are demonstrated in Table 2. In Table 2 three groups of animals have been created: high, medium and low genetic merit. As expected, milk yield increases with increasing genetic merit. More interesting is the observation for liveweight. At calving, high genetic merit heifers are 47 kg heavier compared with the low genetic merit animals. However, at 100 days in milk this difference is reduced to 13 and 19 kg respectively. This is because the high genetic merit animals lose weight, whereas the others gain weight in this period.

Table 3

Energy requirements, energy intake and blood parameters during the first 100 days of lactation, for three groups of heifers differing in genetic merit in the same management system.

Group	High	Medium	Low
Dry matter intake (MJ/day)	134	128	127
Maintenance (MJ/day)	33	32	32
Milk yield (MJ/day)	106	93	86
Requirements (MJ/day)	139	125	118
Energy balance (MJ/day)	-5	3	9
Glucose (mmol/l)	3.60	3.68	3.71
BHBZ (umol/l)	436	395	383
NEFA (umol/l)	254	227	187
Ureum (mg N/100ml)	16.8	17.0	17.8

('t Gen experimental farm, Oldenbroek *et al.* 1997)

The production in terms of energy and the calculated mean energy balance for the three groups is given in Table 3. The pattern is as predicted above: high genetic merit cows have a more negative energy balance when fed the same diet (unlimited intake)) as lower genetic merit counterparts. The blood parameters also indicate that high genetic merit animals are in a more negative energy balance.

Importance of energy balance

The importance of energy balance is demonstrated in Figure 2: the relationship between energy balance and days till first heat is negative. These results support other evidence that cows that are in a more negative energy balance take longer to come in heat. This has obvious consequences when maintaining a 365-day calving interval and is economically important on grass based systems.

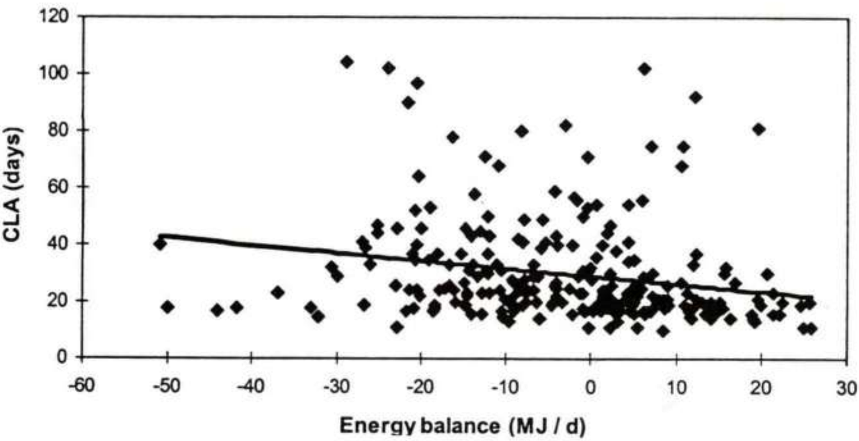

Figure 2 - Relationship between energy balance and days till first heat (measured using progesterone)

(Veerkamp et al. 1997)

Conclusions

High genetic merit cows have a higher production because they consume more food and they lose more body tissue during lactation. The high heritability for energy balance provides an excellent opportunity to improve energy balance by genetic selection. Genetic improvement of the energy balance might be a good method to select animals that have a high yield and a good fertility. The best method hereto is under investigation currently. Easier fertility management, together with a high milk yield might be the benefit. This might be particular relevant in grass based feeding systems, where there is less scope to use concentrates to compensate for a negative energy balance and where it is important to maintain a 365 day calving interval.

Prediction of Animal Performance from Silage Analyses

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For many years dairy cows in Ireland have been managed using a 'blueprint' approach for a particular system. In such methods we think of the average cow, under average grazing conditions, with average sward quality and we design management systems around this. We must recognise that the use of such systems, supported by well-targeted research, has moved the industry to its present very competitive position. While this 'blueprint' approach has served us well in the past it has a number of shortfalls in relation to how we should feed and manage cows in the next 10 - 15 years. Up to the present the penalties have not been great if the feeding and management of the cows has not been correct, but all this is changing very rapidly due to changes in performance potential of our dairy cows.

The rate of genetic improvement in the dairy herd in the United Kingdom and the Republic of Ireland to 1985 was relatively slow, approximately 0 to 0.5% per year. More recently, however, there has been a marked increase in the rate of genetic improvement, with Lindberg *et al.* (1998) reporting the rate of genetic gain in milk fat plus protein yield as 2.2% per year, during the period 1990-1994. The main effect of increasing genetic merit is that a greater proportion of food energy is partitioned to milk production, with less energy partitioned towards body reserves i.e. to body condition. For example, research at Hillsborough indicates that high merit cows (RBI95 138 approx.) produced 12.8% more milk and yet only consumed 6% extra dry matter compared to low merit cows (RBI_{95} 100 approx.). This major increase in yield with only marginal increases in intake means that efficiency of conversion of feed into milk (energetic efficiency) is greater with high merit cows. However, more detailed studies showed that there were no differences in the partial efficiency of use of energy for milk production between high and low merit cows. The net result was that the high merit cows lost weight through lactation while the low merit cows gained weight. The long-term production, health and welfare implications associated with this loss of body condition obviously presents a major challenge in dairying systems. This could be particularly important in systems with a high reliance on either grazed or conserved grass.

In this era of increasing genetic merit of dairy cows and a wide range in the genetic merits of cows on individual farms there is an urgent need to re-examine our approaches to feeding the dairy cow. The future key must be getting greater precision into feeding. We must ensure that our feed rationing systems are appropriate for the high levels of performance that can now be achieved if we are to ensure that our cows survive and produce for long productive lives in our herds. Research must provide the manager with sound and reliable decision support systems which will aid the complex decision making processes which are involved in managing these high merit cows. While in the past considerable effort has been expended in relation to feeding cows to meet the short term economics of our systems, there is no doubt that in the long term we must also embrace the biological needs of our animals to produce, remain healthy and achieve appropriate reproductive targets.

In order to develop these aspects this paper will briefly review:

(a) current information on the feed (energy) requirements of dairy cows with particular reference to recent research at Agricultural Research Institute of Northern Ireland and

(b) the recent programme which has enabled near infrared reflectance spectroscopy (NIRS) to become a powerful tool in feed characterisation.

The paper will also outline how these two components have been brought together to enable the Hillsborough Feeding Information System and associated beef and dairy cattle rationing programs to be developed.

Background to energy nutrition of dairy cows

Within the United Kingdom the amount of dietary energy required to support the maintenance and productive demands of ruminant livestock is estimated in terms of metabolizable energy (ME) with diets being formulated to meet these requirements according to the ME content of the individual components. The ME rather than Net Energy system is therefore the baseline for this paper.

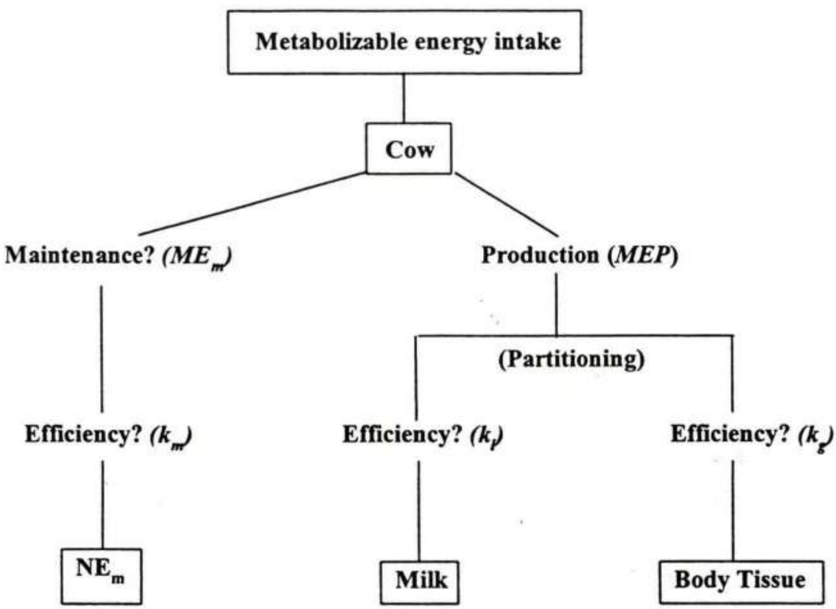

Figure 1 - Schematic representation of dietary ME use in the dairy cow.

Feed energy use by the dairy cow is represented schematically in Figure 1. Cows require energy for maintenance, milk production, liveweight gain and pregnancy. In our present feeding approaches, these are estimated separately and then added together to give an estimate of the cow's total energy requirements. While there is considerable debate about the simplistic approach of attributing energy requirements into these specific compartments in reality there is no other useful approach to formulating diets. The key components which are therefore necessary in ration formulation are the maintenance requirement (ME_m) and the efficiencies with which the remaining energy is converted to milk energy (k_l) or body gain (k_g).

Estimating energy requirements

The estimates of maintenance energy requirement and the efficiencies of ME use for milk production and liveweight gain used in today's ME feed rationing systems (AFRC, 1990 and 1993) were based on classical energy metabolism studies undertaken 30-50 years ago using very different animals and diets to those in use today. However, there is an increasing body of evidence to suggest that total energy requirements calculated by using this route are not relevant to many of the situations which presently exist.

Over a large number of studies (calorimetry and feeding studies) when we have fed animals according to what in theory they required, they have been on average losing weight at a rate of 0.35 kg/d (Agnew *et al.*, 1998). It could be argued that the situation could be remedied in current feeding standards by increasing these feeding standards (AFRC, 1990) by around 5%, as in AFRC (1993). This approach is extremely simplistic and it does not identify which component of requirements is in error. It rather assumes that all components are equally in error. Diets must now be formulated for cows across an ever increasing range of milk outputs and where the error lies has therefore major implications for how we feed animals at opposing ends of the production scale. For these reasons it is important that we develop a more accurate approach to feeding cows and this has been part of our ongoing research programme at Hillsborough.

Current standards suggest that a 600 kg dairy cow requires 58 MJ/d of energy to maintain her body functions (i.e. maintenance). Research at Hillsborough suggests that the dairy cows of today require 75 MJ/d for maintenance (Yan *et al.*, 1997 and 1998), a figure which is approximately 30% higher than that widely used across the industry at present. In addition, during the last number of years, many researchers have suggested that forage based diets are used less efficiently for milk production than the feeding standards suggest. Our research indicates that the feeding standards are correct and energy is used for milk production with an efficiency of 0.65 (or 65%). It is therefore important when calculating requirements of dairy cattle that we recognise these recent findings and incorporate them into our approaches to feeding.

How do cows respond to extra feed?

We have discussed developing feeding standards which will enable the most accurate rationing of dairy cows. However, such approaches are of limited practical value in the real world in which we must be able to predict optimum feeding levels and strategies for animals of differing milk yield potential, producing in a range of physical and economic environments. In this latter context the key factor is how the animal responds to additional feed. This is primarily driven by how the animal partitions that additional feed between milk output and liveweight gain. Only when we fully understand this partitioning relationship, and how it is influenced by both animal and feed factors, can sensible feeding approaches be developed. The question for researchers is therefore to quantify those animal and feed factors which influence partitioning relationships and to build these into a feeding system along with any new estimates of requirements which may come along.

In conclusion, recent research at Hillsborough has demonstrated that we currently underfeed dairy cows and the energy required to maintain a dairy cow is some 30% higher than that in published feeding standards. Having reviewed the animals requirements and indicated how we consider these to be very different to that normally accepted, we must now turn to examine methods to characterise feeds.

Characterisation of grass silage

Grass silage is the main component of winter diets for ruminants and more accurate rationing can only be achieved if methods are available for:

(a) predicting the feeding value and intake potential of the silages which form the basis of the winter diet, and

(b) enabling the most appropriate level and type of supplement to be matched to the silage to achieve pre-set animal performance targets.

Silage feeding value depends on (a) the nutritive value of 1 kg silage (ME concentration) and (b) the quantity of silage the animal will consume (intake potential). It must be especially recognised however that the latter is more important than the former in determining the feeding value of a silage. For example, within the major Hillsborough study using 136 silages, ME content ranged from 9.8 to 13.5 MJ/kg DM (ratio 1:1.4) while intake ranged from 4.3 to 10.9 kg/day (ratio 1:2.5) (Steen et al., 1998). Accurate prediction of both intake and ME concentration (digestibility) of a silage are both therefore essential pre-requisites to the effective rationing of dairy cows and beef cattle offered grass silage *ad libitum.*

The Hillsborough Silage Evaluation System

While numerous other researchers have attempted to develop methods of predicting silage intake from a range of chemical parameters these have been totally ineffective. At the onset of the Hillsborough programme it was recognised that a system could only be developed if the intake, digestibility etc. of a large number of silages, representing the range of types of silages across the industry, were characterised within a standard animal protocol. As a result, the study involved selecting silages on the basis of their pH, dry matter, ammonia and metabolizable energy contents. A total of 136 silages were selected on this basis from farms across Northern Ireland. Approximately seven tonnes of each silage were brought to the Institute, mixed in a mixer wagon to achieve uniformity and then stored in polythene-lined boxes until feeding one to four weeks later. There was no deterioration of the silages during storage and their chemical composition remained constant (Pippard *et al.,* 1995). The silages were offered to 192 individually fed steers, which were crosses of the continental beef breeds and had a mean initial live weight of 415 kg, in a partially-balanced changeover design experiment to measure *ad libitum* intake. Each silage was offered as the sole feed to ten animals for a period of two weeks. Eight silages were offered in each of 17 periods and in addition a further 16 animals in each period were offered a standard hay to enable variation in intake between different periods to be removed. Detailed chemical and biological compositions of the silages were determined including the use of near infrared reflectance spectroscopy and electrometric titration. All silages were offered to sheep to determine *in vivo* digestibility. The rates of disappearance and rumen degradabilities of the dry matter, nitrogen and fibre fractions in the 136 silages were determined *in vivo* using the *in sacco* method.

Thirteen of the 136 silages were also offered unsupplemented to dairy cows to provide a basis by which the intake system developed from the data produced with beef cattle could be translated for use with dairy cows. In addition, sixteen of the silages were offered to dairy cows and growing beef cattle with a range of concentrate types and levels. Each silage was supplemented with high-starch and high-fibre concentrates, each with three protein contents and at three levels of supplementation. This process enabled the examination of the interactions between silage type and concentrate type/level of supplementation in terms of their effects on silage intake.

Data have been used to develop relationships between individual chemical parameters of the silages, or groups of parameters, and intake using simple and multiple regression analyses. These have been reported by Steen and Agnew (1996) and Steen *et al.* (1998). Samples of undried silages, and after drying for 20 h at 85°C, were also scanned through a near infrared spectrophotometer.

Prediction of intake

Chemical parameters (and their combinations) were of limited value in predicting the intake potential of a silage. These relationships produced low correlation coefficients. Near infrared reflectance spectroscopy was first shown to be a rapid method for predicting the chemical composition of forages by Norris *et al.* (1976). Since then numerous workers have explored the use of NIRS for the prediction of both chemical composition and digestibility of grass silages. Attempts have also been made to use NIRS to predict the voluntary intake potential of forages. In the present study the potential of NIRS to predict intake and digestibility through scanning both dried and undried samples was explored. The results of these have been reported in detail by Park *et al.* (1997) and Gordon *et al.* (1998). This technique proved to be by far the best method with R^2 of 0.89 and 0.94 for intake and organic matter digestibility, based on dried silages, respectively. Calibrations based on NIR spectra of undried samples of grass silage, which had been chopped, produced predictions of intake and digestibility with accuracies similar to those achieved using NIRS with dried samples. Table 1 demonstrates the improvement in prediction of OMD with NIRS over other commonly used methods.

Table 1
Comparison of NIRS with other laboratory methods for predicting digestibility (OMD)

	R^2
MAD fibre	0.34
Pepsin cellulase digestibility	0.55
In vitro digestibility	0.85
NIRS	0.94

(Barber *et al.*, 1990)

Subsequent research has also produced accurate predictive equations for a wide range of chemical and biological parameters of undried (wet) silages which are important in nutritional terms to the animal. This work is reported in detail by Park et al. (1998). Examples are given in Table 2.

Table 2
Accuracy of prediction of other silage attributes

	R^2
Dry matter	0.98
Crude protein	0.98
NDF	0.97
Ammonia	0.98
PH	0.94
Lactic acid	0.88

(Park *et al.*, 1998)

This research programme has developed a rapid, cheap and effective method for predicting a wide range of chemical and biological parameters of grass silage for use in dairy cow, beef cattle and sheep rationing systems. This research has been widely recognised as leading, world class research and the system produced, based on near infrared reflectance spectroscopy (NIRS), is widely recognised to be the best system currently available. These new methods, while not yet currently commercially available elsewhere in the UK or Ireland, enable cost effective and accurate predictions of a range of nutritionally important parameters of grass silage.

Development of nutritional models

Combining new information on feed (energy) requirements of both dairy and beef cattle, and an effective method of predicting nutritionally important characteristics of silage, led to the development of the Hillsborough Feeding Information System, and an associated new beef cattle rationing program. Work is ongoing on the development of a dairy cow rationing program.

The Hillsborough Feeding Information System is commercially available to the agricultural industry throughout Ireland. It uses the latest analytical technology to evaluate silages and couples this to a series of computer programs to provide feeding advice for dairy cows, beef cattle and sheep. Commercial silage samples are accurately evaluated in 15 minutes. The Beef Cattle Rationing Program, developed jointly between Agricultural Research Institute of Northern Ireland, Department of Agriculture for Northern Ireland and Meat and Livestock Commission is commercially available throughout the UK and Ireland.

Conclusions

Accurate rationing of ruminant animals depends upon accurately knowing the animals' nutrient requirements for differing functions and having effective laboratory methods for predicting the characteristics of forages. Research has demonstrated that the present estimates adopted for maintenance in cattle are well below those necessary for animals on forage based diets. These new estimates for maintenance coupled with the results of a large scale study to develop improved methods of predicting intake and digestibility of grass silage have enabled much more accurate feed rationing programmes to be developed. These developments, which will be further refined over time, represent a major step forward in accurately rationing ruminant livestock.

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New Energy and Protein Systems for Ruminants

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Energy is the most important nutrient for animals, followed by protein. Animals must be properly fed with energy and protein in order to achieve the desired performance. To assist in this, systems have been developed for protein and energy feeding. These all allow the dietary supply of energy/protein and the animal requirements of energy/protein to be assessed and matched. Some recent developments in energy and protein systems for ruminants are outlined in this paper.

Historical perspective and current situation in Ireland and internationally

For ruminants, the early energy systems such as those devised by Kellner (1905) in Europe and Armsby (1917) in the USA were based on net energy. In 1962, a system based on metabolisable energy was proposed in the UK by Blaxter (1962). To my knowledge, Ireland, Switzerland, and Finland are the only European countries to have adopted the ME approach. The major livestock producing countries of France, Germany and the Netherlands all opted to keep the net energy approach and have developed modern net energy systems. The ME system can be criticised on theoretical and practical grounds. Some Irish scientists, most notably my colleagues in University College Dublin have voiced their criticisms (e.g. Caffrey, 1993). I joined UCD in 1993 to work on these energy systems under the sponsorship of the Irish Grain & Feed Association. I reached the same conclusion that net energy would be a better basis of feed evaluation than ME. That project culminated in the publication of a net energy system (O'Mara, 1996) which was modelled on the French net energy system. Using Irish data (mainly Teagasc), a set of net energy values as specific as possible to Irish feeds was generated and adjustments were made to the animal requirements for growth and fattening to bring them into line with the levels of performance obtained here in Ireland. In this paper I outline the considerations, theoretical and practical, that justify the use of NE instead of ME and to outline the system we have devised.

On the protein side, crude protein has long been recognised as inadequate for ruminants. Terms like *undegradable protein* (UDP) and *rumen degradable protein* (RDP) for many years were attempts to better describe feed protein. More comprehensive systems have been developed in France (the PDI system) and the UK (the MP system). Recently the Dutch evaluated which of the existing systems could best be used under Dutch conditions (Van Straalen et al., 1993) and concluded that the French PDI system was the most accurate in predicting milk protein production. I will illustrate later how the PDI system would rate our typical grass silage based diets.

What is metabolisable energy and net energy?

Of the energy which the animal digests (i.e., after losses in faeces are deducted), some is lost as methane and some is excreted in the urine. The remaining energy is called the *metabolisable energy* (ME). It is an abstract term and cannot be measured directly - it is measured indirectly by measuring losses in faeces, methane and urine, and deducting these from total or gross energy. The metabolisable energy is available to the animal for maintenance and animal products such as milk, meat and wool, but it is not used with 100% efficiency - some is lost as heat:

$$ME \times k = NE$$

where k is an efficiency factor which is very poorly understood. So *net energy* (NE) is the energy used to maintain the animal or which is recovered in animal product. It can be measured indirectly by measuring heat loss (very difficult) and subtracting this from ME or measured directly by measuring animal product and measuring or in most cases, estimating maintenance requirements. This allows net energy values to be derived from or tested and validated by animal production studies.

The advantages of a net energy system

The main advantage of a NE system is that the feed values are inherently more realistic as guides to the usefulness of the feeds than ME values. This can be explained as follows:

- As stated above, NE values can be derived from or can be tested and validated by animal production studies which have been carried out in Ireland. Values so derived must be more meaningful than ME values measured in sheep fed at maintenance which the ME system uses.
- NE ranks feeds on the basis of animal performance and thus allows comparisons of the productive value of different feeds but ***ME values are not necessarily related to animal maintenance or production.*** For instance, it takes about 12 MJ of ME from good quality forage and 14 MJ of ME from poor quality forage to equal the 11 MJ of ME in 1 kg of barley in terms of value for animal production. In other words, the usefulness of ME depends on where it comes from. Obviously ME should not to used to compare the energy value of concentrates and forages.
- ME values as they have evolved have no intrinsic value over DE values because, (a) they are generally measured at maintenance feeding level where there is a very close relationship between DE and ME, (b) methane energy is usually predicted in measurements of ME, (c) the relationship between ME at maintenance and ME at production level is variable, depending on both the physiological state of the animal and the feed, and (d) no attempt is made to segregate urine into animal derived and food derived products.
- While NE systems may predict NE from DE or ME values, the NE values so derived can be adjusted to reconcile them with measured animal performance if necessary. This is a vital element of the Irish net energy system. An ME based system of feed evaluation has no such 'safety mechanism'.

Net energy for Ireland?

In UCD we have taken the view that we should be using an NE based system instead of an ME based system for feed evaluation in Ireland. This view is not taken likely considering the close links we have with the UK and Northern Ireland. However, we believe that the points above are compelling reasons for change - if NE is a better basis for feed evaluation, we should be using it regardless of the difficulty of unlearning the ME system and learning a new system with new terminology, values, etc. Our own system gives us the independence to put our values on feeds in an organised and structured manner. Teagasc and UCD have carried out (and continue to do so) a huge amount of feed evaluation work. What is the point of all that if the results are not used? The easiest way to harness the information generated is in a net energy system of our own. As new information on feeds becomes available from home and abroad, this can be incorporated by updating the feed values. The silage intake values predicted by the Hillsborough NIR calibration are well suited to incorporation into the French intake system (which won't be dealt with in this paper). The net energy system can easily accommodate any developments in the ME approach since the fundamental objective in all systems is that the value attributable to a feed can be used to accurately predict the value of that feed to the animal.

Outline of the recently proposed Irish net energy system

The NE systems developed for use in Ireland are mainly based on the French NE systems (Jarrige, 1989). The French systems have been chosen for many reasons

- They are very comprehensive and are backed up by a huge amount of animal experimentation.
- Systems of production and animal types in France are reasonably similar to those in Ireland.
- Their feed database includes information on several hundred feedstuffs, based on thousands of in vivo measurements.
- The net energy values are all expressed relative to barley as a standard feed which makes the values more meaningful to farmers than abstract megajoules.
- The French also have well developed protein and intake systems (the PDI and Fill Unit systems, respectively) which have been combined with their energy systems and feed database in a computer operated diet formulation package (INRAtion) which is available in English. Together, these systems provide an excellent "conceptual framework" for designing feeding programs.

The Irish net energy systems differ from the French systems mainly in the nutrient values of the feedstuffs. The nutrient values are based as much as possible on Irish data. This ranges from data on the chemical composition of the feeds, measurements of their in vivo digestibility, and measurement of animal performance in comparative feeding trials. Thus, the feed tables are related to the feeds used in Ireland and the use of feeding experiments in deriving the net energy values is important in ensuring that they are the best available values.

The aim has been to provide values that reflect animal performance as closely as possible and thus, to give accurate feed evaluation.

Expressing energy value as feed units

The NE systems for dairy and beef cattle and sheep assign two NE values to the feedstuffs, one for maintenance and lactation in dairy cattle and sheep, and one for maintenance and weight gain in fattening animals. The energy requirements of animals are expressed in the same units. The values proposed for use in Ireland are followed by **(I)** to distinguish them from corresponding French values. The NE of a feed for maintenance and lactation are expressed in the same units called **UFL** (Unité Fourragère Lait - Feed Unit for Milk) in the French system and **UFL(I)** in the Irish Republic. **UFL(I)** values for some feedstuffs are given in Table 1.

One UFL(I) is the NE content of 1 kg of air dry standard barley for milk production

Table 1

Net energy values for milk production

	UFL(I)/kg
Barley	1.00
Wheat	1.00
Beet pulp	1.00
Citrus pulp	1.00
Corn gluten	0.92
Pollard	0.70
Soyabean meal	1.02
Sunflower meal, CF > 30%	0.59
Rapeseed meal	0.88
Grass silage, 70 DMD	0.79 (DM basis)
Spring grass	0.95 (DM basis)

For intensive beef production, the overall NE value for meat production of the feedstuffs at an animal production level (**APL**) of 1.5 times maintenance is used. This is expressed in units called **UFV** (Unité Fourragère Viande - Feed Unit for Meat) in the French system and **UFV(I)** in the Irish Republic.

One UFV is the NE content of 1 kg of air dry standard barley for meat production at an APL of 1.5

An APL of 1.5 corresponds approximately to a daily weight gain of 1 kg/day in finishing steers.

Net energy requirements are expressed in the same units, UFL(I) and UFV(I), as feedstuff NE content, and are treated as being additive. Requirements expressed in UFL(I) are:

- the requirements of dairy cows (or sheep) during lactation, pregnancy or the dry period,
- the requirements of dairy heifers (or ewe lambs), wintering and slowly growing animals (i.e., liveweight gain between 0 and 1.0 kg/d for growing cattle),
- breeding males.

Requirements expressed in UFV(I) are:

- the requirements of rapidly growing and fattening animals (steers, bulls, beef heifers and fattening lambs).

Standard barley

Barley is used as the reference feedstuff in the French NE system and in this system. It is defined by Jarrige (1989) as being the average composition of barley samples analysed in France between 1977 and 1987: 87.0% dry matter (**DM**), 4.36% crude fibre (**CF**), 10.5% crude protein (**CP**), 1.93% ether extract (**EE**), organic matter digestibility (**OMD**) = 0.86 and energy digestibility = 0.837. The OMD is very similar to the average of samples (n = 8) analysed in UCD from 1994 to 1996. The OMD of the Irish samples was slightly lower (0.849) but the DE content of the eight samples (15.6 MJ/kg DM) is exactly the same as the French value. Because the reference feeds in both systems are so similar, UFL and UFV values from the French system can be used for feeds where no specific Irish values are available.

Why do we need a set of Irish feed values?

The French have carried out thousands of in vivo measurements on feedstuffs in developing their comprehensive database. So have the Dutch and the British. Are we re-inventing the wheel or being nationalistic by setting out to have our own values? The answer is no because feeds can differ depending on the region in which they are produced. This is easiest to visualise with forages where varieties and climatic conditions will combine to produce material of different

Table 2
Organic matter digestibility (g/kg) of feeds according to Irish, French and UK databases

	Irish[1]	French[2]	UK[3]
Barley	846	860	860
Wheat	877	890	904
Beet pulp	860	860	893
Citrus pulp	851	850	880
Corn gluten	750	840	824
Pollard	642	680	770
Palm kernel	669	800	676
Cottonseed meal	689	720	668
Rapeseed meal	741	820	766
Soyabean meal	925	910	907

[1]O'Mara, 1996 (values updated with additional information generated in 1997)
[2]Jarrige (1989) [3]MAFF (1992)

quality in different countries. However, with concentrate feeds which are largely imported except for home produced cereals, the quality of material imported into Ireland could differ markedly from that imported by some of our neighbours. This is illustrated in Table 2 which shows the organic matter digestibility of various feedstuffs as given in the Irish, UK and French databases. The Irish data are measurements of digestibility carried out at UCD over the past four years. The methodology used in all three countries was similar.

The data show similar results for many feeds such as barley, wheat, beet pulp, citrus pulp, and soyabean meal but they also show substantial variation in the quality of other feedstuffs between countries. Both the UK and France report much higher digestibility for corn gluten than we have measured at UCD. The French values for palm kernel and rapeseed meal are much higher than our measurements and the UK value for pollard (wheat middlings) is much higher than our measurements. These differences may reflect differences in the grades of materials imported by each country or they may be due to changes in the quality of the by-product over time as the manufacturing processes become more efficient. This reduced quality would be picked up in the Irish values because these have all been generated in the last four years but not in the UK or French data which is much older. Regardless of the reason, they do establish the need to have our own figures on these feedstuffs.

Does the new energy system affect the value of feeds

It is common practice to value feeds in relation to barley and soyabean meal as two reference feeds and to take into account the energy and protein contents. Table 3 shows the UFL(I), ME and CP contents of barley and soyabean meal, and a third feed, corn gluten, whose value we want to ascertain. The price of barley is taken as £100/tonne and the price of soyabean meal is taken as £230/tonne. Using the ME and CP values, corn gluten will have a value of £131.48. However, using the UFL(I) and CP values, its value is only £115.84. Therefore the systems we use have a large effect on the value we give a feed. Using the ME values, we would consider corn gluten to be good value at less than £131/tonne, but it is actually poor value at anything more than £115/tonne when considered using the new energy systems.

Table 3

Energy and protein values of barley, soyabean meal and corn gluten (per kg as fed) and their cost/tonne

	UFL(I)	ME	CP	£/tonne
Barley	1.00	11.2	10.4	100
Soyabean meal	1.02	11.5	16.8	230
Corn gluten	0.92	10.9	19.8	?

Farmers who do not buy straights might think this point is irrelevant to them. But a compounder using ME and CP as the basis for his formulations will use more corn gluten to the exclusion of other better value ingredients. The effects on concentrate cost or quality will not be huge, but on a national scale I consider them significant.

Evaluating forages

The energy value of forages is given in UFL(I) per kg DM and is obviously very important in determining their feeding value. However intake is also an extremely important consideration with forages. The French have published Fill Value figures for the voluntary intake of forages relative to that of spring grass (which is considered the standard forage). For dairy cows, these are given in lactating fill units (LFU). The higher the value, the lower the intake. Spring grass is given a value of 1 and first cut grass silage might have a value of 1.27 (i.e. 27% lower than grass) whereas good quality maize silage might have a value of 1.13 (i.e. 13% lower than grass).

An index of the overall feeding value of forages would be very useful which would take into account its energy content and its intake potential. Again, the French have such an index which is called the Ration Energy Density (RED). The RED of a forage is obtained as follows:

$$\text{RED} = \frac{\text{energy content (UFL(I)/kg DM}}{\text{Fill Value (LFU)}}$$

The higher the RED, the higher the overall feeding value of the forage. Table 4 shows the energy content, the intake capacity and the RED of some forages. These are average figures and obviously both the energy content and intake capacity of individual batches will vary. Energy content can be predicted from DMD and recent Hillsborough work has made it possible to get a Fill Value for a particular batch of silage. The figures in Table 4 show the superiority of grass to grass silage and the superiority of maize silage to grass silage. This is mainly due to its better Fill Value rather than to a higher energy content.

Table 4
Net energy (UFL(I)), Fill Value (intake potential in LFU) and overall feeding value (RED) of forages

	UFL(I)	LFU[1]	RED[2]
Grass	0.95	1.0	0.95
Grass silage, 70 DMD	0.79	1.3	0.61
Maize silage, poor	0.70	1.2	0.58
Maize silage, good	0.75	1.05	0.71
Straw	0.44	1.6	0.28
Whole crop wheat	0.64	1.01	0.63

[1]LFU: The lower the value, the greater the voluntary intake
[2]RED: The higher the value, the better the overall feeding value as it takes both the 'Fill Value' and Feed Value (UFL) into account

The PDI protein system

The PDI system aims to predict the quantity of amino acids the cow will absorb from her diet. This can be limited by either nitrogen or energy availability in the rumen which are used in the production of microbial protein. Energy is assessed by the amount of fermentable organic matter available. Thus, there are two potential amounts of microbial protein production, that from available nitrogen or that from available fermentable organic matter. The supply of undegradable protein is added to this giving two potential supplies of total amino acids:

PDIN = PDI supply when degraded dietary N is limiting
PDIE = PDI supply when fermentable organic matter is limiting

The supply of each from the diet is calculated and the lower one is used as the actual supply of amino acids to the cow (the ideal situation is where PDIN = PDIE in the complete diet, but this is not always achievable). The simplified examples below demonstrate the calculations involved. The following feeds, shown with their respective PDIE and PDIN values, are used.

	PDIN (g/kg DM)	PDIE (g/kg DM)
grass silage	78	62
maize silage	50	68
barley	79	102
soyabean meal	388	263
beet pulp	66	109

Situation A If the cow is eating 11 kg silage DM, 4 kg barley DM and 1 kg of soyabean meal DM

PDIN supply = {(11 x 78) + (4 x 79) + (1 x 388)} = 1562 g/d

PDIE supply = {(11 x 62) + (4 x 102) + (1 x 263)} = 1353 g/d

PDIE < PDIN, and so PDIE is chosen - i.e., PDI supply = 1353 g/d. This is adequate for a cow producing 21-22 kg milk at 30 g/kg protein (Table 5).

Situation B If the cow is eating 6.5 kg grass silage DM, 6.5 kg maize silage DM, 3 kg beet pulp DM and 1 kg of soyabean meal DM

PDIN supply={(6.5 x 78)+(6.5 x 50)+(3 x 66)+(1 x 388)}=1418 g/d

PDIE supply={(6.5 x 62)+(6.5 x 68)+(3 x 109)+(1 x 263)}=1435 g/d

PDIN < PDIE, and so PDIN is chosen - i.e., PDI supply = 1418 g/d. This is adequate for a cow producing 22-23 kg milk at 30 g/kg protein (Table 5), with 1 kg less concentrates than when fed grass silage only (situation A).

Table 5

PDI required/day for 600 kg dairy cows yielding various amounts of milk with various protein contents

Milk yield	Milk protein content (g/kg)			
(kg/day)	28	30	32	34
20	1240	1300	1360	1420
25	1450	1525	1600	1675
30	1660	1750	1840	1930
35	1870	1975	2080	2185
40	2080	2200	2320	2440

With grass silage based diets fed to milking cows, PDIE is usually limiting and the target level in concentrates is 125-130 g/kg as fed. This is difficult to achieve. Table 6 shows the PDIE, PDIN and CP contents of some formulations. Formulation 1 is a simple 3 way mix of barley, corn gluten and distillers grains. Formulations 2 and 3 use a larger number of ingredients. Rapeseed meal is the main protein source in 2 and high quality cottonseed meal is the main source in 3. All three are seriously inadequate in PDIE, even though all are between 18 and 20% CP. This indicates that with many rations of *'normal'* CP content, protein nutrition of the dairy cow is inadequate.

Formulations 4 shows the inclusion rate of soyabean meal that would be needed to bring a concentrate up to a PDIE level of approximately 130 g/kg where barley is the only other ingredient. It is 30%. It is apparent that it will be difficult to design concentrates with 130 g/kg PDIE or greater which implies that high milk protein content will be difficult to achieve. Formulation 5 is a typical concentrate fed as a balancer to maize silage, being 24% CP. It is adequate in both PDIE and PDIN. This is most likely a contributing factor to the better milk protein contents on maize silage based diets along with the higher DM intakes.

Table 6

CP, PDIN and PDIE levels (g/kg as fed) of various concentrate formulations with ingredient inclusions expressed on a percentage basis

	1	2	3	4	5
Barley	33	20	15	70	
Corn gluten	33	20	20		20
Corn distillers	34	20	20		30
Beet pulp		20	15		20
Citrus pulp			15		
Soyabean meal				30	10
Rapeseed meal		20			
Cottonseed meal			15		20
PDIN (g/kg)	**123**	**134**	**128**	**151**	**163**
PDIE (g/kg)	**107**	**111**	**115**	**132**	**131**
CP (g/kg)	**187**	**198**	**185**	**206**	**240**

Summary and conclusions

Irish farmers would be better served by an energy system which puts values on feeds that reflects animal performance on those feeds. It is wasteful of Irish research results not to use them in a systematic manner to put values on feeds. A net energy system is the obvious vehicle for this. We should exercise control over our own feed values. Using our knowledge to put the best value we can on feeds is essential to getting the best return from the huge annual expenditure on feedstuffs. We need a vibrant system that is updated as new information arises and we need to utilise developments abroad such as the silage intake prediction from Hillsborough. Newer concepts of protein nutrition also need to be taken on board.

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Appendix

Estimating UFL and PDI requirements of dairy cows

UFL(I) requirements/day

Maintenance: 5 UFL(I) for a 600 kg cow
± 0.6 UFL(I) for each 100 kg liveweight different from 600 kg

Milk: 0.4 UFL(I)/kg approximately (correct value: 0.43 - 0.44)

Liveweight loss contributes 3.5 UFL(I)/kg
Liveweight gain requires 4.5 UFL(I)/kg

Pregnancy: 0.9, 1.6 and 2.6 UFL(I)/day during 7th, 8th and 9th month of pregnancy

PDI requirements (grams/day)

Maintenance: 100 + (W ÷ 2) where W is weight in liveweight
e.g. 400 g/day for a 600 kg cow

Milk: 1.5 x milk protein yield expressed in grams/day

International Trends in Dairying

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As the debate on the future of milk production in Europe was intensifying, I examined the dairy industry in several parts of the world to see how people viewed the future of the industry from other perspectives and what impact this may have on the future of Irish production. My study tour in 1996 was sponsored by the Farmers' Journal and the Irish Farmers' Association. The major milk exporting areas were of most relevance. I visited the US, then Victoria in Australia and continuing to Chile, Argentina and Uruguay.

As shown below, world milk production has decreased slightly from 475 m tonnes in 1988 to 473 m tonnes in 1996. The largest drop in production is in the E.U. with Eastern Europe and Russia also reducing. Most other parts of the world are increasing production and developing new markets in the growing economies of Asia and Latin America. Milk consumption in Brazil has increased by 20% in the last 2-3 years and it is considered that half of Brazil's 130 m people have not tasted dairy products yet.

WORLD MILK PRODUCTION

	1988 000 t	%	1996 000 t	%	+or- '000 t
Africa	13656	2.9%	16141	3%	2485
North America	83660	17.9%	89910	19%	6250
South America	29974	6.4%	41880	9%	11906
Asia	48264	10.3%	80265	17%	32001
Europe (EU 15)	128123	27.4%	123587	27%	-4536
Other Europe	42223	9.0%	34407	7%	-7816
Australia	6298	1.3%	8986	2%	2688
New Zealand	7650	1.6%	9934	2%	2284
Other Oceania	60	0.0%	77	0%	17
USSR/Russia/Ukraine	106300	22.7%	61130	13%	-45170
Total	**468196**	**100%**	**466317**	**100%**	-1879

Source FAO

U.S.A.

In visiting 10 different states, I got some appreciation of the wide variation in climate and conditions across the U.S. There is one common feature - total confinement. Over 90% of the dairy cows are never managed outdoors unless they are in the warmer states where they are confined in roofless corrals and are never released to forage for themselves. This system has been developed as a result of years of subsidised agriculture. Buildings and machinery in particular were cheap and the typical farm has a graveyard of over 50 years machinery. In the traditional dairy states of Minnesota/Winsconsin and east of there it is common to see sheds which were once dairy farms now abandoned.

Over the past ten years milk price has averaged about 17.6 p per l but it has fluctuated from the Government guaranteed price of about 14.5 p per l to just over 22.0 p per l in that period. The record high of 22.4 p per l was reached in September 1996 but within 3 months it had dropped to below 16.5 p per l equivalent. This volatility is caused by supply/demand variation in what is basically a "home" market - only 2 to 3% of total production is exported.

Data from the U.S. Department of Agriculture show that the cost of producing milk on the average U.S. dairy farm in 1994 was 24.2 p per l. The average price paid for milk in the U.S. in 1996 was 17.6 p per 1. Farmers are basically living off depreciation in this scenario. Production in traditional eastern States is dropping and there is a move to bigger units in the mid-west and west. In Wisconsin there were 120,000 dairy farms in 1950; there are 26,000 today and it is reckoned that in 7-8 years at least half of these will be out of business. T. Graff and Ed Jesse, University of Madison, report that the only solution is a move to larger units with economies of scale. From what I saw, however, this is not always the case. The number of cows per labour unit on some large units is only 50 to 60. The very efficient ones are achieving 100 but these are few and far between. Many of the large farms are dependent on cheap Mexican labour to make a margin.

Costs of feed production and manure handling are increasing more rapidly than the price of milk, placing an economic squeeze on farmers. In addition, the capital investment that is perceived to be necessary is making confinement dairying uneconomic. The problem with confinement dairying is that there is a whole infrastructure built up around it. Everybody involved in that infrastructure makes money except the dairy farmer - feed companies, machinery companies, veterinary salesmen, semen salesmen and other support services. There is a distinct lack of independent support for the farmer to help him avoid the maze of propaganda that is fired at him every day.

Across the U.S. any farmer with a grazing system was hungry for information and was delighted to have a caller who was not trying to sell him something. I began to appreciate Moorepark and the advisory structure in Ireland a lot better after this experience.

There is a very slow move towards grazing in the U.S., less than 10% of dairy farmers, but it is seen by many as a last resort before bankruptcy. It is for many because they do not unload themselves of the capital burden that was breaking them in the first place.

Another surprising feature is the lack of contract operators and the insistence of every farmer in having his own machinery. This includes harvesting maize and alfalfa hay and all the other work involved in confinement dairying. Hence, there is a massive investment in machinery even on small 40 to 50 cow farms which increases milk costs.

Research at Cornell University on grazing showed that the north-east U.S. can grow as much grass dry matter in a season as in Ireland. It is slightly later starting in the spring but they can grow more in the autumn. The main difference is the cold winter during which ryegrass will not survive. Brome grass is popular but is harder to manage and has lower quality than ryegrass. Cocksfoot is also quite common. The red clover is excellent and tends to be dominant. The same applies in Wisconsin. In northern Wisconsin ryegrass can be grown successfully due to the climatic effect of the Great Lakes.

The eastern region of Texas to the Atlantic coast is a milk deficit area and is therefore the highest milk price area - 2.2 p per l higher than other areas. But costs are higher here too. Heat stress is common as summer temperatures are often above 100 degrees F. Confinement sheds are fitted with fans to cool down cows. This is also a hurricane area and electric storms are possible at any time without warning.

Idaho is a fine example of an expanding dairy industry which has grown from $73 m in 1970 to $500 m in 1995 - a growth rate of 23% per year. Idaho dairy farmers produced 636 m litres of milk in 1970. In 1995 they produced 1,873 m litres from 1,162 farms with an average of almost 200 cows per farm - an increase of 194% in production. Average milk yield per cow increased from 4,450 l in 1970 to 8,183 l in 1995. There are about 15,000 people employed in the production, processing, transport and distribution of milk. Avonmore has been part of this growth in Idaho since 1989 and now has three impressive processing sites there. The majority of the growth has come from large units of more than 1,000 cows - with a typical investment being over $4,000 per cow. Corrals are open because of the low rainfall and there is no need for cover except to provide shade. These large units tend to buy feed from small local farms. Most crops are irrigated. The best grazing management which I saw in the U.S. was being practised by a New Zealander in Idaho. He was managing 800 cows on a farm with very low capital investment, that is, stock, land, irrigation and milk shed.

In the western states of Washington and Oregon, there is potential to graze in a reasonably temperate climate but the price of land here means that people are selling and moving to cheaper areas. Grazing is more common but nevertheless frowned upon and poorly managed.

<u>Assessment</u>

I was surprised at the potential to grow grass in many parts of the U.S. and at the lack of knowledge of good grazing technology. The latter probably stems from two generations that have been driven by subsidised agriculture into high output artificial production systems. There is a lack of independent measurement and advice available to the farmer who is very much dependent on commercial salesmen. The advantages of independent research and advice were immediately obvious.

The U.S. has a large home market for dairy produce and exports only 2% to 3% of its production. The population is growing at the rate of 4 m per year and consumption of dairy products is growing also. Prices are likely to be more stable in the U.S. without supports than in an Ireland without supports because of the lack of dependence on exports. Fluctuation in cereal prices caused by extremes of weather or over-production would seem to be the main factor that will influence production of milk in the U.S. for the foreseeable future.

AUSTRALIA

Victoria has the greatest potential for expansion in Australia. The picture was very different from the U.S., namely, an industry that was focused and growing. Australia produces 8.2 billion litres of milk per annum, 62% of which is produced in Victoria. Twenty-five per cent of total Australian milk is used for liquid milk consumption with home consumption of manufactured products accounting for a further 30% of production, leaving 45% of total production for export. But this is growing (about 15% growth in 1996) and 56% of exports are to Asia and a further 18% to Japan.

Victoria accounts for 90% of total Australian dairy exports; production in the other states is practically all home consumed. In each state there are regulations governing liquid milk production with the purchase price on the farm; the farmer is guaranteed almost twice the manufacturing price for liquid milk. In 1996, the liquid price was 25.3 p per l. The manufacturing price was 13.6 p per l.

Marketing of manufactured dairy products is also covered by an industry funded market support scheme; industry funds are used to subsidise exports. A levy is imposed on all milk production, including liquid milk (1 p per l). This generates a fund of about £75 m which is used to subsidise less than half of the production that is exported. This will be reduced because of GATT and cannot be more than 10% of the export price in 2000.

In the years 1990 to 1995 the number of dairy farmers in Victoria reduced by 5% while at the same time herd size increased by 25%, milk production increased by 35%, milk yield per cow increased by 17% and concentrates fed per cow increased by 100%. There are now 8,236 dairy farms in Victoria with an average of 142 cows per farm feeding 524 kg of grain per cow and producing 4,479 l of milk per cow.

The main research centre is at Ellinbank, east of Melbourne in an area well suited for grass growth. Rainfall is 1100mm; average summer and winter temperatures are 20° and 8° respectively; the area is prone to drought in January. The centre has 217 ha of land; there are 450 cows - 50 autumn calving and 400 spring calving. The centre has 15 research staff, 19 technicians and 13 farm staff.

The role of Ellinbank is to undertake research, development and extension relevant to south-east Australia and the main components of the research programme are: Fertility, Environmental impact of fertilisers, Animal nutrition and pasture utilisation, Milk harvesting (machinery), Milk and product quality.

The budget in 1996 was IR£1.5 m funded by the Dairy Research and Development Corporation (DRDC) which also funds other research centres, universities and private companies. The DRDC collects its funds from a farmer levy of 2.3 c per kg butterfat (0.2 p per gallon). This money is matched £ for £ by the Federal Government. Their levy was increased to 2.9 c per kg butterfat in 1997 and raised about IR£11.5 m for both research and extension work.

The most striking feature of Ellinbank was the close relationship between Research & Extension. The main extension drive is through Target 10 and it is also based at Ellinbank. Both research and extension have similar objectives, one of which is to increase the amount of pasture consumed per hectare. The present average in Victoria is 6 t per ha, some farms are achieving 15 t at present - the objective is to increase that figure to 20 t DM consumed per ha. One of the principal methods of getting the message across to farmers is by using A.B.C. Farms - 3 small farms near the research station where regular farm walks are held.

Assessment

Victorian dairy farming is an industry geared up to expand. Close integration of research, extension and education and a clear focus on production from pasture is sure to pay dividends from Victoria's cheapest resource. There is also the advantage of a reasonable home market (55% of production) where consumption is growing, and access to the Asian market which is being developed as fast as possible. The Australian Dairy Council, which promotes dairy products but does not sell them, is operating in several countries in Asia. The levy on milk, including liquid milk, is using the Australian consumer to subsidise exports. The fact that the Government sets the liquid price is a price support which does not cost the Government money. A very large levy in Ireland would be required in order to have the same effect.

CHILE

Total milk production in Chile is about a quarter that of Ireland at 1.7 m tonnes. Up to 20% of this production is in churns but from 1998 churns will not be allowed. The Government has set up an advisory service to help small farmers (less than 80 ha); 60% of farms are less than this and they produce 30% of the milk. Some of the advisers are trying to set up co-ops with storage centres for cooling milk for these small producers.

There are 17 milk purchasers in Chile but they are not all processing. About 70% of the industry is controlled by Nestle (Swiss), Soprole (50% owned by N.Z. Dairy Board) and Paramalat (Italian). These companies are using their position in Chile to bring in products from abroad. In 1995 Brazil increased its tax on Chilean milk imports from 10% to 16% because they believe that cheap N.Z. product is coming to Brazil via Chile. Chile started exporting dairy products only five years ago; exports were worth $25 m in 1995 and $35 m in 1996.

Farmers are being forced into all year round production because processors are trying to flatten the production curve in order to utilise capacity. Farmers who produce milk all year round receive 18.7 p per l and smaller farmers who produce seasonal milk receive only 10 to 11 p per l. The latter are under pressure from processors. Production is growing at up to 20% per year and there will be a need for major investment in processing capacity to maintain this growth. The only subsidy available is a free advisory service to small farmers (under 80 ha). These farmers have 80 to 100 cows and very poor facilities. Mobile milking parlours are common.

Nestle exercises a high degree of control in this country. At least 25% of the products on the shelves were Nestle: milk, butter, yoghurts, flavoured milks in large supplies, condensed milk, powdered milk, baby foods, breakfast cereals, biscuits, chocolate, cream, coffee and many more.

Assessment

While there are some excellent grass farmers in Chile the majority of milk is produced in confinement operations or a mixture of both. There is much U.S. influence particularly in liquid milk producing areas near the centres of population. Keenans have penetrated the market here for diet feeders very well. Average farm size is quite large. The farm owner often lives in a city and comes to the farm 1-2 days a week. Because of this, the farm is dependent on poorly educated workers. The industry will grow steadily but potential is limited by lack of good research, extension and education. Little product is exported and with a population of 15 m people and consumption growing, Chile will be cushioned from the instability of the world market.

ARGENTINA

Milk production in Argentina has grown at about 10% per year since 1989 and is now estimated to be 9 m tonnes per year - almost twice the Irish production. Of this, 25% is in liquid milk consumption and 45% is cheese. Only 8% of production is exported but this is growing rapidly. Brazil is a huge market of 130 m people and as its economy grows, food consumption is increasing. Argentina, Brazil, Paraquay and Uruguay have a common trading block called Mericosur which gives Argentina and Uruguay as dairy exporters priority access to the Brazilian market. Chile is being encouraged into the group for access to the Pacific and exports to Asia.

The main dairy producing area is in the province of Santa Fe where the number of dairy farmers has dropped in the last 20 years from 15,262 to 5,664. In the same period, cow numbers dropped by only 5%, while production doubled and productivity per hectare increased from a very low 30 kg butterfat per ha to 133 kg per ha. Number of cows per farm increased from 40 to 95; average size of dairy farms increased from 85 ha to 100 ha from 1975 to 1996.

The main dairy research centre is in Rafaela and is leading the drive for increased production. Results show that production can be doubled. Traditional farms are averaging 3,000 to 4,000 l per cow per lactation while better farmers are achieving 5,500 to 6,000 1 per cow. In Rafaela Research Centre they are achieving 7,500 to 8,000 1 per lactation. The average stocking rate on more traditional farms is less than 1 cow per ha while at the research centre it is between 2.0 and 2.5 cows per ha.

The main forage consists of alfalfa pasture, brome grass/cocksfoot/clover pasture, some annual ryegrass, alfalfa hay, maize silage and concentrate. Perennial ryegrass cannot be grown because of the heat - over 30 degrees in the summer. Management of pasture is difficult due to types of grasses but the alfalfa hay and maize silage are consistently high in quality. Pasture must be reseeded every 4 to 5 years. Concentrates are cheap, £100 to £120 per tonne.

Farms are well fenced and are equipped with windmills bringing up water from the high water table. No buildings of any significance are to be seen, pointing to low investment as a major advantage. Milking parlours are only now becoming common. Animals are managed outdoors all year round and hay, silage, etc. is fed under electric wires on top of the ground. If the ground becomes mucked up, cows are moved to a new site. Concentrates are fed in parlours all year round and as calving is all-year-round it is difficult to estimate the amount fed. It is generally ad-lib while milking and is estimated to be over 2 tonnes per cow per year on most farms.

Thirty five per cent of the milk is processed by co-operatives and 65% by private companies. The largest processor is a co-operative called Sancor with about 20% of the total. The top 5 processors account for 75% of the total. There are many small processors and purchasers who just sell on the milk for processing. The supply curve is fairly flat with the spring only 25% higher than the lowest point.

The vast plains of arable land in Argentina and the farm structure make it one of the best regions in the world for farming. It is possible to produce milk here all year round at low cost. If production were seasonal it would be even lower cost but because of the lack of farmer control of the industry at processing level, farmers are forced into all-year production.

Conclusions

1. Research

Moorepark Research Centre is one of the best dairy research facilities in the world and is the best centre for grass utilisation. This gives the Irish industry an advantage that must be continued.

2. Research-Extension link

A greater link between research and extension is needed in Ireland. In Australia and New Zealand and also Argentina where the industry is growing, the link between research and extension is very strong. A sizeable proportion of the producer levies is spent on extension. In Ireland all the levy is spent on research and the link between research and extension is poor. I believe that researchers should keep in contact regularly with a number of farms in order to keep in touch with problems. Likewise the advisors should have a greater role in research.

3. Grass varieties

There is need for a major international research programme between Ireland, the U.K., Australia and New Zealand to develop more productive varieties of ryegrass. In north America the development of maize is proceeding so fast that it is moving north at the rate of 10 km per year. Developments in crops like barley and wheat are to be seen in Ireland; 7.5 t of spring barley per ha is common and 12.5 t of wheat per ha is being achieved. Genetic progress in maize is increasing yields by about 4% per annum and by 1.5 to 2.0% in wheat and barley. The seed companies are investing massive amounts of money into researching new varieties. Because grass is not sown every year, seed companies are not inclined to put as much into researching new varieties.

4. Capital investment

Teagasc should demonstrate systems of dairy farming which have low capital investment. We should make better use of shelter belts instead of concrete and it would be more environmentally friendly. One obvious feature on my tour was that a large capital investment tended to be the millstone around the farmer's neck. In contrast, anywhere the industry was expanding, e.g. the western USA with large outdoor corrals or in the southern hemisphere on pasture based systems, the capital investment was low.

In Ireland, farmers with small quotas spend large sums of money on slatted tanks and elaborate facilities which leaves them in debt even after grants. The industry cannot support the type of capital investment that has become the norm especially in a world of freer trade.

5. Fertility

More research is required into fertility and embryonic death in high producing animals in order to maintain a 365-day interval. This is essential for seasonal grass based production.

6. Processing industry

One of the great advantages that Ireland enjoys is farmer control of its processing industry. It is important that farmers retain this control. In Chile, Argentina and the U.S. private industry has forced farmers into all-year-round production at farm level in order to provide them with a level supply of raw material. This reduces processing costs but the savings are not passed on to the farmer. The board members of our co-ops have large responsibilities to ensure a well run business while at the same time ensuring maximum return to the farmer share-holder. Share-holders should take note of this when electing board members. This is particularly true of co-op controlled plc's. In Western Australia a former dairy co-op that went fully plc and expanded into other businesses such as oil and fertilisers, eventually sold off its dairy business because it was not profitable enough. This company lost sight of its roots. Who is to say that this could not happen in Ireland? Can the level of growth expected by the stock exchange investor be sustained long-term?

7. Growing markets

Our politicians must ensure fair access to growing markets in the next world trade negotiations. Europe must argue strongly for greater access to South American and Asian markets because the US and Cairns Group are trying to exclude us from thriving economies and fence us into a European market which is losing its importance.

8. Liquid consumption

There will always be milk production near centres of population and demand will ensure that there is a constant supply of milk for liquid consumption. The farm price for this milk can be up to twice the price for manufacturing milk e.g. Australia. In some countries this accounts for 100% of production at various times of the year. Also near centres of population, there are often by-products of other food industries which provide feed for dairy cows at low cost.

9. World market

Only 6% of total world production is traded across international borders. Of the countries that are trading on that market only two are dependent on exporting over 80% of their production: Ireland 80%; New Zealand 80%; Denmark 50%; Holland 40%; Australia 45%; Argentina 8%; U.S. 2-3%. These figures are important because of the stability a large home market gives to producer prices particularly if a large percentage of production is in liquid milk. Because of this factor, Irish and New Zealand prices are the most likely to fluctuate if there was an open market. Ireland has more access to the European market which should give some cushion but we have seen in the past that this might be of little use when the pressure intensifies, as was the case in the BSE disaster. To move into fresh products, there must be a large home market to fall back on when surpluses arise. There may be niches for some fresh products but they will only require a small volume of milk and this can be supplied on contract as Baileys is at present.

10. Infrastructure

All countries have a higher herd size than Ireland and a lower number of herds relative to their milk production: U.S. 80 cows, Victoria 142 cows, New Zealand 200 cows, Chile 80 cows, Argentina 95 cows, Denmark 50 cows, Ireland 32 cows. When we joined the EEC in 1973, Ireland and Denmark both had about 74,000 dairy farmers. Denmark has a milk quota the same size as Ireland. It presently has 12,000 dairy farmers with an average of 50 cows each. The Danes are restructuring their industry in order to be ready when quotas go. They have already decided that they require 5,000 farmers with 100 cows each by 2005.

Milk quota management policy in Ireland has clearly been much less aggressive and has sought to give smaller producers a chance. Now that the Santer proposals are on the table, it is likely though not certain that the quota regime will be retained until 2006. It is, however, clear that sooner or later it will be abolished and dairy farmers will have to contend with world milk prices. It is vital that we use the transition period to prepare for a more competitive production environment. We will have fewer dairy farmers in years to come.

Commins and Frawley (1995) predicted that there will be 79,000 farmers in Ireland in 2005. If present trends continue, only 16,000 of these will be dairy farmers with an average of about 50 cows each.

Efficient small dairy farmers must be given an opportunity to increase their scale. It is my view that, in a world price environment, a specialist dairy farmer will need at least 60-80 cows to earn the same margin as he does now with 30 cows within the present milk quota regime. Less efficient small dairy farmers must be given opportunities to boost their farm income with alternative farm enterprises and/or off-farm employment.

Reference:

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Milk Quota Policies

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Why quotas?

Throughout the late 1970s and early 1980s the Community grappled with the budgetary and market problems created by rising milk production. Prudent or frozen prices, producer levies and non marketing schemes had failed to deal with the problem. The result was that the Community's self sufficiency ratio in milk which was only marginally over 100% when we joined in 1973 was about 123% ten years later. Despite an active export policy, increasing production was by that time pushing butter intervention stocks towards 1.5 m tonnes and skim powder stocks towards 1 m tonnes. Even with massive subsidisation - FEOGA expenditure in the milk sector rose from 1.6 to 4.4 b ECU in the 1973-83 period - there were no sustainable market outlets for such stocks. Indeed the Community was eventually forced to subsidise both butter fat and skim powder in the manufacture of calf milk replacer - such an inherently illogical subsidy might be accepted as a short term emergency measure, it could not be justified as part of any longer term stock disposal programme.

In those circumstances the Community was forced to take action. There were only two choices:

— a very sharp price reduction, or

— tight supply control.

The prevailing wisdom was that the price cut would need to be of up to 25% to offer a reasonable prospect of solving the problem and, even then, could not be guaranteed to do so in the short to medium term at least. Member States, led by Germany in particular, recoiled from the price cut prospect and in 1984 opted for quotas, warts and all.

And there were warts - production rigidities, disincentives to innovation and development, loss of export markets and vast bureaucracy. But, within the limited objectives set for them, quotas - admittedly having been subsequently adjusted by 8.5% because of setting them too high in the first place - have been successful. Expenditure in the milk sector which was about 35% of total FEOGA Guarantee expenditure on the introduction of quotas, is now less than 10% of total expenditure. EU self sufficiency is well under 110% and milk prices for producers have remained relatively high. Irish prices in real terms have on average remained at their 1983 levels.

Current position

Quotas were initially set generally at 1981 output levels plus 1%. For most Member States that represented sharp cuts in production compared to 1983 levels. There were some exceptions, most notably Ireland, which was given a quota equal to 1983 plus 4.6% - about 23% above 1981 delivery levels. Quotas have been adjusted on a number of occasions since 1984 - on balance substantially downwards but with some upward movement also which was generally small but, in Ireland's case, reasonably substantial as a result of the Mulder adjustments. The current Irish quota is almost 3.5% below the quota level set in 1984 but about 1% above 1993 delivery levels. By contrast the current quotas in the other main milk producing member States are between 10% and 15% below 1983 delivery levels.

That is where we now are. The questions are where do we wish to go and where are we likely to go. The answer to the latter question is influenced by economic factors but even more so by political considerations - national, European and international, in the guise of the WTO. The considerations influencing the answer to the former are no less political but of a more national flavour. The current position is that the quota regime is in place up to the end of 1999. Without a decision in the Council to continue it, it lapses at that time. A decision to extend the regime requires a Commission proposal and a qualified majority in the Council - 62 votes out of 87. As of now, there are at least 5 member States, representing 35 votes, who do not favour continuation of the system in its present form. Thus, extension of the regime requires a proposal for a regime sufficiently changed to be acceptable to at least some of those member States or one which is part of a package which is, in overall terms, acceptable to them. That, to a considerable extent, explains both why the new quota proposal is placed within the Agenda 2000 package and the nature of the proposal itself.

Agenda 2000

Agenda 2000, in its milk section, proposes:

- a 15% cut in support prices;
- premium payments in part compensation, and
- maintenance of the quota regime to 2006, with a 2% increase in quotas - 1% for all member States for distribution with priority to young farmers and 1% for distribution to farmers in mountain regions.

The method of distribution proposed would result in increased quota allocations of:

1% for Belgium, Denmark, Ireland, Luxembourg, the Netherlands and the UK;
1.3% for Germany;
2.3% for France and Sweden;
2.9% for Greece and Portugal;
3% for Italy;
4% for Spain; 7.8% for Austria, and
8.4% for Finland.

In addition Austria and Finland would have further increases in quota of 7.8% and 8.4% made available to them to meet claims from SLOM producers.

Introducing some flexibility to the regime, especially to meet the needs of new entrants and certain regions, is necessary in itself and, in particular, to sway some of the member States at present opposed to the extension of the regime. Therefore, it was inevitable that there would be a proposal which involved some additional quota and a method of distribution of the extra quota based on objective criteria which would have the incidental effect of skewing the allocation towards sensitive member States. Inevitably also, there would be a cautious approach to deciding on the amount of the extra quota to be proposed in order not to risk destabilising the market.

Even seen in that context, however, the present proposal is seriously flawed because:

- it is overcautious in regard to the amount of extra quota to be provided;
- the disparity between the treatment of the individual member States is grossly excessive;
- two of the member States whose views on the extension of the system may need to be changed are in the lowest increase category;
- a number of member States whose support would normally be expected will feel themselves hard done by;
- the Mediterranean bloc may still not be satisfied with the additional quantities proposed, and
- the economic rationale of the proposal is, to say the least, questionable.

It is impossible to see the proposal adopted as it stands. But neither is it likely that what has been offered can be significantly withdrawn. Therefore, almost certainly the solution will be an increase in the overall additional quota in order to provide for a certain degree of equality of distribution among member States who would then be given greater flexibility in the subsequent national distribution.

There is, however, a limit on the extra quota which may be made available and it is not just the limit of what the market will bear. There is a clear WTO constraint also. The Uruquay Round agreement required the EU to reduce overall support levels by 20% compared to the 1986-88 base. But it also required that support levels in any individual sector could not exceed the levels which applied in 1992. Thus, an increase in quota levels, offset in terms of measuring support by a cut in price, would not break that provision. Indeed, roughly speaking, each 1% price cut would allow a 2% increase in quota. Complication arises, however, where the price cut is, as is now proposed, being at least partially offset by direct payments. Such payment must be taken into account in calculating support levels for this provision. The current Commission proposal would not, in my view, bring support levels above the 1992 levels. Indeed, there would be scope for a further 4% or so quota increase and still remain within the 1992 support levels, if the other elements of the Commission proposal remained in place. But any significant improvement in the compensation element of the proposal would eliminate the possibility of further - or, depending on the extent of the improvement, any - quota increase. There is also, of course, the question of how much extra production the market could easily absorb. Recent work done here would suggest that, with a reduction of 15% in EU price levels, a gradual 4% increase in quota would not destabilise the market. In my view this would, as already explained, be comfortably compatible with the WTO commitment.

Next WTO Round

This is on the reasonable assumption that the provision, or a somewhat similar updated one, will be carried into the next Round. Indeed consideration of this issue in that context underlines one every important fact - developments in the WTO will have a major impact on the practicality if the EU maintaining the quota regime into the longer term.

We will begin negotiating a new Round next year. There are two general points about that negotiation which are worth noting:

- It will not take the same protracted length of time as did the last one. Issues of principle were settled in the Uruquay Round, as were implementation mechanisms such as the support measurement system and the tariffication procedure. They will not have to be settled again.
- It will maintain the liberalisation of the last Round.

That means that we could see the outcome of the WTO agreement being applied as from the end of the current period and that the tariff reduction process would continue at, at least, the same pace in the 2001-2006 period as it did in the 1995-2001 years.

The new buying in prices which would emerge from the Santer proposals are equivalent to about 117p per gallon gross. If - and this is the least we could expect - tariff reduction in the new WTO round takes place at the same rate (6% a year) as generally applied in the Uruquay Round, then, in milk equivalent terms, the tariff at the end of the round would be about 42p per gallon gross. Assuming that world prices do not fall, that would leave the landed price of milk products in Europe up to 20% above the buying in prices. Thus EU milk prices would still be adequately protected and so, seen in that context, the continuation of quotas can be justified.

Some factors could, however, emerge which would upset that relatively benign scenario. Firstly, tariff reductions might be greater (e.g. based on the original, rather than the bound rates) although this is, in my view, unlikely. Secondly, world prices might fall as the EU and others increase milk production. On balance, however, it would seem that there is likely to be a sufficient margin to give adequate protection even if international prices fall.

The process of tariff reduction is likely, however, to be relentless and to continue beyond the next Round. If so, before the end of the decade, the tariff would not be sufficient to protect the EU price (indeed, if EU prices were not to be reduced by the Santer 15%, that situation would arise by the end of the next Round). That would happen first in regard to butter but would eventually apply to the other dairy products as well. At that stage the case for maintaining quotas would not be sustainable.

Effect of enlargement

The enlargement process will reinforce the economic pressure for quota dismantlement. Nobody will want to see quotas introduced in the new member States. The administrative complexity of introducing, and enforcing, quotas in those countries is daunting. Even the basis on which to establish quotas in agricultural economies in transition from centrally planned regimes would be very difficult to decide on. But if nobody wants to introduce quotas then, neither will anyone in the existing Union wish to see quotas retained here while farmers are free to produce without restriction in the new areas.

What the future holds

These factors, together with the strong anti-quota attitude of a big minority of existing member States, makes the demise of the regime inevitable. And they may, in fact, cause quotas to be ended a little earlier than is economically strictly necessary. So, if - as I think is almost certain - quotas are to be extended for the six years up to April 2006, this is highly likely to be the last such unconditional extension. If I am right, then two questions arise:

- how will quotas be ended, and
- will farmers be compensated?

The first question involves consideration of whether quotas will be eliminated in one step or in phases. If the Council were to decide in the Santer package that quotas will definitely end in 2006, then phasing would not arise. I believe that that is unlikely and that the issue will probably be fudged in the agreement on the Santer package. In that event, the most likely scenario is a decision closer to 2006 to phase out quotas over a period of years in combination with further cuts in support prices and other changes in the support system.

Will there be compensation? I would think the answer to that is yes. The question is how will compensation be paid - for the quotas or in respect of lower milk prices? The former would be cheaper in that only those with existing quotas would benefit and thus, for instance, there would be no question of producers in the new member States having to be taken into account. It would, however, almost certainly be once off or at least time limited and digressive. Compensation for lower milk prices would be likely to be longer lasting but would in time extend to new entrants to milk production and to those in the new member States. It would, however, be in line with the premium regime being proposed in the Santer package and with recent European Court judgements which have seen quotas more as a licence to produce than a capital asset. At this stage this is a difficult one to call, but, on balance, my money would be on a compensation system related to lower milk prices.

Conclusion - What does Ireland need?

Finally, what do we want in Ireland? I suspect that the majority of existing dairy farmers would like to see the quota system maintained more or less as it is. But, for the reasons already mentioned, I do not believe that that is an option into the longer term. In any event, as the WTO constraints tighten - and limitations on subsidised exports as well as the tariffication process will put increasing pressure on prices - it is very doubtful that it is in our interests to try to maintain quotas indefinitely. In the circumstances likely to prevail, they could be maintained, if at all, only at the expense of sharp cuts in production.

At the same time a sudden abandonment of quotas would cause very substantial disruption in the sector and real hardship to very many farmers. It is, therefore, in our interests to see the quota system extended for a period but on terms which would help to ease the way towards its inevitable elimination. This involves decisions to be taken as part of the Santer package and those which might follow a few years thereafter.

In my view, our interests might best be secured by a package of measures along the following lines:

1) Extension of the quota system for a further 5 to 6 years.
2) The maximum increase in quotas which is technically possible and consistent with what the market can bear.
3) Use of the additional quota over and above what the Commission has proposed to redress the imbalance in its proposal.
4) Provision of compensation which in general is no greater than that proposed by the Commission - to increase that significantly would limit the possibilities for increased quota.
5) If there is an Irish case for improved compensation - and the continuation of the maize silage aid may provide one - then it would be better exercised in seeking to improve our envelope and use the result to deal with any anomalies thrown up by the way the general dairy premium is to be calculated.
6) Maintenance of the proposed 15% price cut - anything lower would not allow any significant exports without refund and these are necessary if market balance is to be maintained.
7) A decision on the phasing out of quotas to be taken some years in advance of the start of that process.
8) Payment of compensation to all dairy farmers, by way of a dairy cow premium or an area based premium, for the lower milk prices rather than compensation just to those holding milk quotas at the time of their elimination. This would bring greater longer term benefit to the sector and encourage a more rational development of production.
9) In the WTO agreement, change the balance in the tariff reduction process in favour of butter and against skim powder, as the butter price will come under pressure from the import price much sooner than the skim price (the balance was the other way in the Uruquay Round agreement).

I believe that represents the best way forward for us. Obviously not all will agree - particularly, perhaps, in regard to compensation and the price cut suggestions. But staying where we are is not an option. Therefore, we need to be thinking seriously about where we want to go. The quota system and the questions of how it is to be continued, modified and eventually phased out are fundamental to the milk sector and we need some fundamental thinking about the answers to these questions. I have put forward these ideas to this conference as a small contribution to the debate. I will be interested in the response.

Feeding Strategies Used by Specialised Winter Beef Finishers: Growth, Efficiency and Cost of Gain

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Introduction

Winter finishing is one of many beef production systems operated in Ireland. In this system, cattle are purchased in the autumn, grown at a high target rate during the winter months before slaughter from January onwards. Profitability in this, as in any beef enterprise, is influenced by many factors including the buying and selling price, daily liveweight gain, input costs and the availability of slaughter premia. In the Teagasc winter finishing budget shown in Table 1, "excellent" performance (i.e. margin) over production costs is obtained from a daily liveweight gain of 1.1 kg with a feed (grass silage and concentrates) cost of £1.15/day. Since the sensitivity analysis (Table 2) shows that animal performance makes a large contribution to the gross margin per hectare realised by the producer it is imperative for profitability that performance be at a maximum but at a minimum ration cost.

Based on studies at Grange Research Centre where concentrates were offered *ad libitum*, the growth potential of finishing continental steers in a non-compensatory growth situation is 1.16 to 1.25 kg/day (Moloney and O'Kiely, 1995; French *et al.*, 1997; Keane, 1995). Similar studies at University College Dublin indicated a growth potential of 1.03 kg/day for steers (O'Mara *et al.*, 1996). However, finishing continental cattle which were likely exhibiting some compensatory growth potential had growth rates of 1.42 kg/day for steers (French *et al.*, 1997) and 1.35 kg/day for heifers (Gottstein *et al.*, 1997). Growth rates, similar or greater than these are often claimed in practice. Thus, exploiting compensatory growth and/or using alternate feedstuffs such as sugar beet, fodder beet, home grown cereals or by-products may result in higher performance at a lower feed cost than indicated in the Teagasc budget (Table 1). Since animal growth is the product of intake by the energy density of the diet, such performance may reflect intakes in practice that are higher than usually seen in a research environment (18 g dry matter (DM)/kg bodyweight, approximately). The objective of the study summarised in this paper was to identify some strategies used by specialised winter finishers and to quantify the performance, intake and feed costs on these farms.

Procedure

- Ten specialised winter finishing units were chosen according to the following criteria:
  - * Winter finishing must be the major cattle enterprise

Table 1
Budget for winter (1997/1998) finishing steers (140 days): gross margin over production costs (Teagasc, 1997)

	Level of performance			
	Moderate	Good	Very good	Excellent
Silage dry matter (DM) digestibility (%)	63	68	72	74
Meal (kg/day)	4.0	4.0	4.0	4.0
Daily gain (kg)	0.8	0.95	1.05	1.1
Silage DM intake (kg/day)	7.57	7.22	7.22	7.14
Steers wintered per hectare on 2 cuts	5.55	5.65	5.65	5.71
Initial liveweight (kg)	588	567	553	546
Final liveweight (kg)	700	700	700	700
Kill-out (%)	53.5	54.0	54.5	55.0
Purchase price @ £88/100 kg	517	499	487	480
Carcass value £1.85/kg	693	699	706	712
Gross output per head (£)	176	200	219	232
Variable costs per head				
Silage(£)	83	83	86	88
Barley (£) @ £130/tonne	73	73	73	73
Dosing, transport and marketing (£)	21	24	26	26
Total (£)	177	180	185	187
Gross Margin Per Head (£)				
(excluding premia)	-1	20	34	45
Gross Margin Per Head (£)				
(including slaughter premium) @ £60.00 per head	59	80	94	105
Gross Margin Per Hectare (£)				
(excluding premia)	-6	113	192	257
Gross Margin Per Hectare (£)				
(including slaughter premium) @ £60.00 per head	328	452	531	600

Notes:
1. Steers purchased for winter finishing assumed NOT eligible for 22 month premium
2. Steers eligible for 22 month premium (Max. No. = 90 pa) could cost between £90 to £120 per head extra (i.e. approx. £20 extra per 100 kg) and margin would be maintained.
3. Slaughter premium is included in above budgets for slaughterings in Spring '98

Table 2
Sensitivity analysis*

			Gross margin (£ per hectare)
Buying price	+ or -	£2 per 100 kg liveweight	62
Selling price	+ or -	2.2 p per kg carcass weight	48
Daily liveweight gain	+ or -	0.1 kg	81
Input costs - meal	+ or -	£10 per tonne	32
- fertiliser	+ or -	£10 per tonne	12
Slaughter premium	+ or -	£60 per head	343

*Based on "excellent" performance in Table 1.

* Must be finishing cattle for the last five years
* Must have 90 plus finishing steers
* Need not be a Teagasc client
* Must be buying in the cattle to be finished

- On each farm, a group of animals was identified for this study. After the animals had adapted to the housing facilities and the diet (~ 3 weeks), they were weighed on two consecutive mornings before feeding. The animals were again weighed twice (on all but 2 of the 10 farms) at the end of the finishing period. The average of each pair of weights for each animal was used in the calculation of growth rate.
- Slaughter data were collected (where possible) for each individual animal.
- The accuracy of the feeder wagon was tested by unloading it onto a calibrated Teagasc scales and comparing the readings on the feeder wagon with the weight of material unloaded.
- Feed intake was measured by recording the amount of each ingredient offered during a 7 day period (two measurement periods on some farms) and subtracting the weight of feed not eaten during the recording period.
- Samples were taken of each individual feed on 2 or more occasions during the period of feed intake measurement. These samples were chemically analysed at Grange Research Centre.
- Feeding and husbandry practices were monitored (feeding methods and routine, feed space per animal, parasite control, etc.).

Results

The experiment was carried out between November 1997 and March 1998 (when final cattle were slaughtered). The 10 farms chosen (labelled A to J) were in counties Kildare (3), Carlow (4) and Laois (3). General procedures on each farm are summarised in Table 3. Each farm used a feeder wagon (various suppliers). The difference between the amount of feed discharged from the feeder wagon and the reading on the feeder wagon dial ranged from 0.3 to 4.0%.

Table 3
Description of winter finishing units

Item	Farm code									
	A	B	C	D	E	F	G	H	I	J
Steers	√	√	√	√	√	√	√	√	√	√
Purchased										
- locally					*				*	*
- elsewhere		*	*	*	*	*	*	*	*	*
Total number of cattle finished		210	450	600	440	350	180	350	330	450
Number of cattle used in study		76	83	89	45	47	70	75	45	27
Housing										
- slats		*	*	*	*			*		
- straw						*	*		*	*
- other										
Feeder wagon	√	√	√	√	√	√	√	√	√	√

The variation in ration composition on the 10 farms is summarised in Table 4. Grass silage was used on all farms but the level of inclusion in the ration ranged from 202 to 579 g/kg DM. In addition, the DM digestibility of the silage, and therefore its feeding value, was variable (range 680 to 780 g/kg, mean 740, coefficient of variation 5.5%). Eight of the farms used fodder beet and one farm used sugar beet. A variety of protein and energy sources were also used (Table 4). A price was assigned to the grass silage, based on its DM digestibility, using the cropcost computer program (O'Kiely et al., 1997). Costs were assigned to the other ingredients based on December prices on the Farmers Journal. Total feed costs ranged from £0.86/kg to £1.71/kg, mean £1.23/kg.

Table 4
Ration ingredients composition (g/kg dry matter).

	Farm code									
Item	A	B	C	D	E	F	G	H	I	J
Grass silage	490	299	202	393	412	209	298	519	383	420
Fodder beet	396	—	396	236	255	—	398	56	319	436
Sugar beet	—	—	—	—	—	332	—	—	—	—
Rapeseed meal	57	—	—	—	—	—	—	—	63	—
Soyabean meal	57	17	128	—	48	—	—	—	63	—
Soda wheat	—	146	156	—	—	—	—	—	172	—
Molasses	—	43	77	—	38	44	—	—	—	—
Potatoes	—	135	—	—	—	—	—	—	—	—
Barley	—	96	—	112	88	146	152	172	—	—
Maize meal	—	87	—	—	—	—	—	—	—	—
Straw	—	9	33	24	10	—	41	—	—	20
Hay	—	—	—	—	—	—	—	7	—	—
Brewers grains	—	168	—	—	—	—	—	—	—	—
Wheat	—	—	—	—	88	—	—	—	—	—
Urea	—	—	8	—	—	—	—	—	—	—
Citrus pulp	—	—	—	116	—	151	—	—	—	—
Cotton seed	—	—	—	119	—	118	—	—	—	124
Sugar beet pulp	—	—	—	—	61	—	—	—	—	—
Protein mix	—	—	—	—	—	—	112			
Super pressed pulp	—	—	—	—	—	—	—	126	—	—
Distillers grains	—	—	—	—	—	—	—	120	—	—

Measured animal performance is summarised in Table 5. There was a wide range in the weight of cattle performance on each farm, the growth rate and feed intake achieved and the cost of animal growth. These data can be compared with the Teagasc budget for a primarily grass silage-based winter finishing system described in Table 1.

As outlined in the introduction, profitability in an individual beef production system is influenced not only by technical performance, but also by buying/selling prices, negotiated prices of ingredients, etc. To examine the impact of

Table 5
Animal performance

Item	Minimum	Maximum	Mean	Coefficient of variation (%)
Initial liveweight (kg)	572	772	631	12.3
Daily gain (kg)	0.73	1.06	0.90	12.0
Carcass weight (kg)[1]	348	489	419	13.2
Kill-out (%)[1]	55.0	57.0	56.3	1.8
Dry matter (DM) intake				
(kg/day)	8.8	14.5	11.0	14.0
(g/kg liveweight)	14.8	19.2	16.7	9.0
Feed conversion efficiency				
(kg DM/kg gain)	9.5	15.1	12.6	15.4
Ration cost (£/kg DM)	8.8	11.7	9.94	8.75
Cost of gain (£/kg)	0.86	1.71	1.23	21.7

[1]Based on

variations in the measured performance on the 10 farms on margin over production costs, the following assumptions were made:

* cattle purchase price was £100/100 kg liveweight (Department of Agriculture, Food and Forestry -weekly price reporting - October 1997)
* carcass value was £1.85/kg
* ration costs were standardised as described above

Calculated gross margin/animal, excluding premia, ranged from A to B (£) mean, coefficient of variation.

Summary and Conclusions

* Of the 10 farms chosen for this study, all were specialised winter finishers located in Leinster, all used feeder wagons, all used grass silage as the basal forage and most used beet (mainly fodder beet). How representative these systems of production are of the winter feeding sector remains to be determined.
* Diverse strategies were used on the 10 farms, i.e. purchase weight of the cattle, finishing period, ration composition, housing, etc.
* Considerable variation in feed intake and animal growth was observed between farms. Average animal performance on individual farms was not better than would be typically recorded in a research environment.
* There is scope on many of the farms to improve technical performance.
* Profitability on an individual farm varied considerably.

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Dairy Feeding Systems for Quality and Profit - Meeting Market Requirements

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Introduction

The return from finishing cattle in Ireland and in particular winter finishing, as a consequence of the B.S.E. crisis and changes in E.U. market supports has, as we all know, reached an all time low. This price crash occurred in the other major European beef producing and importing countries as well. However as a result of a policy of "nationalisation" within these European markets, beef prices have been restored to near pre-B.S.E. levels. Unfortunately this is not the case with Irish beef prices. The further decline in buying power of third country markets and the virtual closure of the Russian market, leave the Irish Beef Industry at a major cross roads. One option is to continue to depend on live shipping of cattle or to erratically produce commodity type beef for third country markets.

The other option is to focus on high value markets on the continent. We need to set about replicating some of the continental production systems, as we have a limited number of cattle currently suitable to meet these continental market requirements. We have to look at our breeding policy and clearly focus on producing the correct specification cattle for these markets. The current production system of finishing top quality continental cross animals at 3 years plus, which are not suitable for any of the premium priced markets in Europe, cannot continue.

The need to breed for and correctly feed the required type of cattle to meet the strict market requirements in these deficit European markets is essential for the survival of the Irish Beef Industry. The continued production of the "traditional" heavy steer/heifer, in particular, over the winter period is grossly inefficient. Feed intakes rarely reach the levels that give a consistent liveweight gain, thus failing to produce carcase gains that give an economic return on feeding cost. Generally the margins obtained from these cattle are only the slaughter premium.

Irish beef farmers must set in place a strategy to supply the correct specification animals which are produced in a profitable production system. The essential elements of this system are that it will promote the most efficient use of feeds, will control costs, particularly those of variable cost inputs such as feed, and will make the most efficient use of the potential of beef cattle across all breeds.

The specification of the cattle required (finished weight, carcase conformation and fat colour) cannot be met from an extensive grazing production system alone. There is a need to supplement with quality energy and protein feeds. This requirement can be met from the use of quality farm-grown feeds, that for the most part can be produced in Ireland, for example, cereals, root crops, oilseeds and pulses.

An essential requirement in producing cattle for such European markets is that the farmer is not alone. The system needs to be operated in partnership with export licensed meat processing plants which market the beef produced. This in turn will lead to a situation where regular supply contracts can be set up between the farmer and the processor for a market led production system.

The Keenan System

The Keenan Total Mixed Ration System is based on the simple principals of feeding a nutritionally balanced ration (i.e. for energy, protein, both quickly and slowly degradable, fibre, minerals and vitamins) which is available to the cattle on a 24 hour basis. This ration must be mixed and presented to the cattle in a form that encourages intake and maintains the ration structure (ration structure being an essential element in promoting rumen health and general animal health and performance).

This system when correctly implemented on farm will result in the following:-

1) Healthy and contented animals
2) Consistent steady intake
3) Good liveweight gains
4) Reduced days on feed
5) Very good feed efficiency
6) Better carcase kill-out
7) Possibility to manipulate carcase characteristics
8) More profitable production - lower cost

Richard Keenan & Co. have, over the years with the help of our large customer base both in Ireland and around the world, endeavoured to develop more profitable beef production systems. These production systems have always had to take into account the following:-

1. Type of cattle being finished - potential for intake and weight gain
2. Feeds available
3. Quality of forages available
4. Relative value of purchased feeds
5. Market outlets for beef

1. Type of cattle being finished - Intake and liveweight gain potential

There are large differences in terms of liveweight gain, feed conversion efficiency and suitability for certain markets between the various breeds of cattle available to the farmer. For example, when feeding Holstein steers the aim should be to meet their appetite requirements by feeding a lower overall energy in the ration. High forage inclusion in the ration is the assured way of meeting their requirements. Continental cross cattle with a great potential for liveweight gain and carcase gain should be fed high energy rations achieving high intakes to reach their full genetic potential. See Appendix 1 for Keenan Beef Ration Specification

2. Feeds available

Winter feed planning and budgeting are an essential part of a winter finishing programme. The types of feeds to be purchased should be examined in terms of:-

1. Consistency of supply
2. Quality/native cereals essential
3. Price
4. Storage facilities and storage requirements

3. Quality of forages available

Quality forages, when included in a T.M.R., have a substantial effect on lowering the cost of the overall ration and in the performance of the cattle being fed. A 60:40 ration of forage to concentrates on an ad lib basis is probably in most cases the most cost effective. The inclusion of a second forage always has a beneficial effect on the ration. Generally, if the following forages are used intakes will increase and also performance;

1. Fodder/sugarbeet
2. Potatoes
3. Maize silage
4. Whole crop
5. Brewers grains

4. Relative value of purchased feeds

Relative values of feeds must be reviewed before any feeding programme can be implemented. Relative protein and energy values need to be examined, in order to fully evaluate a feed being considered. See Appendix 2 for relative feed values.

5. Market outlets for beef

There is a requirement in the market place for younger leaner cattle which can be supplied on a consistent basis. The winter feeding programmes developed by Keenan are an essential part of an overall production blueprint which needs to be implemented in order to meet the specifications for high value export markets that before now have not been met by Irish cattle.

The feeders and producers of cattle for these markets need to:-

1. Have a planned focused breeding policy
2. Proper weanling management
3. Improve grazing management
4. Produce quality forages
5. Feed to maximise cattle potential
6. Feed quality ingredients

Beef production - The Future

Sustaining a rewarding margin in winter beef production in recent years has been difficult. Present market outlets particularly to third countries are in turmoil. The continued high prices being paid in marts for quality finished stores and weanlings leaves the specialist winter finisher with the difficulty of how to return a margin from his enterprise.

Based on the Australian model of "partnership and alliances", whereby co-operation between all strands of the industry results in reduction of waste and the production of cattle to a tight specification to meet high value market requirements, Keenan and Kepak have recently launched the Keenan-Kepak Beef Club.

The advantage of this production scheme for the Keenan customer are;

1. Keenan co-ordinated efficient production system
2. Assured all year round market for quality fed stock
3. Guaranteed premium price

Keenan-Kepak Beef Alliance

The purpose of the club is that Keenan Beef Customers, through a tightly co-ordinated supply group, will supply young bulls and heifers to the Mediterranean market on a fifty two week of the year basis. The club can be summarised as follows:

1. Keenan customers exclusively supplying young bulls and heifers all year round to Kepak
2. Beef sold into high value continental niche markets
3. Feeding regime, controlled by Keenan Nutrition is based on quality feeds.
4. Keenan co-ordinate the production and supply of stock
5. Detailed analysis of slaughter information centralised by Keenan to further enhance the production system.

Using commonly available forages and cereals produced on farm and selected protein balancers both steers and heifers will be finished to ensure a white fat colour. It is also necessary to have an even cover of fat over the carcase, 4L and 4H is ideal. The colour of the meat also is very specific - a light pink colour. When all these characteristics are met then the conformation of the animal needs to be of a high order to meet the required specification. The animals are sold into the Mediterranean market as full carcasses, so poor conformation or fat cover cannot be hidden. The appropriate breeding, feeding and management system is essential to ensure the orderly production of these high value cattle. The age restriction on both heifers and bulls of 16 months when slaughtered will easily be met if the Keenan production blueprint is followed. The Keenan Blueprint comprises the following areas.

1. Breeding

A structured policy whereby proper half to three-quarter breed continental cross animals are produced using the top A.I. or stock bulls available. The possible splitting of the herd between autumn and spring calving will: (a) reduce the work load during busy calving periods and, (b) spread the age profile of cattle to allow flexibility when selling.

Cattle that are purchased for this market must be from sources which ensure finishing to the proper specification.

2. Management

A steady growth pattern is essential so as to avoid a store period in these cattle (see Appendix 3 for possible systems of production).

3. Feed

Grassland management and forage production must to be of the highest stardards in order to:

1. Maximise animal growth potential
2. Reduce costs
3. Enhance carcase characteristics

Young bulls post-weaning require a planned growth phase particularly if they are housed. The use of straw and high quality proteins to supplement available forages will ensure that when the finishing phase of the production is implemented the cattle will:

1. Have sufficient frame to carry the overall carcase weight required within the age restriction.
2. Be able to respond to the high starch and high sugar ration that will ensure the colour of the meat and fat cover.

Conclusion

Opportunities for the beef farmer are:

1. Availability of cheaper feeds.
2. Cattle finished at younger ages
3. Cattle produced to meet specific market requirements
4. Development of meaningful partnerships and alliances
5. Closer farmer to farmer co-operation in cattle supply and feed supply.

The above opportunities have all been addressed by the Keenan Company. We have a large base of customers who are closely following Keenan Nutrition guidelines in conjunction with using a Keenan Feeder, and are producing cattle to meet market requirements. These Keenan customers are seeing improved margins from their beef enterprises.

Appendix 1. Keenan Beef Ration Specifications

Controlled Growth	Maximum Gain
30 - 55% Dry Matter	30 - 45% Dry Matter
15% Crude Protein	14% Crude Protein
ME 10 MJ/Kg DM	ME 12 MJ/Kg DM
3% Fat	5% Fat
15% Starch and Sugar	30 - 40% Starch and Sugar

Appendix 2. Table 1 Relative Value of Feeds

Feed	Cost/Tonne DM	Energy cost
Silage (£20/tonne)	100	10.5
Concentrate (£150/tonne)	171	14.5
Caustic Wheat	96	7.4
Rolled Barley	98	7.6
Beet Pulp	102	8.1
Brewers Grains (£20/tonne)	88	7.6
Pressed Pulp (£20/tonne)	90	7.8
Fodder Beet (£18/tonne)	90	7.3
Straw	35-45	5.7-7.0

Appendix 3. Keenan-Kepak Recommended Production systems

Young Heifers

System	A	B	C
System description	Autumn purchased strong weanlings finished following spring	Autumn purchased light weanlings finished following autumn	Spring purchased lightweight stores finished during the summer
Purchased weight (kg)	300-340	240	350-370
Days to finish	110-140	380	70-100
Liveweight gain (kg)	170	250	130
Finish weight (kg)	490	490	490

Young Bulls

System	A	B	C
System description	Autumn purchased strong weanlings finished following spring	Autumn purchased light weanlings finished following autumn	Spring purchased lightweight stores finished during the summer
Purchased weight (kg)	340	290	280
Days to finish	185	420	300
Liveweight gain (kg)	290	400	340
Finish weight (kg)	630	690	620

The Role of Husbandry in the Prevention of Lameness in Sheep

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The important causes of lameness in sheep and the role of husbandry in the control of lameness are discussed in this paper. Footrot is the most economically significant cause of lameness in Irish sheep and particular discussion will be devoted to that disease.

Footrot

Risk factors

Good husbandry of sheep is synonymous with good welfare. Footrot is a common, infectious condition which has long been associated with the welfare of sheep. Over 50% of lowland lambs can be lame with footrot if the weather and pasture conditions are suitable. Breed susceptibility is a well-known feature and Down breeds, in particular the Suffolk, are more susceptible than crossbred sheep. Most hill breeds are less susceptible while the Merino breed is notoriously susceptible. The prevalence of footrot in hill sheep is generally low. Footrot prevalence varies with rainfall and temperature and also on the concentration of sheeps' feet on pasture (stocking density). Prevalence is highest in warm, wet weather when there are many ewes and lambs together i.e. lowland flocks in the spring and autumn. Sheep with footrot suffer chronic pain, they have reduced liveweight gain (equivalent to a loss of 0.5kg/week in the fattening lamb) and reduced wool growth. Importantly, ewes with footrot in late pregnancy are more likely to develop twin lamb disease. Despite the availability of a number of treatments, footrot remains a significant problem and it also represents a significant animal welfare issue. Welfare issues are prominent in the public domain and the day may soon arrive when marketability of lamb or the application of headage payments may partially depend on appropriate attention to prevention of lameness on sheep farms

The causative organisms

Footrot is caused by the dual infection of *Fusobacterium necrophorum* and *Dichelobacter nodosus*. *Fusobacterium* is found in the environment, has many hosts and represents an ever-present risk. Ten different strains of *Dichelobacter* have been recognised and individual flocks are usually affected by two or more of these serotypes. Carrier sheep acting as reservoirs of infection are the most significant means of transmission. These carrier sheep are often recovered cases or sheep with low grade chronic foot rot. *Dichelobacter* is confined to the feet and can survive for only short periods (up to 2 weeks) on the ground. It can also be carried by cattle, deer and possibly horses. Both bacteria require warmth and moisture, both are anaerobic i.e. they thrive in tissue unexposed to the air, and both are sensitive to chemicals.

The disease

Two clinical forms of footrot have been described. These are virulent or "classical" footrot and benign or non-progressive footrot. Virulent footrot begins between the cleats with the production of red, foul-smelling material and leads to separation of the horn from heel to toe. This results in severe lameness, loss in thrive and the characteristic "praying posture". In benign footrot there is slight heel separation only.

The theory of control of footrot

The principles of control of foot rot are based on factors associated with the bacteria, host factors associated with the sheep and factors associated with the environment.

1. Bacterial factors. Control is based on reducing the level of bacterial challenge by foot-paring, footbaths, antibiotics, vaccination, segregation and culling. The use of clean pasture/premises (*Helicobacter* survives a maximum of 2 weeks outside host) is a very important principle in this context.

2. **Host factors.** Emphasis is placed on increasing flock resistance by vaccination, selective breeding.

3. **Environmental factors.** Provision of adequate dry, bedding at housing is important. Land drainage may need consideration. Housed sheep are at risk if the bedding is not kept clean and dry. Sheep outdoors are at risk during warm, moist weather when footrot and scald are readily transmitted through the flock.

Prevention of footrot

The methods available for prevention and treatment of footrot include footparing, footbathing with 3% formalin, or 10% zinc sulphate, antibiotic therapy and vaccination.

Footparing

Reluctance to handle and pare pregnant, housed ewes is associated with a fear that the handling may precipitate abortion. However, pregnant ewes can be examined and treated successfully by, either, lifting the leg with the ewe restrained standing against a wall, or carefully putting the ewe on her side using the "neck flexed back on flank" technique to examine the foot. For sheep at other times of the year, the use of a cradle which enables the sheep to be turned and dealt with without bending is a great benefit.

A good pair of foot-clippers and a sharp penknife are all that are required. The foot and claw should be cleaned of any mud or manure, and any obviously loose horn trimmed away. Sheep may also be walked through a water bath. Trimming should be radical to remove all loose and dead horn but should not be excessive. In particular, care must be taken not to cut too deeply near the toe. Trimming too hard back leading to excessive bleeding at the toe is a common fault and may lead to the development of "toe fibroma" which never heal without radical treatment. Paring should be sufficient to tidy up the foot to allow air access to the deeper tissues (N.B. the bacteria are anaerobic) and allow penetration of footbath chemicals.

Footbaths

Footbathing is a traditional method for treatment and control of footrot. When carried out effectively it is a very valuable technique. The traditional footbaths used are Formalin 3%, Zinc sulphate 10%, (Stand-in time 2-10 minutes). The use of footbaths should be preceded by paring and followed by drying on hard surface for one hour. The penetration of Zinc sulphate may be enhanced by using a penetrating agent such as sodium lauryl sulphate. This requires a long stand-in time (30-60 minutes) for full benefit so a large foot bath is required for many sheep. This penetrating agent also prevents blood clotting so bleeding should be minimal when paring. Foaming may prevent the sheep from entering the bath.

Antibiotics

The judicious use of antibiotics topically (aerosol) and parenterally (by intramuscular injection) has an important role in the treatment of acute cases of footrot in the context of an overall control programme.

Vaccines

There are 10 different strains of helicobacter. The vaccine can be used in face of outbreak. Avoid vaccinating ewes between 4 weeks prior and 4 weeks after lambing. Lambs can be vaccinated at 4 weeks of age. There may be severe local reactions at the site of injection and duration of immunity is relatively short-lived at approximately 12 weeks.

Why does footrot continue to be such a problem?

The primary reasons for failure of prevention programmes may include haphazard attempts at control in association with inefficient paring, inadequate footbathing and/or antibiotic therapy.

Timing of treatment is important

Australian research has illustrated that any treatment is less effective if it is applied when the disease is actively spreading through the flock. It is important therefore to treat at time of the year when the disease is not active and ideally to target the treatment prior to an expected period of disease transmission. Treatment is less effective if applied during the period of disease spread. Using this information, a "Blitz Tactical Treatment" regime has been studied at the Moredun Research Centre in Scotland. Treatment was applied prior to an identified period of risk, in this case, at housing before lambing. All sheep were footbathed for two minutes in 10% zinc sulphate. All sheep with affected feet were pared and received an intramuscular injection of combined penicillin-streptomycin. A second treatment group received the same treatments plus footrot vaccination. A further group of untreated animal was monitored as controls.

A treatment programme based on this Moredun trial with blitz treatment once or twice a year should reduce the prevalence of the infection within the flock to a level at which disease spread does not occur, even at times favorable for transmission. This type of programme would greatly reduce the time and money spent continually treating individually affected sheep during outbreaks of footrot, provide a more efficient use of resources and improve both the welfare and productivity of the animal itself.

Eradication of footrot. Is it a feasible option?

Vast areas of New South Wales in Australia are now footrot free. Eradication requires time, commitment and complete dedication. It may not be feasible for many farmers. An eradication programme should begin when the disease is not actively spreading. All feet need to be examined. Those sheep that are normal are designated to a 'clean' main flock. Those with footrot are designated to a "hospital" flock. The sheep in the clean flock are separated from the hospital flock, footbathed and moved to clean grazing (a pasture that has not carried sheep seven days).

The sheep in the hospital group have their feet pared, are treated with antibiotics and footbathed or treated topically with oxytetracycline spray. These sheep are then moved to a separate clean pasture. They are re-examined 5 days later, retreated where necessary and re-footbathed before being removed to another clean paddock. At 10 days the main clean flock is gathered re-footbathed, any infected sheep transferred to the hospital flock and the remainder of the flock then moved to a further clean grazing.

At this time the hospital group is re-gathered and inspected and any cured and sound sheep are transferred to the main flock. The remainder are re-footbathed and returned to either the same pasture or preferably clean pasture. Ten days later, the clean group are re-inspected and re-footbathed. The hospital group is examined and all sound sheep are added to the clean flock. The remaining sheep which have not recovered or still show lesions are culled. Culling of chronically infected sheep is the key to the eradication of footrot.

Vaccination can be assisted in an eradication programme, all sheep being vaccinated at the time of the first gather. Such vaccination will often shorten the time required to cure the hospital flock and on occasions if a severe culling policy is to be adopted the whole operation can be finalised in 154 days.

Recent reports of "severe footrot" in sheep

The year 1997 was a particularly bad year for foot rot, particularly in the period August to September. The meteorological conditions for those months in 1997, warm, wet weather were ideal for the spread of footrot. Two bacteria (*F. necrophorum and spirochaetes*) associated with severe footrot in cattle "superfoul" were isolated from sheep in these severe virulent cases. The affected sheep were from farms where cattle and sheep were held together and where there was a history of Mortellaro in the cattle. Few of the flock were vaccinated.

Foot scald

Foot scald is a superficial inflammation of the skin between the cleats and is caused by *Fusobacterium necrophorum*. Scald sometimes occurs as an outbreak in young lambs grazing on wet, warm or sometimes icy pasture causing substantial lameness. It can also be a significant problem in housed sheep. It can be controlled using footbathing and or the topical use of antibiotics; paring and vaccination have no role to play in the prevention of foot scald.

White line disease

Separation of horn from sensitive laminae. The white line becomes impacted with dirt particularly towards the toe. Responds well to paring.

Foot abscess

Usually affects only one foot. A severe lameness which is associated with penetration of the foot by a foreign body. The joint inside the claw becomes infected. Pus fistulates out above the coronary band. This may be a problem on stubble fields and may require culling or surgical amputation.

Joint ill in lambs

Joint ill is an infectious arthritis. In young lambs infection usually gains entry via the navel. In tick areas, concurrent tick-bome infections predispose lambs to this disease. Joint ill in younger lambs is caused by E. coli and erysipelas infection. Control depends on hygiene in the lambing area and navel treatment with tincture of iodine. The incorporation of the erysipelas vaccine may be worthwhile in flocks where the significance of that disease has been established. However, severe problems have occurred in flocks where hygiene is excellent and other organisms other than the ones mentioned e.g. *Streptococci* may be involved in those cases. Erysipelas generally affects lambs greater than 2 months of age. It is associated with docking and castration and may be a problem where pig slurry has been spread on pasture.

Post-dipping lameness

Caused by eryspipelas and associated with use of Organophosphate dips. The older phenolic dips were bacteriostatic. A sudden outbreak of severe lameness may occur 2-5 days after dipping. Up to 80% of the flock may be affected. It mainly affects the forelegs, the feet may be hot and the skin above coronary band swollen. Control is based on reducing soil contamination of the dipper and the use of dip bacteriostats such as zinc sulphate at 1:1000. Vaccination may be an option in flocks where it is a particularly severe problem

Vitamin E/Se deficiency myopathy

Risk factors include selenium deficient pastures, Vitamin E deficient diets such as weathered hays, moist or preserved grains, root crops. Lameness may be seen in older lambs (3-6 months) and there may be also be ill thrift, with generalised stiffness, trembling and exercise intolerance. Treatment is based upon the use of injectable Se-vitamin E preparations. Ewes can be treated in late pregnancy and neonatal lambs can be treated with the injections repeated at three months of age.

Osteochondrosis

This is a degenerative change in articular and growth plate cartilage and is associated with rapid growth, particularly in pedigree ram lambs, at 5-8 months. There is no consistent evidence of genetic heritabilty. Dietary factors such as high calcium diet to ewes may also have a role. Intermittent chronic lameness involving the shoulder, elbow and hock joints is produced. There is little or no heat or swelling of the joints.

Putting Profit Back Into Sheep Farming

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A severe downturn in the financial viability of UK sheep farming occurred in 1998. Contributing factors include a 30% reduction in lamb and hogget values from a year ago. Finished lamb prices fell during the third quarter of 1997 and again in the third quarter of 1998. Breeding ewe values have also fallen in the UK by up to 50% of the previous year's value and cull ewes are down £15 per head, a similar percentage reduction.

Other changes in the economic background include increases over the year in labour costs of around 7% but a fall in cereal prices to around £70 per tonne (11% reduction on the year). However, currently there are high prices for forage and straw and the unit cost of energy is currently lower in concentrates than in forage which is an exceptional circumstance.

While some of these fluctuations in prices may be short term, in the medium term the outlook is for continuing pressure on profitability owing to a strong currency, increased competition through the reduction in tariff barriers owing to the GATT agreements and in particular competition from New Zealand chilled lamb which is directly competing with fresh home produced hogget during January to June. Lamb is currently positioned in the market in the luxury sector along with the better cuts of beef. However, over the long term, reductions in beef prices resulting from low cereal prices and the cessation of slaughtering of bull calves under the BSE compensation scheme will occur.

There is therefore an urgent need to address the relevant technical issues for reducing the costs of lamb production. This paper draws on experience of New Zealand farming techniques seen as a result of a Stapledon Fellowship.

Are we using the right breeds and genetic improvement techniques?

UK sheep breeding has concentrated on carcase traits. However, in NZ farmers can also select on EBVs for wool production and resistance to worms. With wool prices depressed there is little interest currently in improving quality or yield but resistance to parasites and 'easy care' attributes are of interest. In New Zealand research workers (McEwan *et al.*, 1997; Morris *et al.*, 1998) have concentrated on achieving a low flock faecal worm egg count. Their research programme started with an estimation of the heritability of this trait (0.23) and its correlation with production traits. Unfortunately, challenged lambs with a low egg count tend to be more daggy and have lower fleece weight. There followed development of an overall production and disease resistance index with its application to the industry. In addition a blood test based on nematode antibodies (marketed by AgVax as the Blood Antibody Host Resistance Test) has been developed. Despite the negative correlations over 50 farmers are actively using the selection indices in New Zealand.

Results have been favourable. Those farmers operating the selection process for the longest (10 years) demonstrated significant reductions in worm egg output from ewes and lambs with improved wool production and higher growth rates. Genetic links are made by rotating rams between farms. Currently 30 flocks are involved in 3 separate sire referencing schemes, as well as some 20 unlinked flocks. In 1997 more than 7000 two tooth and older rams retained for sale or use within the reference flocks were ranked on the index in these three schemes. BLUP repeated trait animal model analysis is used to remove environmental effects between farms, years and sexes. No evidence for problems of genotype x environment interactions has been reported.

The benefits to production mainly come from reduced levels of pasture contamination and challenge owing to lower faecal egg output. Around 10% of recorded sires were sold in 1995 with information on their resistance to worms, seen as valuable to commercial farmers buying rams. The high uptake of the work which was carried out at AgResearch, Invermay has been due to the close contact between researchers and farmers in the development of the selection programme.

Work is ongoing in NZ to identify markers for the genes responsible for parasite resistance (Crawford *et al.*, 1997). Major genes are also known to operate in UK breeds, e.g. the Blackface, conferring resistance to worms (Schwaiger *et al.*, 1998). Thus it may not be necessary to import sheep to gain the genetic benefits in the future.

Many New Zealand farmers have practiced rigorous culling to eliminate problems such as lambing difficulty, mismothering and metabolic disorders with rapid reductions in the incidence of these time-consuming problems. Farmers also practice lambing methods that respect natural sheep behaviour, minimising disturbance and achieving better bonding between ewes and lambs, resulting in less mismothering (Geenty, 1997). This has allowed an increase in the typical number of sheep per farm from 2,200 in 1981 to 3,300 in 1998 without compromising health/welfare.

Can we make more use of grassland?

Should the sheep industry adapt New Zealand inspired extended grazing seasons, feed wedges and control systems based on DM/ha as leading farmers in the dairy industry have? In practice, few NZ sheep farmers use DM/ha for management decisions. Most rely on sward height for day to day decisions about moving stock and pasture control. Estimates of DM/ha are mainly used in all grass wintering systems typically involving 100 paddocks and daily shifts. These are operated from the post-mating period to late pregnancy to ration grass and build up pasture cover, often involving groups of over 1,000 ewes (Geenty, 1994). Scaling this down to our flock sizes would increase fencing costs. Questions arise about the ability of our soil types to withstand such stocking pressures and in wet weather welfare could be compromised.

One element of this system that has immediate application is the use of grass to provide late pregnancy nutrition. This has already been incorporated into May lambing systems (Vipond and Mitchell, 1996). May lambing systems have effectively cut feed costs in recent years but cheaper concentrates and lower finished prices for lambs have reduced their attractiveness and those practising May lambing currently justify it on reduced fixed costs (mainly labour). Current New Zealand technologies worth exploring in pasture based systems include seedhead and weed suppression in pastures using ultra-low glyphosate treatment and on-farm monitoring of faecal egg counts (nematode worms). This can reduce reliance on anthelmintic usage to control worms and delay development of anthelmintic resistance.

The way forward - current systems

Current lowland systems are characterised by an overemphasis on breeding objectives towards meat characteristics - growth rate and conformation - in relation to what the market is currently paying for these traits. Where these developments increase the labour element of keeping sheep, e.g. extreme conformation associated with lambing difficulty or increased cost caused by lack of milk in ewes and the need for supplementary colostrum, then we are locked into an unprofitable business. Tinkering with such a basically unprofitable system is not likely to put it back into profitability. Major cutbacks in inputs of feeds or medicines can quickly become counterproductive. Useful savings can be made however by monitoring for diseases, trace element deficiencies and underfeeding, knowing the value of feeds and efficacies of supplements and medicines and making the appropriate inputs on the basis of this information and knowledge of requirements.

New systems

We could take a useful lead from the dairy industry and look at how we measure economic success by throwing out gross margin analysis which ignores fixed costs and looking at total costs of production in pence per kg of lamb sold. We need also new indicators of efficiency. Biological expressions such as kg DM fed per ewe wintered could be borrowed from New Zealand and modified to our subsidised systems. Indicators that are currently more relevant include identification of those costs critical to ensure annual headage payment. Dry sheep farming in remote hill areas may be the most profitable option at current low lamb and cast ewe values. Most farmers will be uncomfortable with such developments. However, they reduce the power of the large-scale multiples who have become beneficiaries of subsidised agriculture because farmers provide them with products at less than the cost of production through the subsidies they receive.

The details of profitable new sheep farming systems are not clear but their elements can be identified. These include higher product prices based on:

- Costs of production.
- Selling lambs under the EU initiative for Protected Designations of Origin and Protected Geographical Indication.
- Farm assurance and organic premiums.
- Group marketing schemes on a regional basis.·
- Use of sheep with genetic and behavioural characteristics that reduce labour input.

- More use of grass as a feed, reduced inputs of animal medicines, supplements and labour.
- Re-direction of the focus in sheep farming towards providing the environmental and social benefits derived from keeping sheep.

The challenge is to achieve these objectives without a major reduction in the rural population.

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