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Irish Dairy Farming – Past, Present and Future

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Milk production is a vital component of the agricultural sectors within both Northern Ireland and Republic of Ireland. However there is continual downward pressure on the returns from milk production, especially in Northern Ireland, due to reducing milk prices and value of cull cows and calves. It is hoped that some of these pressures may be at least partially alleviated as the impact of BSE is reduced in the years ahead. However it remains clear that survival of the industry in the short term, and growth in the longer term if/when milk quotas are eliminated, will depend on the competitive sector producing a quality product appropriate for the market place (including timing). The objective of this paper is to look at the technical development of the dairy sector over the past 20-25 years and provide a look forward to the future. To achieve this the paper is divided into three sections which endeavour to address the issues (1) Is our industry competitive? (2) what progress, at a technical level, has been made in the industry? and (3) what are the technical issues for the future?

1. Is Irish dairy farming competitive?

There are many ways of comparing the competitive positions of the milk production sectors in different countries and economists do not always agree on how such comparisons should be undertaken. Also because of the major fluctuations in currency values (especially between UK and ROI) it can be

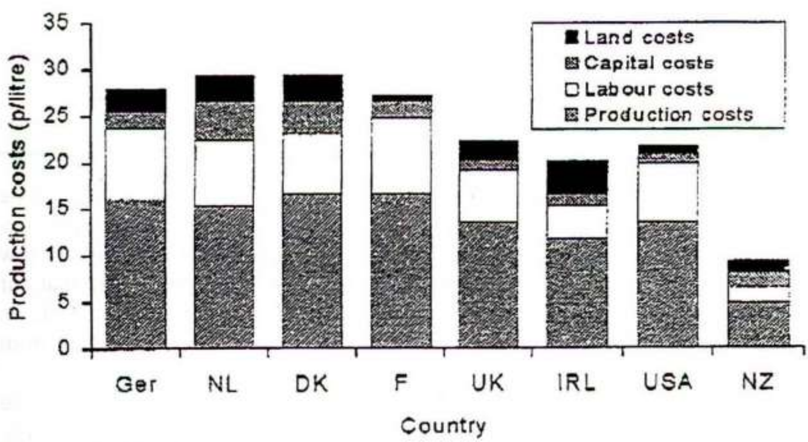

Fig. 1 – Production costs of milk across countries (from McBurney, 1998)

very difficult to produce meaningful comparative data. Not withstanding these difficulties McBurney (1998) produced comparative milk production costs across a number of countries by interpreting data obtained in a recent study carried out by German workers. In this study costs were grouped under four main headings; production costs; paid and unpaid labour; capital costs (loan capital and equity) and land costs (rent paid and calculated rent on own land). A summary of the total economic costs calculated by McBurney (1998) is presented in Figure 1. These data show that in comparison with our main competitors across EU both UK and Ireland are relatively competitive and also competitive in relation to USA. However when you consider the total economic costs of production for countries such as New Zealand, the difficulties of Irish dairy farmers competing on a world market are obviously clear.

McBurney (1998) also undertook a more detailed comparison across the different areas within the British Isles and a summary of the total economic costs which he computed is given in Table 1. The key points in these data are that in the cost areas which many of us debate so vehemently, i.e. variable and fixed costs, there were no differences between the regions. However when the calculation was taken to full economic costs, (which includes imputed costs for unpaid labour by the farmer and spouse and unpaid rent) then there are very major differences.

Table 1

Milk production costs (p/pl) across British Isles (From McBurney, 1998)

	England & Wales	Northern Ireland	Republic of Ireland
Total variable costs	7.94	6.49	7.73
Total fixed costs	6.13	6.82	6.81
Total input costs	**14.07**	**13.31**	**14 54**
Unpaid labour	2.51	3.16	6.07
Unpaid land rental	0.98	1.39	2.24
Total economic costs	**17.56**	**17.86**	**22.85**
Milk output/farm (1)	479,310	248,646	167,018

In the Republic of Ireland these imputed costs are more than double those in England and Wales and almost double those for Northern Ireland. The key factor driving this high cost in the Republic of Ireland is the relatively low milk output per farm. This highlights the absolute necessity to ensure that our units have sufficient scale of operation. This tremendous influence of scale on total economic costs is also demonstrated by the data in Table 2 derived from the Northern Ireland Farm Business Survey data (McBurney 1998).

These data (which relate to 1997/98 year) are grouped on the basis of herd size. They clearly show that herd size has no effect on variable costs, only marginal effects on fixed costs but a very major effect on imputed labour costs.

Table 2
Effect of herd size on milk production costs (p/pl) in Northern Ireland (from McBurney 1998)

Herd size	Variable costs	Fixed costs	Imputed labour	Total economic cost
Under 20 cows	6.8	5.9	6.2	18.9
30-40	6.7	5.5	4.0	16.2
50-70	6.3	5.8	2.5	14.6
70-100	6.1	5.4	1.3	12.8
Above 100	7.0	4.8	1.5	13.3

These latter costs decline from 6.2 to 1.5 p/l as herd size increases from under 20 cows to over 100 cows.

All these data highlight the need for growth in herd size, or more correctly milk output per labour unit, if we are to remain viable. It is always necessary to prune variable and fixed costs but in those units where there is relatively low outputs per farm we must accept that it is almost irrelevant in terms of total economic costs. The only way forward for such units is growth. We all realise that due to milk quota restrictions it has been extremely difficult for small units to grow but this must not stop us appreciating its importance and recognising that it is the key to progress.

A more simplistic approach to assessing the competitive ability of any sector is to consider how it is competing in the market place for the resources which it employs. While in theory within UK milk quota is attached to land it is in practice traded between farms and regions and can therefore be considered as a flexible resource. Against this background Table 3 indicates the level of milk production in Northern Ireland prior to the introduction of milk quotas along with quota held for the year 1998/99. Even though there have been numerous deductions from quota allocations the Northern Ireland quota holding in 1998/99 was well above the 1983/84 baseline production level. Presently Northern Ireland has purchased, or leased, milk quota from Great Britain to the extent of approximately 20% of its supplies. This is probably the best indication that Northern Ireland dairy farming has been competitive, in a UK context, since 1983. It also highlights the fact that those

Table 3
The ability of Northern Ireland dairying to compete across United Kingdom (U. Agnew 2000 personal communication)

	Million litres
Milk produced pre quota (1983/84)	1418
Quota leased/purchased into NI	280 (+20%)
Present Northern Ireland quota	1550

dairy farmers who are serious about remaining in milk production have continued to grow in order to provide more viable enterprises - and lower total economic costs.

2. What technical progress has been made in the industry?

It is always interesting to consider the technical progress which any industry has made over a reasonable time-span. Such progress could be considered in terms of changes in average performance at farm level but because of the tremendous variations which occur in on-farm performances I have confined the assessment of progress to that achieved at research level. Table 4 provides the performance of the Hillsborough spring calving system in 1978 and the recent performance of a relatively similar system operated at Moorepark during 1999. These two sets of data, which either were, or are, at the forefront of performances within their relevant time periods clearly demonstrate the tremendous progress which has occurred over this 21 year period. Similarly the data in Table 5 for an autumn calving system represent the outputs at research level for this system at Hillsborough over a relatively similar timescale. Both these autumn calving systems adopted *ad libitum* access to ensiled grass plus a flat rate of 5.4 kg concentrates per day for the total winter feeding period, and grass only during the summer.

The major increases achieved in animal performance in both the autumn and spring calving systems reflect a range of factors? but most particularly improvements in dairy cattle genetic merit coupled with enhanced feeding regimes to maximise the contribution which forage could make to the diet of these higher producing animals. For the autumn calving system the feeding

Table 4
Progress in the performance of spring calving systems during the past 20 years

	Hillsborough - 1978	Moorepark - 1999 (Dillon Pers. Comm.)
Stocking rate (cows/ha)	2.9	Approx 2.35
Concentrate input (kg/cow)	550	365
Milk yield (kg/cow)	5504	7500

Table 5
Progress in the performance of autumn calving systems over the past 20 years

	Hillsborough - 1980	Hillsborough - 1993 and 1999
Stocking rate (cows/ha)	2.9	2.1
Concentrate (kg/cow)	1140	980
Milk yield (kg/cow)	5689	7854

Table 6
The effect of dairy cow genetic merit on efficiency of converting feed energy into milk energy (Gordon, *et al.* 1995)

Genetic merit (PTA fat + protein kg)	Milk yield (kg)	Feed efficiency (%)
5	29.0	25
15	30.6	27
45	37.2	30

value of the silage has been increased through more frequent harvesting coupled with rapid wilting to 25-30% dry matter. Equally over the summer the traditional rigid system of paddock grazing, which had the objective of achieving maximum utilisation of the grass grown, has been replaced by a lax grazing approach, with herbage allocations adjusted daily. The grazing objective has now moved to maximising pasture intake per cow. It is my view that little if any of this increased output has arisen by either producing more grass, growing grasses of higher inherent feeding value or even during the grazing period allowing animals access to material of higher feeding value.

We must therefore recognise that the increasing genetic merit of our animals coupled with our ability to develop systems to exploit this has been our man route to improved technical performance. After all it is now well recognised that dairy cow genetic merit is the single most important factor influencing the efficiency of conversion of feed nutrients to product output - and this remains the central point in competitive dairying systems. The data in Table 6 which are derived from a study at Hillsborough in which animals of different genetic merit were given ad libitum access to the same feed demonstrates this effect. The efficiency of conversion of feed energy to product output increased from 25 to 30% (an increase in milk product output of 20% from a given feed input) as the genetic ment of the dairy cow was increased. No other single factor can approach achieving such a dramatic response.

We must recognise however that there is nothing magic about higher genetic merit cows - they can only sustain increased levels of performance if our management systems enable them to consume extra feed nutrients This is the factor which puts extra pressure on our management systems and must drive our research horizons. If our management systems do not develop sufficiently to enable good quality cows to consume more feed then the responses in performance from increasing genetic merit will be greatly reduced, or even minimal. This has been demonstrated in the work by Cromie *et al.* (2000) (Figure 2) which showed that in low feed input systems the performance benefits from increasing genetic merit were only approximately half those achieved in more modest feeding regimes. I have no doubt that this difference is ever increasing as we widen the difference in feed inputs. For example we are fully aware that the response in performance from increasing

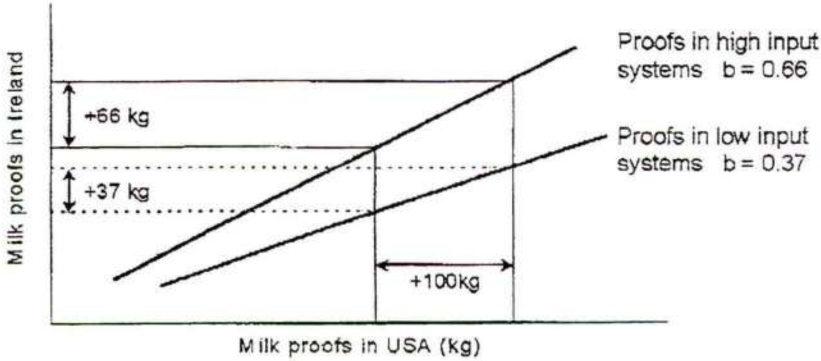

Fig. 2 - A comparison of milk production proofs from high input and low input herds (from Cromie *et al.* 2000)

genetic merit in New Zealand is only 26% of that recorded in USA (Cromie *et al.* 2000). This must not however be construed to imply that the benefits from high genetic merit cows can only be achieved in high concentrate systems. Higher concentrate levels are only one approach to achieving high nutrient intakes. This is amply demonstrated by the data presented for the spring and autumn calving systems outlined in Tables 1 and 2 in which major performance benefits have been achieved without any increase in concentrate input. In these examples increased nutrient intakes were obtained by more appropriate grazing management, and higher quality silage for animals producing milk over the winter period. These are the issues which research must address.

3. Looking towards the future - being aware of the options

The past 20 years have been a period of considerable technical progress. Unfortunately delivery of much of this potential progress at farm level has been stifled by the political constraints which have been placed on the development of our industry. This has been particularly true in the Republic of Ireland where the inability to freely trade milk quota has placed an extra constraint on the development of dairying enterprises, particularly for the smaller milk producer. While the milk quota system has also been a constraint in Northern Ireland the ability to trade quota between farms, and across the UK, has eased some of the potential blockages in farm development and growth. Hence the outcomes in the two industries have been somewhat different.

The key limiting constraints to development and progress are generally quota, land and capital, although other constraints, such as cow and stock person potential, must not be forgotten. As our industry strives to grow and make further progress there will be a range of options for progress open to farmers, and the best option for one farmer may not be the best for another (depending upon the limiting constraints in the individual enterprise). It is clear that the future is unlikely to be based on the stereotype production systems which have been adopted (or advised) in the past. Where milk quota has greater flexibility individual enterprises can grow (and many must grow) and a range of options are available to achieve this growth. For those where land is limited, and there are many enterprises within this category in Northern Ireland, then more radical options must be sought. In Northern Ireland a considerable proportion of dairy farms have grown markedly over the past 10 years (and this is demonstrated by the major transfer of quota into Northern Ireland) to the extent where now it is often the availability of land accessible to cows which is the limiting factor - and with land at its present high price such farms cannot easily grow even if land became available. These are the issues which are presently constraining many Northern Ireland dairy farms.

(a) Calving season options

To members of a Grassland Society it is often considered axiomatic that we consider spring calving systems as the optimum, or only, way forward. There are production, processing, and marketing reasons why this is not always so. A competitive milk processing sector, if it is to operate in high value products, will increasingly require a degree of balance in its milk flow across the year. At farm level we neglect this at our peril with for example some milk purchasers in Great Britain likely to be offered 12 p/l for milk during the early summer of 2000. While I strongly believe that farmers must consider the market place this does not absolve milk purchasers from providing the appropriate price signals back to the producer. The key point however must be that at farm level we recognise that good quality grassland can provide a major proportioniion of the feed nutrients in systems which calve at other times of the year (eg autumn calving) provided we can operate at high yields/cow. At Hillsborough our autumn calving cows are now going to grass at the end of a winter in which they have received *ad lib* silage and 6 kg concentrate/day and yielding around 28 litres milk per day. In 1978 the spring calving herd (Table 1) on 31 March averaged 24.8 litres per day. The lactation curves for both groups of animals are given in Figure 3. This shows that the high genetic merit

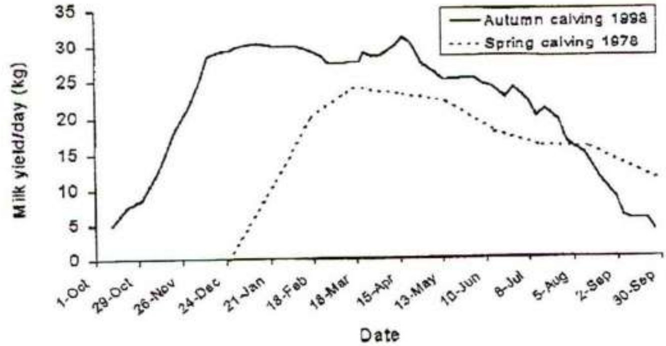

Fig. 3 – Daily milk outputs from two systems of milk production; spring calving in 1978 and autumn calving 1998

autumn calving cow has even greater potential to exploit milk from pasture than our spring calving cows of 20 years ago (and we must remember that the latter system was by no means an inefficient system, achieving a yield of 5504 litres per cow). If a premium can therefore be achieved for winter milk then there are excellent opportunities to produce very viable systems using the autumn calving animal. It is often considered that autumn calving inevitably leads to high fixed cost systems. In many parts of Ireland, where some form of housing, feed storage and slurry handling are essential, then autumn calving systems may require only marginal increases in fixed costs over most spring calving systems presently in place. Recent estimates would also suggest that autumn calving may only marginally increase variable costs per litre provided good milk outputs per cow can be achieved.

It is readily accepted that many autumn calving herds (and also spring calving herds) presently adopt high fixed cost systems. These however are more a reflection of the past profitability of these systems rather than a necessity of the system. Indeed across Northern Ireland there are many farmers operating autumn calving systems, using simple but effective techniques to efficiently utilise fresh and conserved forage and producing high milk outputs (of around 700,000 litres) per labour unit. These types of systems can provide a good return to the farmer and are an important component of the milk intake by many milk buyers.

(b) Feeding options

Throughout Ireland we have rightly focussed on the maximum incorporation of grass into the diet of the dairy cow, irrespective of season of calving. There is no disputing this as a starting point for effective/economic production but we must recognise that as the cost of cereals, or by-products, declines relative to forage costs (both grazed and conserved forage) and individual farmers move towards an expansion mode, our industry must examine other approaches to profitably converting ruminant feed into milk. This is particularly true as the genetic merit (or feed conversion efficiency) of our dairy herd increases - and is extremely relevant for those farmers who have limited access to grazing land. For example Table 7 presents data from a systems comparison at Hillsborough in which autumn calving, high genetic merit, cows were grazed during the summer period using two very contrasting

Table 7
There are other options for achieving high outputs at pasture (Data from Systems Study at Hillsborough)

Grazing system Grass allowance (kg/DM/d)	Lax and flexible 23	Fixed paddocks 16	
Conc/cow (kg)	0	400	
Yield of fat + protein (kg/cow)	232	253	+9%
Area/cow (ha)	0.26	0.20	-23%

approaches. In one system (lax/flexible) animals were managed to achieve maximum intake of grass per cow, by allocating 23 kg DM/cow/day above 4 cm, and given no concentrates. In the second system, the fixed paddock grazing system, animals were rigidly grazed in a conventional paddock grazing system at a much higher mean stocking rate over the season (5 cows per ha) and allocated concentrates according to yield and herbage availability. They received 400 kg per cow over the grazing season. The system which received concentrates used 23% Less grazing land, produced 9% greater output of milk fat and protein per cow and was relatively simple to manage. While all types of economic conclusions could be drawn from this, the key factor is that there are different options available and what is correct for one situation will not be correct in the other. Where a farmer has been (or is) expanding output from a limited land base then the concentrate route may be the most effective while if a farmer has ample grazing land available the other option is the most appropriate. Possibly one of our weaknesses at research level is that we tend to consider that there is only one way of moving forward rather than providing the farmer/adviser with tools by which he can look at options and make decisions which are suitable for each individual producer. For example if I am grazing dairy cows at pasture I would consider it important to know if I offer more grass to the herd, how much more of this grass will the cows eat, and what is the reduced efficiency of herbage utilisation - or alternatively what is the impact on herbage intake and grass utilisation of giving say 2 kg concentrates/day to a herd which is presently being tightly grazed.

(c) The genotype option

The declining fertility in our National dairy cattle population is now well recognised with calving rates in large scale surveys being as low as 40%. Equally the most recent Moorepark study indicates conception rates of 49%. However these figures may be hiding a much more severe decline which lies ahead as genetic merit increases further. For example at Hillsborough the conception rate for the group of very highest genetic merit cows has declined to under 30%, a figure which is now not uncommon in the USA. While undoubtedly through research we can provide a better understanding of the physiological reasons for such low reproduction rates, and hopefully management practices may be developed to improve fertility, this will be a very difficult road. The very simplistic hypothesis that the decline in reproductive performance can be rectified by reducing the extent of the negative energy balance in early lactation is unrealistic. This fails to recognise that a feature of high genetic merit cows is that as plane of nutrition is increased, milk yield increases with often little reduction in the extent of the energy gap during the early lactation period. Equally it does not recognise that in studies to date where differences in planes of nutrition have been imposed no strong links between fertility and nutrition have been obtained, except at extreme nutrition levels. Nevertheless, while accepting that this road will be difficult, we must endeavour to make progress as quickly as possible.

While there are few immediate answers to the problem of reducing fertility, in looking further ahead we have the opportunity to make progress through improved breeding strategies. Many countries have now recognised that there is genetic variation in reproductive performance within the black and white population and this opens the door to include this within selection goals. The Black and White population in Scandinavia has embraced this approach for some time and other European countries are now making this information available. The work in Republic of Ireland will also hopefully make progress in this direction.

Recently there has been considerable interest in using other breeds to address this problem, and this is a route which we are exploring in Northern Ireland. Two large scale research projects, with co-funding from dairy farmers through AgriSearch and Department of Agriculture and Rural Development, are exploring two different approaches. One approach is involving cross breeding and the other examines breed substitution. The latter project involves a large scale comparison of Norwegian NRF and Holstein Friesian cattle, the former being a breed which has been selected for many years using a total merit index which includes fertility as well as health parameters. This study will involve 600 animals, 300 of the Norwegian NRF breed and 300 high genetic merit Holsteins, in two components. Sixty of each breed will be subjected to detailed scientific research at Hillsborough to examine aspects such as nutrient metabolism, feed efficiency and grazing behaviour while 240 of each breed will be compared on 20 farms, across a wide range of production and management systems. When both components of this study are brought together they will provide a very accurate and comprehensive comparison of the two breeds in systems which are representative across our industry. It is only through this type of research that we can produce reliable information which will be appropriate for the future of the industry.

Conclusion

Irish dairy farming has made considerable technical progress over the past 20 years and now has the expertise to enable high outputs to be achieved from grassland by both spring and autumn calving systems. However the future for many farms on this island must involve growth, in terms of milk output per farm, and this can only be achieved through us all recognising that there are a range of options by which this can be effectively achieved. There is no single system which everyone should, or must, follow. The key point which I would make to my research and technical support colleagues is that we must have a sufficiently open mind to be able to create options, and the tools to help these to be delivered, which will enable our dairy enterprises to grow by whatever methods suits each individual farm.

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Better Dairy Cow Fertility Down Under - What Can We Learn?

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Having spent a twelve month sabbatical working in both New Zealand and Australia my objective in this paper is to describe how scientists and farmers in these countries approach the challenges of successfully breeding dairy cows at grass. Specifically, this paper focuses on two issues of current concern, the lower fertility of high yielding cows and how to improve conception rates at grass.

Dairy herd fertility - how do we compare?

The completion of the preliminary herd level analysis of the Moorepark Fertility Project allows us to benchmark Irish dairy cow fertility performance with our international competitors.

Unlike the current Irish interpretation of herd fertility performance, based on target values largely derived from UK data, in Australia, median results from the top quartile of herds (based on their 6 week pregnancy rate) are used as achievable figures for the dairy industry. Moorepark data suggest that the characteristics of herds achieving high pregnancy or calving rates may not be the same as those achieving low pregnancy rates and so it may not be a valid target for the latter group.

Table 1
Dairy herd fertility performance in seasonally calving herds in Ireland, New Zealand and Australia

Index (mean)	Ireland[1]	New Zealand	Australia[2]
Submission rate (3 week) (%)	70.0[3]	78.9	75.1
Conception rate (1st service) (%)	48.0	55.7	48.7
Pregnancy rate (6 weeks) (%)	?	77.0[4]	62.1
(overall) (%)	85.7	91.6	90.5
Breeding season (days)	104	100	132

[1]Moorepark Fertility Project (1999); [2]Seasonal herds; [3]All cows calved at MSD are eligible; [4]45 day PR.

Submission rate

Even allowing for the strict definition of submission rate (SR) currently used in DairyMIS (Table 1), the average SR in Irish herds is only slightly lower than that reported in Australia, but considerably lower than that reported in New Zealand. In New Zealand there is a major emphasis placed on submitting cows early in the breeding season for AI. It should be noted that in

New Zealand, cows generally do not ovulate or show signs of oestrus within 4 to 6 weeks of calving. With an existing compact calving pattern, possibly aided by induction, late calving cows do not lower the SR as they do in Irish herds. A more lenient definition of SR (eligible cows ≥21 days calved at mating start date, MSD) shows a dramatically increased SR (90%) in Dairy MIS spring calving herds (Mee, Fahey and Crilly, 1999). The definition of SR for Irish herds is currently under review.

Currently there is interest in Ireland in preventing oestrus in finishing heifers and cull cows using 'cow pills' (bovine intra uterine devices, BIUD's). In Australia this problem is solved by bilateral ovariectomy performed per rectum/vaginum with a special surgical instrument (Willis Dropped Ovary Spay).

Conception rate

The conception rate to first service of Irish herds is similar to that achieved in Australia, but substantially lower than that reported in New Zealand. It should also be noted that New Zealand scientists consider their actual conception rates 'below performance objectives' (Hayes, 1998), (60%), suggesting that this target value is no longer being achieved even in countries with a reputation for high dairy cow fertility.

Six week in-calf rate

Whereas there are currently no Irish data on the six week in-calf rate, this has been adopted in both Australia and New Zealand as a national benchmarking tool to set standards and compare herds. In Australia a target of 75% has been set as achievable, based on the average (77%) for the top quartile of herds (Morton, 1999a). In New Zealand however, the goal of the dairy cattle fertility research programme is to increase by 10% (from 77 to 87%) the proportion of cows conceiving during the first 45 days of a seasonal breeding programme.

Infertile rate

The higher infertile rate reported in Irish herds (Table 1) may reflect better recording of data, slightly different definitions or a higher late embryonic and foetal mortality rate. The extremely high (34%) individual herd infertile rates detected in the Moorepark Fertility Project suggests the latter problem is present in a proportion of well managed herds. Probable causative factors include neosporosis and BVDV infection. While calving induction is not widely practiced in Irish herds (approximately 4% of large intensive herds induce more than 10 cows in at least one year), between 5 and 15% of cows are induced to calve prematurely in Australia and New Zealand thus adding to the real foetal mortality rate.

Duration of breeding

The wide variations in the duration of the breeding season, both within and between countries (Table 1), renders national and international comparisons of limited value. On average, the breeding season in seasonal calving herds is shortest in New Zealand, (particularly the AI season), followed by Ireland and Australia. More valid comparisons may be made by using a fixed breeding season (as with the six week in-calf rate), for example, 13 weeks, to compare the reproductive performance of herds both nationally and internationally. This is currently under review at Moorepark.

High genetic merit cows - a breed apart?

Research groups in both Australia and New Zealand are examining the problems associated with breeding high Australian Breeding Value (ABV) and high New Zealand Breeding Worth (BW) cows at pasture. Due to the expense associated with this research, the impact of genetic improvement for milk yield and composition on fertility has had a low priority. However, in both countries there is concern amongst farmers over the perceived reduction in conception rates associated with genetic improvement. This reduction is thought to be related to the under nutrition of genetically superior cows during early lactation and has stimulated recent research work.

Australian results

Australian studies with high genetic merit Holstein Friesian cows have shown poorer expression of oestrus (Lean, Westwood and Porter, 1999), longer calving to first ovulation interval, first oestrus interval and conception intervals (Jonsson et al 1997), lower submission rate (Fulkerson et al 1997) and more abnormal cycles (Fulkerson et al 1997) compared to lower genetic merit cows. Altered progesterone metabolism in such cows is also being examined. All of these factors, detected in small scale controlled experiments, contribute to poorer herd fertility. However, the Australian National Dairy Herd Fertility Project did not detect a significant difference in first service conception rates between cows of differing yields (from < 2,000 to > 4,000 L/120d), (Morton, 1998) or between cows with sires of differing ABV, (Morton, 1999b),

New Zealand results

New Zealand research work had shown that Holstein Friesian cows genetically selected for heavy body weight (60% Holstein genes) had a shorter calving to first ovulation interval but a lower first service conception rate and later onset of puberty than light body weight cows (10% Holstein genes), (Laborde, 1998). This study suggested a strain difference in fertility. Hence a retrospective analysis was carried out of strains of Holstein Friesian (HF) cows, Jersey cows and their crosses. (Harris et al 1999). This showed that as the proportion of overseas HF genes in both HF and HF-Jersey crossbred cows increased, the risk of culling and infertility increased. HF-Jersey crossbreds were at least risk of culling. Heterosis estimates indicated improved fertility from crossbreeding for all fertility measures. Research at Moorepark is currently examining the reproductive performance of different breeds (Norwegian Red, Normande, Montbelliard) and crossbred dual purpose cattle.

Similarly, a joint New Zealand/North American project found that plasma progesterone concentrations after CIDR treatment were inversely associated with body weight and milk yield in US and NZ Friesian cows. Higher plasma progesterone concentrations and a shorter oestrus cycle were present in CIDR-treated NZ versus US cows (Bilby, 1998). The results of this study stimulated a project at the Dairying Research Corporation in New Zealand to compare NZ (13% Holstein genes) and Dutch Holsteins (100% Holstein genes) in New Zealand on both pasture and total mixed ration, (Kolver, et al 1999). Preliminary results on reproductive performance show that grass-fed cows had a longer postpartum interval than those fed a TMR, while the Dutch cows had a shorter postpartum interval than the New Zealand cows (Verkerk, pers. comm.).

More recently, a joint Teagasc-New Zealand (DRC, LIC, Massey University) Holstein Friesian strain comparison study has been set up to compare, in Ireland, North American, New Zealand and Irish Holstein cows and similar cows in New Zealand. Calves in both countries are currently entering puberty and pubertal development and maiden heifer breeding performance will be closely monitored.

Thus, farmers in Ireland, Australia and New Zealand have similar concerns over the fertility performance of high genetic merit, high yielding Holstein Friesian cows. Results from Moorepark suggest we need to differentiate between the effects of the percentage Holstein genes and type, in cows from their actual milk yield and composition. While the former has been associated with reduced fertility, the latter has not (Snijders et al 1999). The origin of the Holstein genes and the environment under which cows are bred and selected may also have a central bearing on their reproductive potential.

Can conception rates be increased?

The ongoing Australian National Dairy Herd Fertility Project has identified significant risk factors for low conceptions rates (low BCS precalving, short calving to service interval, old cows, low milk protein %, dystocia, twin calving, retained placenta, vaginal discharge more than a month after calving, doubt about certainty of heat, sire, and DIYAI). However, as the compactness of breeding and hence, calving is the ultimate objective of seasonal breeding programmes, conception rate alone is an inadequate measure of reproductive success to compare different herds. The Australian national study has suggested using the six week in-calf rate as a national benchmarking tool.

Table 2

Effect of submission rate and conception rate on 6 week in-calf rate

Index (%)	Median herd	Top herds
Submission rate	77	87
Conception rate to 1st AI	49	54
6 week in-calf rate	63	75

Source: Morton, J. (1999) The In-Calf Project. A Progress Report. DRDC.

As the data in Table 2 show, the herds with the best 6 week in-calf rate achieved this primarily through a higher submission, not conception rate.

Longer anoestrus for better fertility?

A novel approach to increasing conception rate in high producing dairy cows is being examined in Australia. The central hypothesis of this work is that early postpartum ovulation, with the attendant growth of a corpus luteum producing progesterone, prolongs normal uterine involution due to the locally immunosuppressive effects of progesterone. Delayed uterine involution is associated with lower conception rates (Smith and Wallace, 1998) as seen in cows served in the early postpartum period. This may be a real issue for well fed, high genetic merit cows in Ireland who ovulate early postpartum (Snijders et at 1998). It is not a problem in New Zealand where cows calve in moderate body condition and nutritional anoestrus delays ovulation until more than six weeks after calving, by which time uterine involution is complete. This is one of the critical reasons why first service conception rates are high in New Zealand cows.

Having described this process, the objective of the Australian research is to use a GnRH agonist to temporarily and reversibly suppress ovulation postpartum until involution is complete, thus mimicking the situation in suckled cows where suckling prevents the onset of oestrus. Research to date has shown that pituitary down regulation with a deslorelin implant can be successfully achieved but there is a lag phase before both ovulation and oestrus resumes. This idea may have particular relevance to Irish high genetic merit cows, as both early postpartum ovulation and delayed uterine involution are common features in our herds (Buckley, Dillon and Mee, 2000).

Progesterone metabolism

The hypothesis that one of the reasons why well-fed high yielding cows have lower conception rates is because their higher metabolic rate results in a higher clearance rate of progesterone, and thus compromised early embryo development, is being examined in Australia. While studies in North America have shown that the frequency of feeding dairy cows has a significant effect on peripheral progesterone levels, the effects of genetic merit and milk yield have not yet been examined. These studies may lead to nutritional or progesterone supplementation regimes which optimise progesterone metabolism during the critical period of early embryonic development.

Hormone replacement therapy

In conjunction with these projects, which are designed to explain why conception rates are lower in high yielding cows, large scale field studies are being conducted in Australia which attempt to improve conception patterns in commercial dairy herds. In a recent review of post-insemination hormonal therapies, Macmillan et al (1999) concluded that promising results in one trial have not been confirmed in others; but negative effects (except with metoestrus progesterone supplementation) have rarely been reported. The cost effectiveness of such therapies was not discussed.

Pregnancy diagnosis

In Australia, both early and late diagnosis of non-pregnancy are being examined. Ultrasonography is being used to predict the risk of non-pregnancy based on corpus luteum diameter and follicular population as early as two weeks after AI. This technique has been reported both for bovine embryo recipients (Dovenski et al, 1999) and in mares (Sevinga et al 1999). For late (>6 weeks) nonpregnancy diagnosis, a National Cattle Pregnancy Diagnosis Scheme has been set up by the Australian Association of Cattle Veterinarians to accredit its members' skills.

New Zealand research

While the focus of dairy cattle fertility research work in New Zealand has been on anoestrus and oestrus synchronisation, nutritional strategies to improve the probability of pregnancy establishment have recently been investigated. Herd reproductive performance is now being modelled as a component of the whole farm system (Verkerk and Sherlock, 1999) and farmers can now use the DRC website (www.drc.co.nz) to calculate their own individual oestrus synchronisation programme. Attempts to use individual cow milk progesterone concentrations on selected days after AI to predict pregnancy proved unsuccessful, except on day 22 (Verkerk and Macmillan, 1998).

GnRH to increase pregnancy rate

Early work had shown that progesterone supplementation during metoestrus reduced conception rates (Van Cleeff et al 1996) but that additional treatment with GnRH on days 12 or 13 raised conception rate to the level of controls (Lynch and Macmillan, 1996). Hence, research is being conducted on the role of GnRH agonists in improving conception rates in conjunction with anoestrus treatment regimes and synchronisation protocols. Inclusion of GnRH in a CIDR/PG/OB programme resulted in induced ovulation or turnover of the dominant follicle, synchronised initiation of a new follicular wave and increased progesterone concentration from day 4 after treatment in non cycling cows (Xu et al 2000). It is suggested that these factors may contribute to the increased conception rate of cows after treatment with this programme compared to cows treated with CIDR/OB alone. Other studies have shown that GnRH enhances early trophoblast growth to improve the maternal recognition of pregnancy.

High vs low pregnancy rate heifers

A large scale project has been conducted comparing the physiological characteristics of heifers selected for either high or low conception rates based on ET results (Mcmillan et al 1999). These experiments concluded that most of the difference in conception rate occurred within 3 weeks of AI or ET. Ovarian factors were unlikely to contribute to the higher conception rate in the high group (52% in-calf at day 60) compared to the low group (29% in-calf at day 60 after AI). The major differences occurred after blastocyst hatching and probably depend on differing uterine environments before day 14 which stimulate the expression of interferon tau by the embryo.

Predicting late embryo mortality

Attempts to predict late embryonic mortality using ultrasound proved successful at day 42 with a 90% chance of fetal mortality by day 60 if the fetus was small or very small in size or had a small foetal fluid volume. Predictions from earlier scanning were poorer (Mcmillan et al 1999). A similar project has been conducted recently by Teagasc Athenry and Moorepark (Silke et al 2000). In large synchronised herds in New Zealand, an intra-rectal extender is used instead of the veterinary practitioner inserting his/her arm into the rectum to introduce the ultrasound probe, thus reducing stress on both the cow and the vet.

Neospora

Neospora infection has been described as the most significant cause of abortion (25% of cases) in New Zealand causing losses of $24 million annually (Thornton, 1998). Nationally, abortion accounts for approximately 3% of fetal loss. Case studies suggest sero-positive cows have a 5-times greater risk of abortion compared to herdmates (Pfeiffer et al 1998) and sero-positive dairy heifers produce less milk. Reabortion was not found to be a usual sequel, but can occur. Neosporosis is emerging as a major cause of both abortions and foetal mummification in Irish dairy herds.

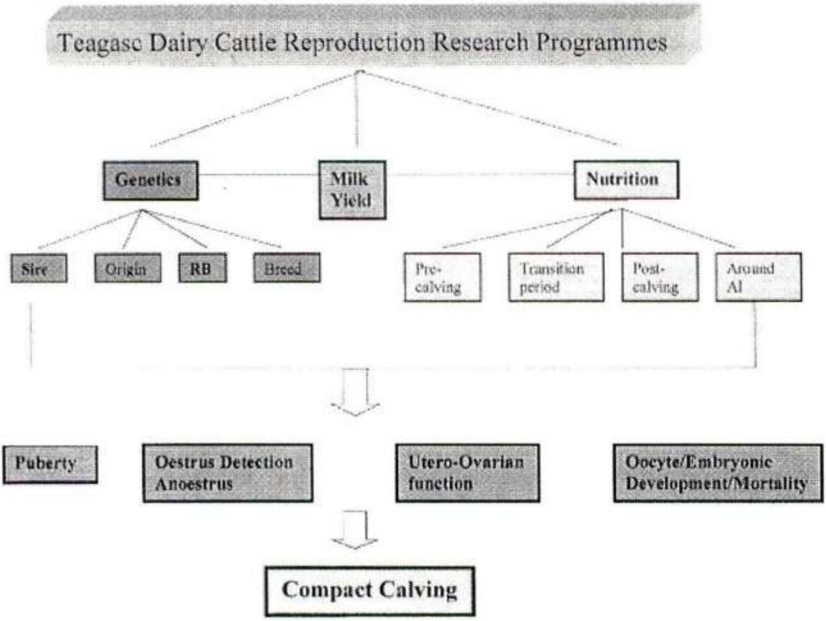
What about Irish dairy cattle fertility research?

Teagasc, in collaboration with other national and international institutes and universities, has an active, innovative research programme addressing the challenges faced by farmers in breeding the dairy cow of the future (Figure 1). The three major axes of this programme are the interrelationships between genetics, nutrition, milk yield and fertility. The genetic aspects of this program are focussed on the effects of sire, breed, cross breeding, RBI and origin of genotype on cattle fertility. The nutritional aspects of the program are addressing the effects of dietary energy, protein and fat on cattle fertility. Basic research on embryonic development and the timing and extent of embryonic mortality is being conducted in conjunction with these studies.

International research links

The joint Teagasc Moorepark/New Zealand Holstein Friesian Strain Comparison Study will foster research links between the two countries over the next five years. Links between Athenry and Moorepark Research Centres will become closer with the submission of a joint proposal for funding under the Teagasc re-tooling programme. Current links with Cornell University will be strengthened following the completion of joint research proposals on the relationship between nutrition and fertility in highproducing cows. Links with Wageningen Agricultural University and ID-DLO in The Netherlands are ongoing with the Moorepark Fertility Project.

Figure 1:



...... so what can we learn?

- We need to focus on compactness of breeding, rather than on late embryonic mortality alone.
- We have a better chance of improving compactness of breeding by improving submission rate than by attempting increase pregnancy rate.
- We need to consider the benefits of heterosis to improve fertility.
- We should examine altering postpartum ovulation patterns to hasten uterine involution.
- We need to extend heifer model work, on energy balance and progesterone metabolism, to high genetic merit dairy cows.
- We have a better chance of solving fertility problems in Irish cows by collaborating with scientists and farmers internationally that have similar problems.

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Moorepark Farm Fertility Study – Initial Results

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In recent years Irish dairy farmers have expressed concern about the reproductive performance in their herds. Since the mid-1980's the rate of genetic improvement for milk production has increased markedly to about 1.3% per year. The high rate of genetic improvement has mostly been achieved through the importation of both North American and European Holstein-Friesian genetics. There is considerable evidence in the literature from other countries that selection for milk production may lead to reduced reproductive performance (*Arendonk et al.,* 1989; *Hoekstra et al.,* 1994; *Pryce et al.,* 1999). In recent years there is evidence that this may also be occurring in Ireland. Mee et al. (1999) showed that there was a significant decline in calving rate to first service between 1991 and 1998 in the order of 0.9% per year on Irish dairy herds participating in the Moorepark Dairy Management Information System (Dairy MIS). Two long-term experiments conducted at Moorepark have shown much reduced reproductive performance with high genetic merit Holstein-Friesian (100%) dairy cows (*Dillon and Buckley,* 1999).

The objective of the present study was to relate (1) genetic merit for milk production, (2) system of feeding management and (3) health and reproductive management to the reproductive performance being achieved on commercial spring calving dairy herds. Also of interest is the possible existence of a possible interaction between genotype and feeding system for reproduction traits. In other words the study is an attempt to identify the major factors causing differences in reproductive performance between cows and between herds.

The study involves a total of 73 herds with fertility performance from 6,399 cows in 1999.

Herd selection

The key factors in herd selection were:

- Predominantly spring calving herds
- Pedigree (HFS) herds or at least two generations of sires for most cows
- Participating in A4 milk recording
- Accurate data recording
- Previous reproductive performance not considered

Data collected during 1999

- Milk production performance as per A4 milk recording
- Live weight and condition score on 8-9 occasions throughout the year
- Fertility performance recorded using Dairy MIS II system.
- Detailed pre-breeding ultrasonography carried out to determine ovarian cyclicity and uterine condition.

- Feeding and management practices were recorded on each farm using Dairy MIS II system
- All first lactation animals were type classified by the HFS
- Blood metabolites and trace element status was analysed for a proportion of cows in each herd during the first 3 weeks of the breeding season.

Fertility and preventative herd health management practices

Table 1 shows the fertility and preventative herd health practices applied on the farms involved in the study. Of the participating farms, 93% and 54% practised vaccination for leptospirosis and salmonellosis, respectively. Almost all farms (96%) supplemented with dry cow minerals in the dry period. Pre-breeding oestrus detection was carried out on 88% of the farms, while 92% observed cows > 2 times daily during the breeding season, while 99% of herds used tail paint ± vasectomised bull as an aid to heat detection. Artificial insemination (AI) was carried out by DIY on 62% of herds, while 78% of herds used a stock bull as part of the breeding programme.

Table 1

Fertility and Preventative herd health management practices applied on study farms

Management Practice	Details	% of farms
Vaccination	Leptospirosis	93
	Salmonellosis	54
	Calf Diarrhoea	18
	BVD	7
	Virus pneumonia	3
Mineral Supplementation	Dry cow minerals	95
	Copper	12
	Selenium	8
	Iodine	7
Oestrus detection	Pre-breeding season	88
	>2 observations/day (breeding season)	92
	Tail paint ± Vasectomised bull	99
Synchronisation	Maiden heifers	55
	Problem cows	81
DIY AI	All cows	62
Stock bull	Heifers or cows	78
Calving induction	>10 cows	4

Physical performance

Table 2 shows the variation in milk production, stocking rate, plus the nitrogen and concentrate usage for the farms on the study from January to September 1999. The average milk production per cow was 1,085 gal per cow with a range of 840 to 1316. There was large variation in stocking rates (0.72

to 1.35 LU/acre) and nitrogen application (168 to 370 units/acre) across the farms in the study. Concentrate supplementation levels per cow averaged 625 kg with a range from 200 to 1175 kg/cow for individual farms.

Table 2
Physical performance of the herds on the Moorepark study Jan-Sept. 1999

	Mean	Min.	Max.
Milk Yield (gal.)	1,085	840	1,316
Fat + protein (kg)	341	251	417
Fat (%)	3.77	3.54	4.11
Protein (%)	3.28	3.14	3.44
Stocking rate (L.U./acre)	0.99	0.72	1.35
Nitrogen (units/acre)	261	168	370
Concentrates fed (kg/cow)	625	200	1,175

Live weight and condition score

Table 3 shows the average live weight and condition score for the herds in the study pre-calving and 30, 60 and 90 days post-calving.

Table 3
Pre- and post-calving live weights and condition scores for the herds on the Moorepark study 1999

		Mean	Min.	Max
Pre-calving	Live weight (kg)	620	565	696
	Condition score	3.37	3.00	3.62
Day 30	Live weight (kg)	538	486	603
	Condition score	2.95	2.72	3.25
Day 60	Live weight (kg)	541	484	592
	Condition score	2.84	2.64	3.07
Day 90	Live weight (kg)	549	484	594
	Condition score	2.82	2.56	3.03

The average for pre-calving condition score was 3.37, varying from 300 to 3.62 on an individual herd basis. The average pre-calving live-weight was 620kg varying from 565 to 696kg. On average herds lost 82kg and 0.42 units in condition score from pre-calving to 30 days into lactation. On average live weight remained static or slightly increased from day 30 to 90 post-calving while condition score continued to reduce slightly.

Grazing management

During the breeding season average pre-grazing herbage yield was 2,050 kg DM/ha, ranging between 1493 and 2,922 kg DM/ha. Average post-grazing sward height was 8.1 cm ranging from 6.4 to 11.1 cm. The higher post-grazing sward heights were to be generally found in areas of wetter soil type where turnout to pasture in spring was delayed. Average pre-grazing herbage crude protein content was 20%, ranging from 14.4% to 24.9%.

Reproductive performance

Submission rate (SR)

While the average SR achieved is low (70%) relative to the target value of 80% (Table 4), the wide variation among herds (33-96%) suggests higher values are achievable. A high SR is critically dependent upon the previous years calving pattern, efficiency of pre-breeding season and breeding season heat detection and prevalence of 'anoestrus' cows. Given the fact that oestrus detection practices on the farms were reportedly very good (Table 1), and pre-breeding scanning was carried out on all cows in all herds, late calving cows and cows either not cycling or expressing weak signs of heat, (or for short periods), are likely to have contributed substantially to lower SR in certain farms.

Table 4
Reproductive performance of the herds on the Moorepark study 1999

	All herds	Top 25%	Target
Pregnancy rate to 1st service (%)	48	59	60
Submission rate (SR) (%) 70 88	70	88	80
Services/conception(no.)	2.1	1.7	1.65
Calving to 1st service interval (CSI) (days)	72	66	70
Calving to conception interval (CCI) (days)	89	82	85
Non-detected oestrus (%)	15	5	<10
Infertile rate (%)	14	8	<10
Days breeding	104	77	91

Table 5
Reproductive performance ranked on pregnancy rate to 1st service for the herds on the Moorepark study 1999

	Top 25%	Bottom 25%
Pregnancy rate to 1st Service (%)	59	36
Pregnancy rate to 2nd Service (%)	56	46
Submission rate (SR) (%)	73	62
Services/conception	1.8	2.4
Calving to 1st service interval (CSI) (days)	74	70
Calving to conception interval (CCI) (days)	88	93
Non-detected Oestrus (%)	13	20
Infertile rate (%)	11	18
Days breeding	97	107

Pregnancy rate (PR)

The first service PR reported here (Table 4) of 48% is well below the target value (60%) set some years ago. However, in the intervening years, internationally conception rates have declined, particularly in populations with a high proportion of high genetic merit Holstein Friesians. The variation between herds (26 to 73%) for PR to first service also suggests that higher levels are achievable. However the characteristics of the top quartile who achieved 59% may not be the same as those in the bottom quartile (36%).

A comparison of the top and bottom quartile of herds on PR to first service (Table 5) showed that second service was also higher in the top 25% of herds, while services per conception, calving to conception interval, non-detected oestrus, infertile rate and length of the breeding season were lower. The calving to service was similar.

Calving to service and conception

In order to maintain a 365-day calving interval, the optimum interval in seasonally calving herds, cows need to be served within 60 to 80 days of calving and conceive within 80 to 85 days of calving. Unlike indices such as PR the farmer decides the voluntary waiting period after calving, hence the calving to first service interval (CSI) is highly dependent upon management breeding policy. The calving to conception interval (CCI) is determined by the CSI and the conception rate. In the present study the CSI ranged from 59 to 91 days. On average, across all herds the CSI was within target although the CCI at 89 days was indicative of a 4 day slip in mean calving date. In one instance (CCI 115 days) mean calving date will have slipped on average 1 month later if all cows bred in 1999 remain in the herd. In 23% of herds mean calving date has been pulled back (CCI 77 days).

Infertile rate, number of services and length of the breeding season

While in the top quartile of herds only 8% of cows were empty at the end of the breeding season, those in the lower quartile had on average 22%. It must be borne in mind that the variation in this parameter is not only dependent on SR and PR etc. but also on the duration of the breeding season. A longer breeding season means more services per cow and thus a greater chance of conceiving. The average no. of services received per cow on the study was 2.1. Given the pregnancy rates achieved in the present study (48% PR to first service) it is not surprising that the average length of the breeding season (15 weeks) was longer than the recommended (Dillon et al., 1996) 13 weeks. The range was from 9 to 25 weeks across individual herds. Thus in the absence of widespread calving induction, late calving cows will continually be present unless an aggressive fertility management and culling approach is taken.

Pre-breeding ultrasonography

Three quarters (73.7%) of all cows had normal uterine involution by the start of the breeding season (Table 6), as expected given the CSI of 72 days. However 16% of cows were not cycling regularly at the start of mating. In the

Table 6
Pre-breeding utero-ovarian ultrasonography for the herds on the Moorepark study 1999

Scan result (%)	G code	Mean	Min.	Max.
Cycling (CL)		84.4		
Normal uterus	1	62.6	41.1	84.8
Mild endometritis	2	20.2	7.7	37.5
Moderate endometritis	3	1.6	0	6.7
Anoestrus (no CL)	15.6			
Normal uterus	6, 8, 9	8.0	0	21.0
Moderate endometritis	4	2.3	0	13.7
Pyometritis (CL)	5	2.2	0	7.8
Cystic	7	3.1	0	9.6

majority of cases (10.3%) the cows had not yet begun to cycle after calving. In a minority of cases the cows were cystic (3.1%) or had pyometra (2.2%). The proportion of anoestrus cows detected would be considered high but may reflect the limitation of a single scan in detecting true anoestrus. Uterine infection/inflammation/delayed involution was detected in a quarter (26.3%) of cows based on scanning and palpation of the tract. The majority (20.3%), however were mild cases, the relevance of which has not yet been determined. Pyometra, on the other hand, is a definite risk factor for conception failure and although over all it was uncommon (2.2%), the high incidence in some herds (7.8%) warrants further investigation of possible links with calving history, post-partum luteal function and related factors.

Blood and milk biochemistry

In general the energy levels of the first lactation animals was normal as assessed by the blood betahydroxybutyrate (0HB), non-esterified fatty acid (NEFA) and glucose concentrations (Table 7). This is perhaps not surprising given that the samples were taken during the first three weeks of the breeding season, therefore on average >70 days post-calving. Thus cows would be expected to be in a positive energy balance. This is supported by the stable condition scores and live weights observed between 60 and 90 days post-calving (Table 3). The protein status of the first lactation animals was on average normal as indicated by blood total protein (TP) and blood urea and milk urea concentration (Table 7). The tendency for high TP reflects the test used and the relatively low normal reference range. The blood urea concentrations reflect the milk urea values (Table 7). Whether the low milk urea levels are representative of Irish herds in general, or merely a year effect, will be determined following analysis of samples collected in 2000.

Blood trace elements

Both the copper and selenium levels of the mature cows were normal (Table 7). This may be explained by the location and soil types of the farms, the inclusion of trace elements in the diet of the lactating cow or a carry over effect from such supplementation. Quite different results have been reported where animals were sampled in both the spring and the autumn due to this effect (Mee, O'Farrell and Rogers, 1994). The wide variation in herd iodine status, is due to the supplementation of iodine containing concentrates during the breeding season in some herds and herbage iodine levels. Blood iodine levels do not reflect long-term iodine supplementation, but rather intake in the hours and days preceding blood sampling. Hence very low levels were detected in some herds. The reference range used to assess iodine levels in cattle is currently under review.

Table 7

Blood and milk parameters measured in the herds on the Moorepark study 1999

Analyte	Ref. Range	Mean	Min.	Max.	Normal (%)
ßHB	0-0.95	0.54	0.30	1.13	98
NEFA	0-0.7	0.22	0.09	0.53	100
Glucose	2.8-4.0	3.99	3.60	4.29	70
Urea	3.5-7.1	4.90	2.01	7.88	92
Protein	59.8-78.9	78.00	63.70	85.60	58
Copper	10.7-19.4	12.9	11.1	15.4	100
Selenium	42-161	124	82.7	164.1	98
Iodine	105-285	118	2	302	49
Milk Urea	3.0-6.0	2.65	1.54	3.60	

Genetic Parameter Estimation

Heritability (h^2)

The observed performance of an animal (its phenptypic value) for any given trait is a function of its genotypic value for that trait together with the effect of environmental effects. The heritability value for a trait is the contribution of the genetic variation as a proportion of the total phenotypic variation for the trait. Its value ranges from 0 to 1. The higher the h^2 for a trait the easier it is to select genetically superior animals for that trait.

The h^2 estimates for a range of performance traits measured in the Moorepark study are shown on Table 8. The h^2 estimates are very similar to that published previously (Veerkamp and Brotherstone, 1997). The h^2 estimates for milk traits varied from 0.24 to 0.57. The h^2 estimates for live weight and condition score vary from 0.38 to 0.47. As expected the h^2 estimate for pregnancy rate was low at 0.05.

Daily milk yield and associated parameters comprised of the average of at least 3 tests within 150 days post-calving, Average live weight and condition score was calculated in a similar fashion. Minimum live weight and condition score was determined from the lowest value observed during the 150-day post-calving period. Pre-calving condition score was taken to be the last condition score value recorded before calving. Condition score change was calculated as the difference between the pre-calving and minimum condition score post-calving. Pregnancy rate was determined by rectal palpation in late autumn.

Table 8

Heritabilities (h^2) for performance traits measured on the Moorepark study 1999

Trait	h^2
Daily milk yield	0.25
Daily SCM milk yield	0.29
Daily fat yield	0.38
Daily protein yield	0.25
Daily lactose yield	0.24
Fat%	0.57
Protein %	0.51
Lactose %	0.43
Average live weight	0.45
Minimum live weight	0.38
Average condition score	0.47
Pre-calving condition score	0.36
Minimum condition score	0.41
Condition score change	0.08
Pregnancy rate	0.05

Genetic correlation

Although the h^2 estimate for pregnancy rate is low there is general agreement that there is considerable genetic variation within the trait. In recent years there has been great interest in traits that may help predict fertility traits. A genetic correlation illustrates correlation between the breeding values for two traits. As shown in Table 9, and as expected the genetic correlation between milk yield and yields of milk solids is high.

Preliminary results indicate that high milk yield is positively correlated with high live weight and both of these traits are negatively correlated with pregnancy rate. As milk yield increases condition score decreases. Minimum condition score postcalving is correlated with milk yield. As milk yield increases minimum condition score decreases, and minimum condition score in turn is negatively correlated with pregnancy rate. Protein percentage is negatively correlated with yield, and positively correlated with pre-calving condition score.

The preliminary results suggest that both live weight and condition score might be important traits in the selection process for improved reproductive performance because both have high h^2 and are strongly correlated with pregnancy rate.

The present data set ranged between 3,888 and 2,785 cows for the various traits investigated. In order to strengthen the reliability of the h^2 and genetic correlation estimates, further data will be added. As previously outlined performance information from a potential 6,399 cows in 1999 is currently available. Traits pertinent to the fertility measures must be careful defined and time will also be given to improving/refining the models used to analyse the data.

Table 9

Genetic correlations and regression coefficients between some performance traits measured on the Moorepark study 1999

Traits	Genetic correlation	Regression coefficient
Yield * SCM yield	0.74	0.677
Yield * fat yield	0.46	0.023
Yield * protein yield	0.80	0.025
Yield * lactose yield	0.97	0.044
Yield * fat %	-0.29	-0.052
Yield * protein %	-0.36	-0.028
Yield * Lactose %	-0.17	-0.008
Yield * mean live weight	0.42	7.662
Yield * min. live weight	0.49	8.517
Yield * mean condition score	-0.34	-3.770
Yield * PCCS condition score	-0.19	-2.032
Yield * min. condition score	-0.43	-5.335
Yield * condition score change	-0.51	-2.563
Yield * preg. rate	-0.47	-0.019
Fat % * preg. rate	-0.51	-0.101
Protein % * min. condition score	0.11	17.167
Protein % * PCCS condition score	0.22	30.458
Live weight * mean condition score	0.31	0.187
Live weight * preg. rate	-0.40	-0.001
Mean condition score * preg. rate	0.44	0.002
Min. condition score * PCCS	0.91	0.835
Min. condition score * preg. rate	0.56	0.002
PCCS * preg. rate	0.39	0.001

Key observations

- The results to date are preliminary and further analysis is required before key results are established.
- The first service pregnancy rates of 48% is well below the target value of 60% set some years ago for seasonal calving herds.
- The average submission rate achieved was 70% which is below the international and target Irish value of 80%.
- The top quartile of herds for pregnancy rate to first service also achieved a more favourable pregnancy rate to second service, no. of services per conception, calving to service interval, infertile rate and length of breeding season.
- Both the calving to conception interval of 89 days and the infertile rate of 14% indicate that calving date is slipping by on average 4 days per year and the infertile rate is greater than the target 10%.
- The h^2 estimates for milk traits varied from 0.24 to 0.57. The h^2 estimates

for live weight and condition score vary from 0.38 to 0.47. As expected the h^2 estimate for pregnancy rate was low at 0.05.

- Preliminary results suggest significant genetic correlations between milk yield, live weight, condition score and pregnancy rate.

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Embryo Loss in Dairy Cows: Implications for Breeding Management

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Reproductive failure in dairy cows results in lower milk production, fewer calves born, slower rate of genetic progress and consequently, significant financial loss to individual producers and the overall industry. There is evidence that dairy cow fertility is declining in association with increased milk yields, increased herd size and decreased labour investment per cow. Following insemination early embryo death is recognised as the major cause of reproductive failure. Artificial insemination of cattle is the most important reproductive technology developed in the past 60 years and most dairy producers use it to improve the quality of their cows. However, reduced conception rates in lactating cows substantially reduces the impact of this technology as well as increasing the cost of using it. In this paper new information relating to the timing, extent and causes of embryo death as well as new research technologies to overcome problems with heat detection are discussed.

Importance of heat detection and conception rate in determining herd reproductive efficiency

For herds using AI heat detection rate and calving rate are the two major determinants of compactness of calving and the proportion of cows that fail to conceive in a defined 13-week breeding season (Table 1) and ultimately of the calving to-calving interval.

Heat detection efficiency and conception rate are of equal importance in determining compactness of calving and ultimately the proportion of cows culled as infertile at the end of the season. Days lost as a result of low

Table 1
The effect of heat detection and conception rates on the % of the dairy herd that is pregnant at 90 days after onset of breeding season

		Conception Rate %			
		60	50	40	30
	90	96	91	83	71
Heat Detection	70	89	82	73	61
Rate %	50	76	68	59	48
	40	67	59	50	40

conception rate can be offset by improving heat detection or submission rate. Improving heat detection efficiency from 70 to 90% is equivalent to the effect of increasing conception rates from 40 to 52%. However, producers are often much more concerned about low conception rate than poor heat detection.

Long-term trends in conception rate

Dairy cow fertility is usually measured by calculating the percentage of cows that conceive to a single service. Conception rate to a single service however has dramatically declined over the past 5 decades as production per cows has increased (Fig. 1). It is argued that this decline in conception rate is the direct result of changes in cow genetic merit for milk production. However, there is no evidence, over the same time period, of a decline in heifer fertility (Fig. 2). This would argue against this particular hypothesis and suggests that

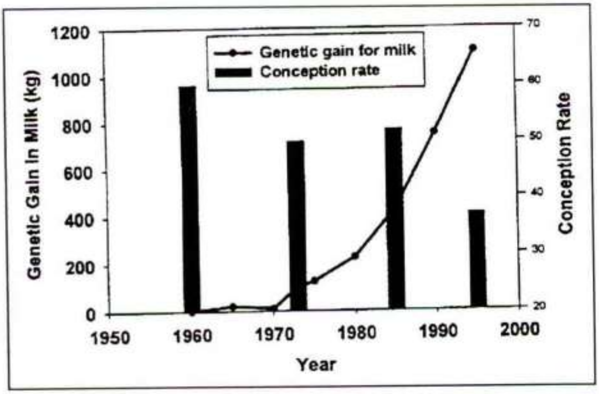

Fig. 1 - Trends in genetic gain in milk and conception rate in Holstein cows in the USA. Conception rate data from (Darwash et al 1999)

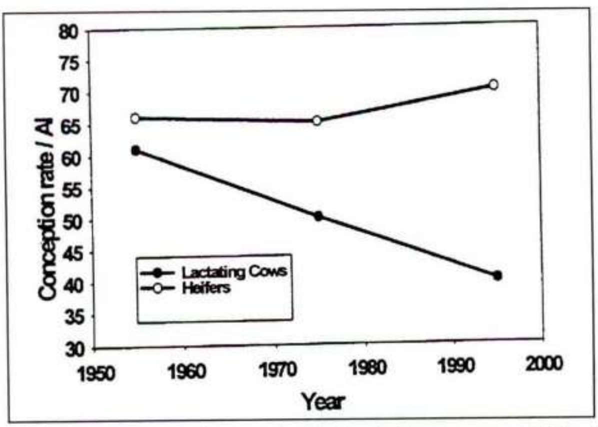

Fig. 2 - Changes in conception rates in lactating cows and heifers in the USA from 1955 to 1995 (Source: Pursley et al. 1997)

the Holstein is inherently fertile but that its reproductive performance is significantly compromised by relatively high levels of milk production (Nebel & McGilliard, 1993).

Factors determining conception rate

Four interacting factors determine cow conception rate viz., 1) Cow-related factors such factors as nutrition, production level and metabolic load, 2) Bull factors such as semen quality, 3) Accuracy of heat detection and, 4) AI technique. The interactive effect of these factors on the probability of conception is presented in Table 2.

Table 2
Interactive effects of four factors that determine conception rate to AI in dairy herds

	Female Fertility	Bull Fertility	Accuracy of heats	AI Technique	Conception rate
Heifers	80%	95%	95%	95%	73%
Lactating dairy cows	55%	95%	95%	95%	47%
Lactating dairy cows + inaccurate heat detection	55%	95%	80%	95%	40%
Lactating dairy cows + insemination problems	55%	95%	95%	50%	25%

When all factors are optimised as for heifers, a projected pregnancy rate of 73% is obtained. However, even in well-managed herds cow pregnancy rate is reduced as a result of reduced female fertility notwithstanding, that all of the other three factors are optimised. Insemination at the wrong time due to inaccurate heat detection, improper handling of semen, or poor insemination technique can all substantially reduce pregnancy rate. Although fertility varies among bulls the fertility of semen acquired through AI organisations is controlled and should not generally limit conception rate. Of these four factors, accuracy of heat detection and AI efficiency can be maximised through the adoption of good management practices. Thus, most of the observed differences in fertility between heifers and lactating cows is likely to be attributable to "female" factors.

Female factors affecting conception rate

Female-related factors affecting conception rate include calving to service interval, energy balance and protein nutrition.

Fertilisation rate and early embryo mortality

The extent and pattern of early embryo loss has been established for heifers and moderate yielding dairy cows. Published estimates of fertilisation rate of about 90%, and of average calving rates of about 55% indicate an embryonic and foetal mortality rate of about 38% with little evidence of a difference between moderate-yielding cows and heifers provided that calving-to-service interval is greater than 60 days. Of this total loss, 70 to 80% is sustained between days 8 and 16 after insemination, a further 10% between days 16 and 42 and a further 5-8% between day 42 and term (see review, Sreenan and Diskin, 1986; Peters, 1997).

Studies characterising the time and extent of early embryo loss in high-yielding dairy cows are difficult and expensive to conduct and thus there is little published information on the pattern of early embryo loss in high genetic merit, high yielding dairy cows.

Late embryo mortality

One US study (Vasconcelos et al., 1997) indicates that intensively fed and managed dairy cows, yielding 11,000 - 12,000 kg of milk per cow sustain a relatively high increment of late embryo loss. These authors reported an embryo loss rate of 20% between 28 and 98 days of gestation. It is frequently suggested that there is a high increment of late embryo loss in high yielding dairy cows in seasonal, grass-based calving systems in Ireland but there is no published evidence to support this. A study to measure the extent and the pattern of late embryo loss in high genetic merit, high yielding dairy cows and heifers was conducted by Teagasc in 1999 (Silke et al, 2000). A total of 835 lactating dairy cows, yielding between 4,000 and 8,500 Kg milk and 158 dairy heifers located on seven farms were used in the study. Herd size ranged from 60 to 180 cows. In order to measure the extent and timing of embryo and foetal loss, cows and heifers that had been inseminated and had not been observed to repeat and were, therefore, presumed pregnant were presented for first scan on day 28 following insemination. Each animal confirmed pregnant at day 28 was subsequently scanned at two-week intervals until day 84 of gestation. Diagnosis of pregnancy was based on the presence of a competent corpus luteum, a viable foetus with heartbeat evident and clear amniotic fluid. Results are presented in Table 3.

Table 3
Embryo survival rate between Days 28 and 84 of gestation in dairy cows and heifers

	Day of Gestation					
	28	42	56	70	84	Overall
No. Cows	601	581	569	565	557	
Embryo survival %	100	97	95	94	93	7%
No. Heifers	132	130	127	125	124	
Embryo survival %	100	98	96	95	94	6%

Silke et al., 2000

The extent and pattern of embryo loss recorded in this study is similar to that previously published (see review, Sreenan and Diskin, 1986) for heifers and moderate yielding dairy cows and suggests that the incidence of late embryo mortality is relatively small (about l/10th) compared with incidence of early embryo mortality. The higher increment of late embryo loss reported by Vasconcelos et al (1997) may be due to the higher milk yield and other possible environmental factors particular to that study. It is probable that the low conception rates 30-40% in high yielding cows in grass-based systems of milk production is the result of a higher incidence of early embryo loss.

Possible causes of embryo loss in cattle

As indicated earlier, following insemination, there is an embryonic and foetal mortality rate of about 30-40% in heifers and moderate yielding cows, of which about 3/4 of it is sustained between days 8 and 16 after insemination. In high-yielding cows it seems that embryo mortality rate is about 50-60%. The biological mechanisms, which cause embryo death especially in high genetic merit, high yielding dairy cows, are poorly understood. Many factors have been implicated, though usually wit a lack of supporting experimental data. Progesterone, secreted by the corpus luteum is essential for both the establishment and maintenance of pregnancy.

Progesterone and embryo survival

Progesterone has also been shown to directly affect the growth and development rate of the bovine conceptus (Garrett et al., 1988) and to be positively correlated with interferon-τ secretion. In conjunction with the trophoblastic proteins, endometrial proteins also constitute part of the maternalembryonic dialogue; essential for embryo survival and progesterone plays a major role in controlling uterine secretion of proteins and growth factors. In sheep the concentration and secretion of a number of endometrial proteins has been shown to be affected by progesterone. The specific role of many of these proteins, which may be modified either directly or indirectly by nutrition, in facilitating embryo survival is not yet established. It is frequently postulated however, that the lower fertility observed in high yielding dairy cows is the result of a reduction in systemic progesterone, resulting from high rates of metabolism associated with lactation and with high energy intakes.

Negative energy balance during the early postpartum period

High producing dairy cows are in negative energy balance for a period after calving and this is frequently implicated as the most significant cause of the reduced fertility. At this time cows mobilise their body reserves because they simply cannot consume enough food to support maintenance and milk production. Rapid mobilisation of body fat may further depress appetite causing an even greater increase in the difference between the energy required for milk synthesis and maintenance and the feed energy intake.

The severity of the NEB depends not only on the milk production level but also on the body condition score at calving, cow age and parity and the amount

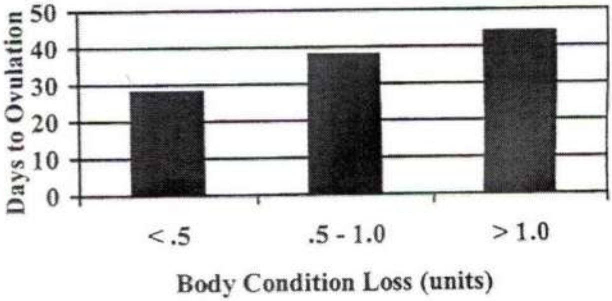

Fig. 3 – Body condition loss during the first 30 days of lactation and interval to first ovulation postpartum

and quality of feed available. The consequence of severe negative energy balance in early lactation is excessive loss in body condition score (BCS) and the delayed resumption of oestrous cycles (Butler, 1999) (see Fig. 3). The number of ovulatory cycles preceding first ovulation has in turn been shown to positively influence subsequent conception rate. Therefore it is important to ensure that BCS score loss is minimized after calving.

Relationship between BCS and conception rate to 1st service in lactating dairy cows

Besides the effects that excessive loss of body condition has on delaying the resumption of oestrous cycles post-calving there is also evidence that the decreased fertility seen in high yielding cows is associated with excessive BCS loss between calving and breeding. In almost all published studies each 0.5 unit loss in BCS between calving and insemination has resulted in a decline in conception rate of 10-15%.

Possible mechanisms by which energy balance affects embryo survival rates

The mechanisms by which negative energy balance during the early postpartum period may affect subsequent embryo survival rate are yet not established. Ovarian follicles may be detrimentally affected by NEB during their early growth and development (Britt, 1992) which could affect the secretion of progesterone which would directly affect embryo survival rate. Another possibility is of NEB effects on developmental competence of oocytes (Britt, 1992) and there is some recent evidence to support this hypothesis. Lactating cows were fed high or low energy diets after calving and NEB lasted for three versus seven weeks of lactation, respectively (Kendrick et al., 1999) and oocytes were aspirated twice weekly between 30 and 100 days of lactation. Cows on the high-energy diet produced more oocytes and oocytes of higher quality compared with cows in greater NEB. In a similar study, cows having more severe postpartum NEB due to over-fatness at calving, consistently produced lower developmentally potent oocytes compared to controls (Kruip et al., 1999).

Another important link between NEB and embryo loss may be the carryover effects on blood progesterone concentrations. Previous studies have shown that progesterone in the peripheral circulation increases during the first two or three postpartum ovulatory cycles. Consequently, if onset of regular oestrous cycles is delayed cows may be inseminated at a cycle when blood concentrations of progesterone are sub-optimal for high embryo survival rates.

Concurrent energy nutrition - metabolic rate and embryo loss

An inverse relationship between energy intake and systemic progesterone has been established for pigs, sheep and dairy cows. The lower blood concentrations of progesterone in animals fed the higher diets and presumably having the higher metabolic rate has been attributed to increased clearance rate of blood progesterone by the liver. Therefore, lower blood concentrations of progesterone would in turn negatively affect embryo growth and thereby could fatally compromise the embryo. In dairy cows, dietary intake increases about two-fold while metabolic rate would increase 3-fold during early lactation, which in often situation is coincident with the onset of the breeding period. In this situation any increase in progesterone clearance due to high dietary intake (including both energy and protein), combined with the aforementioned carryover effects of NEB that result in lower plasma progesterone concentrations, would act to further compromise progesterone-dependent uterine mechanisms during early pregnancy and, thereby, reduce fertility in cattle. The reduced progesterone effect may operate either at the follicle level reducing oocyte competence or by retarding the growth and development rate of the embryo or by controlling uterine secretion of proteins and growth factors essential for early embryo development.

A heifer model was used by Dunne et al (1999) to determine the effect of changes in energy intake near the time of insemination on systemic progesterone concentration and directly on early embryo survival. Embryo recovery between days 8 and 16 after AI was used to measure embryo survival rate.

When energy intake was reduced from a high level of twice their maintenance requirement to 0.8 times maintenance for two weeks immediately after AI, embryo survival rate in heifers was consistently less than 40%. When heifers were provided with a constant level of energy or when they were

Table 4

Effect of nutrition on embryo survival rate in heifers

	Level of pre partum nutrition				
	Low-Low	Low-High	High-High	High-Low	Pre x Post interaction
No. Heifers	66	65	60	56	
Total Pregnant	46	46	39	21	
Embryo survival rate	70%	71%	65%	38%	$p < 0.05$

Source Dunne et al., 1999

changed from a low to a high level embryo survival was high at 65-70%. In that study there was no indication of any association between energy intake and systemic progesterone concentration. Unlike the situation in the sheep and pig there was no change in systemic progesterone following either an increase or reduction in energy intake. Changes in progesterone metabolism may have been balanced by changes in progesterone production.

Delayed progesterone rise and embryo survival rate

In lactating dairy cows there is some evidence (Vasconcelos et al., 1998) that high dietary intakes results in an acute reduction circulating concentrations of progesterone. There is also evidence (Mann et al., 1999) that a delayed rise in progesterone concentrations during the first 5 days after breeding results in smaller embryos that produced lower uterine quantities of interferon-r and therefore, would be expected to be less capable of inhibiting luteolysis and the cow returning to oestrus. These studies have been followed by progesterone supplementation studies where the cows that were given exogenous progesterone had a significant but a small (5%) overall improvement in pregnancy rate. However, in herds where pregnancy rates were low (<50%) a large improvement in pregnancy rate (+19.3%) was obtained whereas not improvement was obtained in herds with was already high. In a more recent study, Starbuck et al. (1999) showed that progesterone supplementation of cows with a low (<2 ng/ml) of milk progesterone on day 5 after breeding resulted in almost a doubling of pregnancy rate from 28% to 55% with no effect in cows with higher milk concentrations of progesterone on day 5. Cumulatively, these studies would suggest that in lactating dairy cows, progesterone concentrations during the early phase of the cycle have an important role in determining the fate of the embryo, and that progesterone supplementation starting at day 5 post breeding may well improve pregnancy rates in cows that have a low or delayed rise in progesterone.

Elevated body temperature and embryo survival rate

The early embryo is adversely susceptible to small increases in maternal temperature. While heat stress is normally associated with climate it can also arise if metabolism is high and if animals are unable to quickly dissipate the extra heat produced. High yielding dairy cows on a high plane of nutrition have an increased metabolic rate and dissipating heat takes longer.

Protein nutrition and cow fertility

Dairy cows respond to high levels of protein in early lactation with an increased milk output, though such increases are dependent on an increased intake of energy. There is evidence that the concentration and type of protein in the diet can affect dairy cow conception rate (see review by Butler 1999). During the metabolism of excessive quantities dietary protein by rumen microorganisms or during the rapid mobilisation of body protein reserves in early lactation relatively large quantities of ammonia are generated. Rumen ammonia not utilised by rumen microorganisms is absorbed through the rumen wall and must be rapidly detoxified to urea in the liver to prevent ammonia toxicity. High protein diets elevate plasma urea nitrogen levels. In US studies plasma urea nitrogen (PUN) in excess of 19 mg/dl has been associated with a 20% depression in conception rate in dairy cows. Ferguson and Chalupa (1989) concluded that in most published studies, diets with a high content of crude protein decreased reproductive efficiency. While the US studies have shown a clear negative association between elevated blood urea and pregnancy rates there is little European data showing such clear-cut negative associations. In Ireland, well fertilized Spring pastures would have crude protein contents of 20-30%, which would be expected to result in elated blood concentrations of urea. We have recently examined the association between herbage protein content, blood urea, and blood ammonia and embryo survival rate.

While there are several reports of putative toxic effects of elevated systemic urea and, or ammonia on both gametes and embryos there is no published information on the direct effect of protein nutrition on cattle embryos. Kenny et al. (1999) have concluded from a study of the effects of high nitrogen pasture that intakes of such pasture while leading to significantly elevated systemic concentrations of ammonia and urea in heifers do not affect embryo survival rate (Table 5).

Table 5

The effect of pasture protein content and molassed sugar beet pulp supplementation on plasma urea and ammonia concentrations and embryo survival rate in heifers. Low- and high-nitrogen pastures and crude protein contents of 13.0% and 25.4%, respectively.

	High Nitrogen + 0 Pulp	High Nitrogen + 3 Pulp	Low Nitrogen + 0 Pulp	Low Nitrogen + 3 Pulp
No. heifers	44	44	43	44
Plasma Urea (mmol/L)	7.41	5.89	2.68	2.84
Plasma Ammonia (mg/L)	0.45	0.33	0.27	0.21
No. Pregnant	29	31	28	36
% Pregnant	66	70	65	82

Kenny et al., 1999

Even at systemic concentrations of blood urea nitrogen as high as 25-27 mg/dL in heifers embryo survival was not affected. Clearly, elevated systemic concentrations of ammonia and urea per se do not reduce embryo survival rate but there may be other modifying factors such as negative energy balance operating in the high yielding dairy cow.

Strategies to minimise the consequences of early embryo loss

A major challenge facing researches is to gain a better understanding of the significant factors that affect embryo survival. This involves studies of the parameters of cattle embryo growth and determining how these are affected by protein and energy nutrition, milk production, metabolic rate and energy balance. Without such information it will not be possible to reverse the downward trends in cow fertility. In the mean-time producers must concentrate on factors directly under their control and or use technologies that have the potential to increase improve reproductive performance.

- Calve cows in a moderate BCS and minimise BCS loss in early lactation.
- Have cows gaining in BCS at breeding.
- Have heifers well-grown (350-380 kg) at 15 months. Breed to calve early. Consider using synchronisation for heifers.
- Minimise the risk of calving difficulty
- Increase submission rates by paying particular attention to heat detection. Use tail-paint. Carry out pre-breeding heat detection.
- Ensure that the semen used is of high fertility and that the storage and handling of semen as well as insemination technique are all correct. Do a refresher AI course every second year.
- Inseminate cows at the correct time.
- Avoid sudden reductions in dietary intake during the breeding period.
- Avoid sudden reductions in concentrate feeding during the dry period.
- Maintain good records, early identification of and appropriate treatments of potentially problem cows.
- If using natural service bulls be vigilant to ensure that bull(s) is fertile.

New ongoing research on method of heat detection

Heat detection is a time consuming repetitive chore that must be carried out up to 5-times a day each day for as long as AI is used. Heat detection rate, usually measured as submission rate, is hugely variable from herd-to-herd but between 40 and 70% of cows that exhibit heat are actually detected in heat by the stockman. About 10% of the reasons for failure to detect heats can be attributed to cow problems and 90% to "management" problems. The latter would include too few observations per day for checking for heat activity, too little time spent observing the cows or observing the cows at the wrong times or in the wrong place such as at feeding time or in the collecting yard at milking time. Currently, there are a number of technological methods of oestrous detection that offer potential to improve heat detection efficiency at farm level and these are currently being studied.

Pressure activated heat mount detectors

These devices including those marketed as KAMARs are fixed to the tail head of the cow and change colour when pressure is applied by the mounting animal. The relatively low accuracy (56-94%) of heat detection combined with difficulties in keeping the devises affixed to the tail head limit the potential of this approach.

Pedometers

Oestrus in cattle is accompanied by increased physical activity. Cows in heat do walk 24 times more than non-oestrous cows. Pedometers are devices that can be attached to the leg of the cow to measure the amount of her activity over a certain time span. New improved pedometric technology has now led to improved information storage systems, improved analytical capabilities to allow comparison of current with previous physical activity, incorporation of internal power supply to operate the electronics, the development of self-contained devices to interrogate the pedometers in milking parlour and relay or store information in a personal computer. Some systems have an inbuilt alert system such as a bleeper or flashing light, which alerts the farmer when a cow is deemed to be in heat. A number of pedometric systems are commercially available in the US. While scientific information on their operating efficiencies is not yet available these systems would appear to have significant commercial potential.

HeatWatch (DDX Inc.)

The primary sign of heat is standing to be mounted. A number of research laboratories have attempted to develop pressure sensitive devices that measure such standing activity. Such a system (**HeatWatch**; DDX INC, Colorado, USA) is currently commercially available in the US and in a number of other countries. This system involves the location of a pressure sensitive battery-powered transmitter on the cows tail head which, when activated by the mounting cow emits a radio signal which is picked up by either a receiver or repeater (see Figure 4) and relayed to a buffer and ultimately to a personal computer where the information is digitized and stored. The time, date and duration of each mount along with the identity of each cow are recorded. From this information the time of heat onset is calculated. The HeatWatch software generates management and individual cow reports that can be viewed or

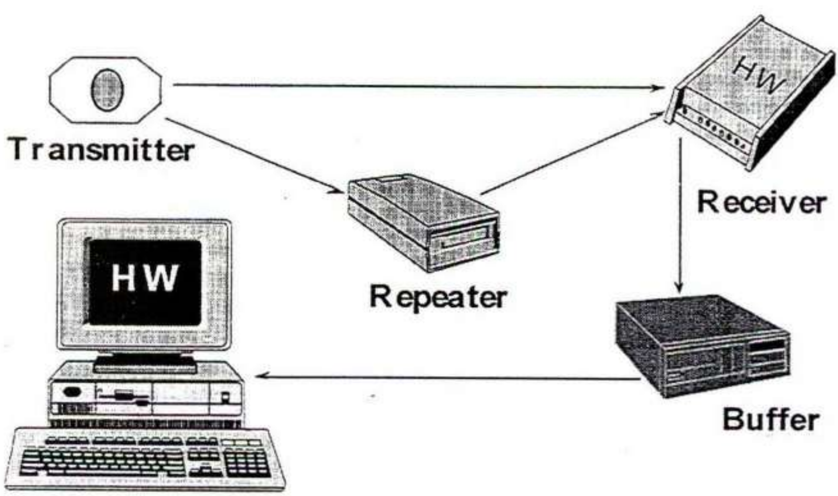

Figure 4 - Components of the HeatWatch 24h oestrus detection system. (Courtesy DDx, Inc.)

printed. Periodically during the day the farmer checks the computer for a listing of cows in heat. The limited data available suggests that HeatWatch operate with both an efficiency and accuracy of almost 100% in detecting cows in heat. Teagasc at Athenry are currently evaluating the HeatWatch system for heat detection in both dairy and beef cows. HeatWatch is an extremely powerful research tool, operates well under both indoor and

Preliminary results from the Teagasc, Athenry study is presented in Table 6. Heifers were also scanned at 4-hour intervals to determine time of ovulation.

Table 6

Heat activity and time of ovulation date for heifers

No. heifers	23
No. observed in heat	23
Average number of mounts per heifer	39
Range	(6 - 98)
Average duration of heat	14.5 hours
Range	6 - 32 hours
Average interval from start of heat to time of ovulation	30.6 hours

The results of this study illustrate the wide variation in both mounting activity and the duration of standing heat among heifers.

The current HeatWatch system is expensive (£10,000 for a unit for 100 cows excluding cost of computer and printer). The cost is currently exacerbated by low Euro:Dollar exchange rate. The HeatWatch system is not yet commercially available in Ireland or in any other country within the EU. DDX Inc. is redeveloping the system to operate on the radio band frequencies that are available for such devices within the EU.

As a lower cost alternative to the complete HeatWatch system DDX have recently launched a system (**MountCount**) that counts the number of mounts received by a cow in heat. The MountCount is a manual version of the current HeatWatch transmitter. The battery-powered unit is affixed to the tail head of the cow. It contains a pressure switch that is activated when the cow is mounted. When a certain threshold of mounts is reached a light is activated on the device the alerts the farmer that the cow is in heat and should be inseminated. Different flashing light patterns alert the farmer when the cow is in suspect heat, standing heat and when she is considered ideal for breeding. The cost of one MountCount unit is about £60 and is good to detect up to 20 heats.

Yet another alternative and cheaper system **HeatWatch Express**. This does not need a computer or software to process and display the data. Again like the other DDX systems a small batter-powered radio transmitter is affixed to the tailhead of the cow. The mount data is relayed to a radio receiver and then to a buffer in the farm office from which the data can be printed. The cost of this product is about \$2,000 or about £1,700.

DEC (IMV Technologies)

IMV Technologies in France have also developed a pressure sensitive mount count detector. This system known as **DEC** is commercially available in Ireland. The device is programmed in such a way that when a certain number of valid mounts have been recorded a light, incorporated into the DEC, starts to flash. The number of flashes is in proportion to the time elapsed since the first valid mount was recorded. The number of flashes in a 10-second period indicates the time of heat onset and most appropriate time to inseminate the cow. The unit cost of the system is about £60 and each unit is good for up to 30 heats. This system would appear to have potential and is being evaluated at Teagasc, Athenry this year.

Some of these systems are being used in a research programme with dairy and beef cows and heifers at Teagasc Athenry with the objective of accurately defining the parameters of heat activity and ultimately with the objective of finding a practical cost effective system for both dairy and beef farmers.

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Profitable and Enjoyable Dairy Farming

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In an ideal world most dairy farmers would set the objectives of producing an acceptable level of profit, based on return on labour and investment on the farm, whilst having an enjoyable lifestyle. Whilst dairy farming needs to be profitable to be enjoyable, it can also be profitable but not necessarily enjoyable, for example if the farmer is committed to long hours of drudgery in order to generate an acceptable level of profit. The aim of this paper is to examine some of the key factors influencing both the profitability and enjoyability of dairy farming in the 21st century. At the outset, it is important to highlight the increasing opportunities at present for potential young farmers to move to other sectors of employment. Many of these alternative employment opportunities offer relatively short working hours, good working conditions and high salaries relative to those sustainable from dairy farming. If dairy farming is to attract bright, young entrepreneurs into the industry in future, we need to demonstrate that it has the potential to generate acceptable profit levels combined with an enjoyable lifestyle.

Key issues affecting profitability

Profit margins

Profitability of dairying in Northern Ireland has declined markedly over the last 5 years as shown in Table 1, in line with trends throughout the UK. These data are based on full farm accounts information for approximately 150 specialist dairy farms across Northern Ireland (McBurney, 2000). The major factors contributing to the decline in profitability include the strength of sterling versus the euro, European Union dairy reforms and the aftermath of

Table 1

Changes in milk production costs and farm income on Northern Ireland farms

	92/93	93/94	94/95	95/96	96/97	97/98	98/99
Herd size (Cows)	48.3	49.3	50.9	52.6	53.7	54.3	55.2
Milk price (p/litre)	19.8	21.3	21.6	26.1	23.7	20.4	18.9
Total farm output (£)	65116	68305	71628	77088	73497	63852	58218
Total fixed costs (£)	28280	26880	28260	29225	31292	31613	30056
Total variable costs (£)	22700	24990	25990	25810	27290	24134	22651
Net farm income (£)	14140	16430	17380	22055	14920	7283	3940

(McBurney, 1998 and McBurney, 20000

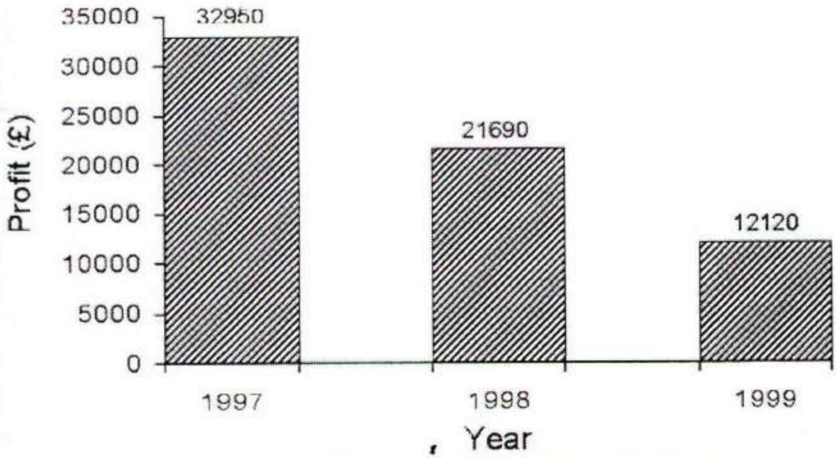

Fig. 1 - Profit trends in dairying - specialist dairy farms in England and Wales (Axient, 2000)

the BSE crisis. The net effect of these changes is that milk price has declined by 36% from a peak of 27.9p/litre in January 1996 to the current value of 17.8p/litre in January 2000. In addition, the value of cull cows and surplus bull calves has declined by approximately £200 and £55 per head over the same period. These reductions in price have resulted in a reduction in farm output of almost £19,000 over the period 1996-1999. Whilst some of this reduction in income is partially offset by lower input costs, many dairy farms in Northern Ireland are currently struggling to reach breakeven. Similarly, data from 100 Axient-costed dairy herds in England and Wales (see Figure 1), based on an average herd size of over 120 cows, indicate that farm profit, adjusted for inflation, has declined from £32,950 in 1997 to £12,120 in 1999.

Whilst the data presented above highlight changes in profitability for the "average" dairy farm in recent years, one of the most significant issues emerging from all costing schemes on dairy farms is the massive range in production costs between farms. McBurney (1998) in a further analysis of the Northern Ireland Farm Business Survey showed that 21% of farms had total input costs less than 10p/litre, whereas 13% had input costs greater than 16p/litre. The average cost of producing each litre was 13.3p (excluding family labour). This huge range in production cost per litre largely reflects the wide range in variable and fixed input costs per litre as illustrated in Table 2.

What are the Options?

The main options to maintain profitability with declining milk and livestock prices are:

i) Increase output
ii) Increase product value
iii) Reduce production costs

Increasing Output. In theory, increasing milk output offers the opportunity

Table 2

Distribution of variable and fixed input costs per litre of milk produced on Northern Ireland farms (1997/98)

Cost per litre (p)	Variable Costs	Fixed Costs
	(% of farms costed)	
Less than 4.0	1	18
4.0 - 4.9	21	30
5.0 - 5.9	31	16
6.0 - 6.9	29	14
7.0 - 8.4	14	12
8.5 - 11.5	4	10
Average	6.49	6.82

(McBurney, 1998)

to reduce the cost of each litre or gallon of milk produced by improving economy of scale. For example, fixed costs are spread over a greater number of litres, thereby reducing the fixed cost per litre. However in practice the benefits of fixed cost dilution on dairy farms are relatively small, with most survey data indicating similar fixed costs per litre across a wide range of farm size. There is also little point in producing more of something, if you are already making a loss on what you are producing - the risk is that you will go under more quickly. The main advantage of increasing herd size is to improve the efficiency of labour use and therefore reduce labour costs per litre. Increasing output can help to maintain/improve profit levels in situations where production costs are already low, and where the value of the extra milk produced is greater than the variable and quota costs of the extra production, as shown in Table 3. The data presented in Table 3 indicate that in the case of a high cost producer, producing an additional 100,000 litres of milk only

Table 3

Effect of increasing milk output or reducing production costs on farm margin assuming a base quota of 500,000 litres

Option A*   Increase milk output by 100,000 litres

	High Cost Producer	Low Cost Producer
Milk price (p/litre)	18	18
Leasing cost (p/litre)	6	6
Variable costs etc (p/litre)	8	6
Margin/litre (p)	4	6
Farm margin (£)	+4000	+6000

* Assumes no change in fixed costs to produce additional milk

Option B   Reduce costs of production by 2p/litre

500,000 litres @, 2p = £10,000 increase in farm margin.

improves farm margin by £4,000. In contrast, a similar increase in production by a low cost producer increases farm margin by £6,000. In both cases it is assumed that increasing production by 100,000 litres results in no change in fixed costs. If fixed costs were to increase, the increase in farm margin through increasing production would decrease accordingly. However, rather than increasing production, farm margin could be increased by £10,000 on both farms if production costs were reduced by 2p/litre.

Increasing Product Value. Increasing milk value or the value of cull cows and surplus bull calves offers some opportunity to maintain farm profitability. For example, development of added value niche markets and/or organic production systems offers scope for a very limited number of producers to improve the value of farm output. However, such options need to be carefully considered, particularly from a milk marketing viewpoint, as short term price incentives may be eroded very quickly in the longer term.

Reducing Production Costs. The primary opportunity to maintain farm profit levels, given lower farm output value, involves cost reduction. As shown in Table 3, reducing production costs per litre has much more impact on overall farm profitability than increasing milk output in a quota situation. The key to surviving and growing the dairy farm business in Ireland today, both north and south, is firstly to focus on cost reduction in the short term and then plan to expand the business in the longer term.

Whilst producers will argue that cost reduction is a difficult route, it is worth noting that even in New Zealand, renowned for lost cost production systems, milk producers responded to lower milk prices in 1989-1991 by reducing their costs even further, as shown in Table 4. These data indicate that producers responded immediately to a 24% reduction in milk price between 1989-1991 by reducing variable costs by 15%, and in the longer term, fixed costs were reduced by up to 22%. It is also worth noting the significant longer term trend for a reduction in fixed costs in New Zealand. For example, only 27% of gross income was spent on fixed costs in the 1994/95 season in comparison with 42% in 1986/87. In comparison, data from the Northern Ireland Farm Business Survey (McBurney, 2000) indicate that fixed costs, as

Table 4
Response by New Zealand dairy farmers to lower milk prices

	88/89	89/90	90/91	91/92	92/93	93/94	94/95
Milk price ($/kg MS)	3.71	3.29	2.83	3.93	3.83	2.78	2.92
Gross Farm Income ($/ha)	2621	2863	2090	2250	2687	2664	2556
Fixed Expenditure		751	683	682			
($/ha)	874	878	823	690			
Variable Expenditure	907	1036	882	945	1200	1267	1182
Farm Income ($/ha)	1006	1056	416	672	779	747	691

Attrill and Miller (1996)

a proportion of total farm output, increased from 43% in 1992/93 to 52% in 1998/99. The problem on many dairy farms today is that over investment in machinery and buildings, during a period of high milk price, has resulted in greater reliance on higher cost production systems (e.g. increased use of silage and indoor feeding rather than grazed grass). Given the increased pressure on dairy farm incomes, there is a real need to reduce fixed costs and to replace purchased inputs with increased management expertise, particularly in the area of grazing management.

One of the potential difficulties of moving towards milk production systems with higher reliance on grazed grass, in a high fixed cost environment, is that if this is accompanied by large decreases in milk yield per cow, margins over direct animal costs (e.g., machinery and housing costs) become too low to generate an acceptable level of profit. This effect is illustrated in the data presented in Table 5. When fixed costs per cow and milk price are relatively low, as in New Zealand, increasing milk yield per cow produces relatively little benefit in total farm profit. In this situation there is only 0.9 p/litre available to cover the increased variable costs of production. In contrast, when fixed costs per cow are high, as in many dairy farms in Northern Ireland, increased farm profitability can be obtained by increasing milk yield per cow, providing less than £510 or 4.5 p/litre are incurred in the increased variable costs of increasing production from 4000 to 7000 litres per cow. These data highlight two key principles which need to be taken into consideration in developing grass-based production systems:

- If the grazing system adopted on the farm results in a major reduction in milk yield per cow, e.g., high stocking rate systems, fixed costs of production must be reduced.
- If fixed costs on the farm are relatively high, and difficult to reduce, the grazing system adopted must be capable of sustaining relatively high individual cow performance.

Table 5
Effect of milk production at two milk price levels

	Milk price (pence/litre) 10		17	
	£/cow	p/litre	£/cow	p/litre
Fixed costs	85		425	
40001 cow				
Milk sales	400	10	680	17
Margin to cover variable costs & profit	315	7.9	255	6.4
7000 1 cow				
Milk sales	700	10	1190	17
Margin to cover variable costs & profit	615	8.8	765	10.9
Increase in margin available to cover variable costs and profit by increasing yield/cow	300	0.9	510	4.5

Moving forward with grazed grass

One of the main advantages of grazing relative to other systems of milk production is the potential to significantly reduce production costs through savings on buildings, machinery and labour, and in many cases to improve the lifestyle for the farm family. However, effective use of grazed grass requires high levels of management input, particularly with respect to knowledge of grass growth rates through the season and implications for stocking rate. This requires a change of mindset from indoor feeding where planning of feed supply etc has much lower priority relative to undertaking the actual feeding out of silage and/or concentrates.

The critical areas in relation to effective grazing management include:

1. Planning next year's grazing season in the autumn.
2. Growing high yields of grass by attention to sward type and soil fertility
3. Ensuring grass grown is efficiently harvested by the grazing animal.
4. Ensuring animal has appropriate genetic merit to efficiently convert grass to milk and to get back in calf within 80 days of calving.

Whilst the top 5% of milk producers in Ireland are already achieving high levels of utilisation and production from grazed grass, there is huge potential to increase production at a national level. In order to fulfil this potential researchers and advisors need to deliver more accurate prediction of grass growth and better guidelines for grass budgeting through the season. There is also a need to recognise that grazing can have a major role in a wide range of production systems - ranging from the low cost New Zealand approach to high yielding, high genetic merit cows. For example, recent work at Hillsborough, presented in Figure 2, indicates that high yielding cows offered grazed grass plus 5.7 kg concentrates/day produced over 40 litres milk/day in early May and were still producing over 25 litres milk/day in late September.

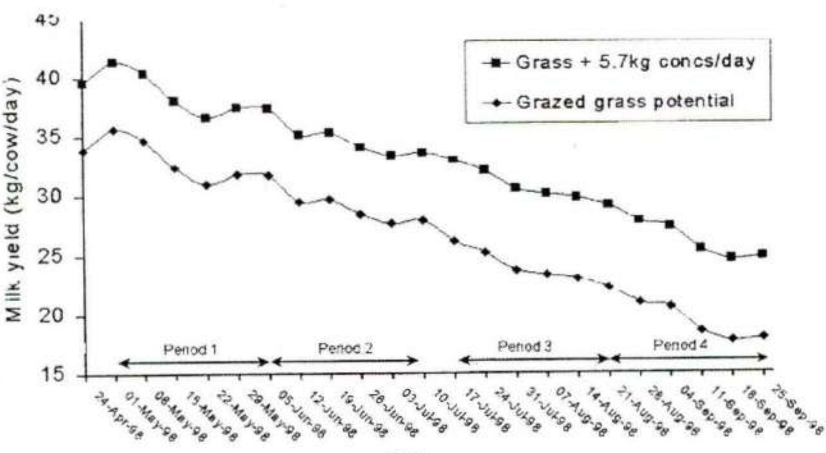

Fig. 2 - The real milk yield potential from grazed grass
(Sayers, et al., 2000)

Consequently, production from grazed grass peaked at approximately 35 litres/day in April/May, declining to 20 litres/day m mid September. These data indicate that grazed grass can play a very important role, even with very high yielding cows, whilst significantly reducing production costs relative to labour and capital intensive indoor feeding systems.

Controlling Costs

Current reductions in milk price have really focussed attention on the need to control costs in dairying. This implies much tighter financial budgeting on farms than has been the case previously. However the reality is that on many dairy farms, financial records and forward technical and financial budgets take second priority to the day-to-day management of the farm. This is despite the fact that the return on time spent on forward planning is many times greater than time spent on routine manual tasks.

Effective technical and financial planning involves three main areas:

1. *Preparing a five year forward plan*

   This involves preparing a five year technical and financial plan, setting targets and detailing levels of technical performance (cow numbers, herd yield, milk composition, replacement rate etc) and yearly financial budgets (based on anticipated milk prices and changes in variable and fixed costs).

2. *Monitoring physical and financial performance*

   This involves continual monitoring of technical and financial performance in addition to bench marking with other farmers using a similar production system. Given the current pressure on dairy farm incomes, justifying every £ spent off the farm and assessing comparative rates of return on investment is essential if reasonable profit margins are to be obtained from dairying. Bench marking provides the opportunity to compare technical and financial performance with other farms, enabling identification of the strengths and weaknesses of the farm business.

3. *Revise forward plan*

   Regular updating of the five year forward plan is required to adjust for changes in levels of physical or financial performance. Examination of what if scenarios also allows preparation for planned changes in the production system if individual farm circumstances change.

   With continued pressure on milk price, through EU reforms, over the period 2000-2006, reductions in cost coupled with forward technical and financial planning will become increasingly important if profit margins on dairy farms are to be maintained. Increased emphasis in these areas is likely to lead to a greater impact on overall farm profitability than small improvements in the level of technical efficiency.

Enjoyable Dairy Farming

Defining enjoyable dairy farming is difficult as every individual farmer has their own definition of enjoyment. Nonetheless, enjoyable dairy farming is likely to be characterised by a number of common features, irrespective of the actual production system being used:

1. Dairying should provide a reasonable return for the labour and investment input into the business.
2. Must have low or tolerable levels of stress.
3. Must provide opportunity for quality leisure/family time.

I would suggest that, in order to sustain these aspirations, dairy farming systems should be characterised by the following goals:

i) System used should be based on a simple, effective production base. Systems should be relatively easy to manage with clearly defined targets and goals and avoiding the need for complex decision-making on a daily basis.

ii) Labour input needs to be sustainable. Whilst stressful work routines can be tolerated for short periods, prolonged periods of high stress inevitability reduce both productivity and enjoyment.

iii) Cows of appropriate genetic merit should be selected to suit the production system being used. The system should involve using efficient, healthy cows that calve down and rebreed when required, preferably avoiding cows that are continually on the knife edge in terms of feeding and management.

Having identified these goals, I would contend that block, seasonal calving with maximum use of grazed grass offers the best opportunity of delivering profitable, enjoyable dairy farming. Furthermore, this system with its reduced labour and capital investment requirements, is much more likely to attract the next generation of young farmers into the industry, compared to the high labour and capital input alternatives.

Conclusions

Profitability of dairy farming in Northern Ireland has declined substantially over the last 5 years with net farm income for a typical 55 cow herd declining from over £22,000 in 1995/96 to £3,940 in 1998/99. Furthermore, current EU reforms imply that incomes will continue to be under pressure until at least 2006. In order to continue to attract bright, young entrepreneurs into dairy farming in the future, we need to ensure that we are using production systems that generate acceptable profit levels combined with an enjoyable lifestyle. The key to profitable dairy farming at present is to focus on cost reduction in the short term, whilst at the same time planning to expand the business in the longer term. This inevitably means that average herd size will continue to increase in the future, putting more pressure on family labour. Enjoyable dairy farming involves reducing stress levels, producing an acceptable profit level and providing opportunity for time off from the day-to-day routine. I would contend that the twin objectives of profitable and enjoyable dairying can best be achieved by using block seasonal calving systems designed to maximise the use of grazed grass with cows that will efficiently convert grass to milk and get back into calf within 80 days of calving.

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Growing a Business from a Dairying Base

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In addressing the issue of "growing a business from a dairying base", I intend to give a short outline of where we have come from as dairy farmers, where we are now, the direction we decided to take, and why. A look at some of the issues involved in taking that decision and the issues involved going forward.

My wife Helen and I are farming in our own right for a period of 8 years. In 1992 we took over the family dairy farm near Clonakilty, West Cork. At that stage the farm had 127 adjusted acres, 90 cows and a quota of 108,000 gallons.

We quickly realised that the business had to grow substantially to deliver the sort of free cash surplus we required to achieve our goals.

At this stage I should add that our principal financial goal is to deliver a comfortable lifestyle, a comfortable retirement (whenever that may come) and a significant start in life for our 3 children. There is nothing special with these goals, and I am confident that they are in common with the vast majority of people here today.

Financial goals, of course, are only a small part of the equation. They are not the most important, or the most difficult to achieve, but they are what we are discussing here today.

It was essential that we grow the business. While the farm was delivering a reasonably healthy free cash surplus, this was not sustainable over time. Falling dairy returns, rising overheads and the reduced purchasing power of farm profits, as a result of inflation, meant that the status quo was not an option. Looking forward over a 20-year period, in order to achieve those goals, we had little option but to grow the business.

Over the past 8 years we have grown the farm business at a steady pace. Quota has gradually been added through both purchase and lease to bring the farm up to sufficient scale. Most necessary investments have been made in infrastructure, such as roadways, milking facilities and grassland. Next year we expect to farm 195 acres with 220 cows producing a quota of 290,000 gallons. The farm has been set up as a milking platform of cows only, 100% autumn calving, with special emphasis being placed on milking and calf rearing facilities. Replacements are reared on a separate unit 100 miles away.

In practice we have achieved compounded growth in net worth of 24.5% pa. This excludes land values on the home farm, as we only see ourselves as trustees for the next generation.

Before attempting to grow the business, there are a number of factors, which had to be addressed before any decisions were taken. These needed to be addressed, irrespective of whether growth was to take place on or off farm.

The primary objective was to set up the farm so that it could be sustainably managed at arms length. This necessitated major changes to the farm business structure and the way I approached my attitude to time and knowledge management.

The move to 100% autumn calving was principally done for this reason. In order to have a sustainable system over time it was necessary to simplify the system as much as possible. As the farm is supplying liquid milk, the move to 100% spring calving was not an option. Also, because of the limited land base, a low cost spring calving system could not sustain the level of quota on the farm. We saw split calving in winter and spring as unsustainable in the longer term. Too many conflicts of interest, and a difficult business to run from a management point of view.

Quality labour is one of the major constraints to growth within farming today. To address this issue we have invested in a simple, low cost, labour efficient parlour. Good facilities and working environments such as this are essential in order to attract the right calibre of staff. Another related change has been a much-simplified calf rearing system, with all cows now calving outside.

We have been working towards these decisions over the past 3 years and it can be said that this was the start of a constantly evolving strategic planning exercise. At around the same stage we realised that we had reached an impasse as regards the strategic direction of the business.

In developing this strategic plan, we had 2 options for growth. Options which every farmer here will face sooner or later.

To continue vertical growth within farming, or pursue a strategy of horizontal growth into other areas. (By vertical growth, I mean growing one single business, which in our case is dairy farming, and concentrating all growth in that single area). But pure vertical growth was becoming increasingly more difficult. Vertical growth within farming would have been within our area of expertise, the area that we know best. But it is in a relatively low return area. We would have been putting all our eggs in one basket, in an industry where we are price takers rather than price makers. The business would have been 100% exposed to the vagrancies of GATT, and other areas outside of our control. Strategically we felt that this was not the correct option. We wanted to maintain control over the growth of our business. We wanted the decisions that we make, not the decisions of others, to be the ones which influence the direction of our lives. There are a number of key steps, which we took to control that direction. Firstly we sat down and had a good look at where we were. We clarified our goals in life, which helped us to decide where we wanted to be. Then we decided on a strategy to get from where we were, to where we wanted to be. This strategic plan is our road map for growth. Like any road map, it has to be referred to occasionally to confirm direction, and is absolutely essential if one is to arrive in the correct place at the right time. When we looked at our plan, it became clear that the option of horizontal growth (which I would define as growing the business simultaneously in a number of different areas) was what we needed to achieve our strategic objectives.

By doing this;

Assets were spread across sectors, reducing risk.

We were able to achieve a higher return on equity than in farming.
We were able to continue farming, which is still first choice.
We were able to operate in an environment not controlled by quotas, etc.
We would end up with more liquid type assets spread across different sectors.
And most importantly of all, the challenge was exciting.

It is one thing to talk about doing this; it is an entirely different matter to do it successfully. The first step was for me to increase my knowledge in the area of growth outside farming. If there is one message to be taken from today, it is that this step is absolutely vital. As Bill Clinton said, "Knowledge is power".

Informed decisions can only be taken with sufficient knowledge. Strategic plans can only be addressed with knowledge of the options. Detailed research and planning is only possible with sufficient knowledge. This careful research and planning is paramount to reducing risk and maximizing returns. I would place such emphasis on what I call knowledge management, that now at least 50% of my time is spent on study and research. It is an ongoing process, one which is never complete, but one which I find hugely stimulating and enjoyable.

All this of course, takes one major input, which is time. Very early on we had identified the need to free up time for what I call knowledge management. This single decision of course had far reaching implications for the farm business. It was the driving force behind the decision to move to 100% autumn calving, the decision to set up a milking platform and a simple, labour efficient environment on farm. These decisions were not taken lightly, and resulted from a hard-earned lesson. The move from on farm manager to off farm was one of the most difficult transitions that I have ever made. I felt that I could easily delegate, with efficiency to follow. Nothing could have been further from the truth. The complicated, split calving unfocused system put enormous pressures on everyone concerned. Lessons learned include the need for measurement, monitoring and regular communication with top quality staff.

At this stage I will outline what we consider to be the critical factors which are necessary to grow a farm business.

- Firstly, a clear, precise well thought out strategic plan is essential. If we don't know where we want to go, or if we don't have a road map to get there, we have little chance of reaching our destination.
- Competency. Going outside one's area of expertise, (which in our case is dairy farming) is fraught with risk. We have to be very clear and honest with ourselves, in making sure that we have the competency to achieve a certain goal. Competency can only be achieved by setting aside time for study and research.
- We target return on equity as the benchmark when evaluating investment decisions. (This is the return we get from our own money invested, as opposed to return on capital, which would be total money invested in a business). A good example can be got when comparing total returns from properly or equity investment. Return on capital employed is normally higher for equities, but when the higher gearing is taken into consideration, property investment quickly catches up.

- We try to maximise free cash in all areas of the business. I would describe free cash as the surplus available for reinvestment each year after paying all costs. These costs would include taxation, drawings and necessary capital expenditure. Free cash can also include money introduced from other sources. As the saying goes, "cash is king". This is the driving force behind all business growth and should not be understated. Every effort should be made to maximise free cash from a business.
- It is important to get scale in any investment. One is left with far more profit by getting a return of 15% on an investment of £100k rather than a return of 25% on an investment of £5k.
- Prudent risk analysis is one of the keys to successful investing. Generally speaking, the higher the potential returns, the higher the risk. Risk has to be analysed very carefully, and if possible ring fenced against damaging other parts of the business. Properly planned, spreading one's risk across asset classes greatly reduces overall risk. We believe that it never pays to put the overall business at risk.
- Proper tax planning is essential as a business grows. While it rarely makes sense to invest from a pure tax saving point of view, one should always bear in mind the tax consequences of any investment. I would also add that it never makes sense to operate outside the system. All business transactions should be totally legal. In the relatively benign taxation environment, which we operate in, the moral and financial consequences of doing otherwise, are sheer lunacy.
- Time is precious. As a business grows time becomes a very limiting factor. For that reason we would have a bias towards passive investments. These would include equities and certain types of property investment. Time is our greatest limiting resource, and has to be jealously guarded.
- In today's environment, people are among the most valuable assets of any business. A trusting, open, 2-way relationship is essential with all people involved with the business. This includes farm management, staff, bankers, accountants and fellow professionals. Time should also be taken to identify the correct people to work with on an ongoing basis.

So you may ask, what have we done to grow the business over the last 2 years?

We are reasonably happy with progress to date. The farm itself bas been set up as a springboard for growth. Scale has been achieved on farm, and efficiencies are such that we would expect a sustainable cash flow. This free cash will be used to drive other areas of the business. Off farm at present we have a 3-pronged approach to growth.

- We have set up a fledgling properly development company. We would look at this enterprise as a driver of free cash, for investment in other areas of the business. While the returns are not as regular and predictable as a dairy farm, they are quite acceptable if the deal is correct.
- Property investment. Two years ago we made a commercial property investment. We would regard this investment as low risk, and because it is in a different asset class, it fits well with the overall strategic plan.

- Equity investment. We would regard short-term equity investment as relatively high risk, so it has to be managed very carefully. A lot of time and effort has to be put into researching the best companies. This is particularly true in the technology area. While there are some great opportunities, there are a lot of over hyped companies in this sector, with poor fundamentals and a poor business model, so great care has to be taken. Viewed over the longer term, we would consider equity investment in blue chips as being low risk. Properly managed, the returns from this type of investment are just too high to ignore. We would expect to average at least 15% compounded on capital, while in practice to date, we have exceeded this figure.

As dairy farmers we see ourselves as being in a perfect position to exploit these opportunities. Efficient dairy farmers should be a banker's dream, with regular cash flow and a large asset base for security. This gives ample scope for debt servicing. We would regard money as a commodity, to be traded and bargained for in the same way as we may trade with a feed compounder. It is essential, of course, to get a return substantially higher than the cost of that money. Using the bank's money, in the form of leveraging, is the key to achieving a high return on equity. This is an approach, which may not suit everybody, but we are fortunate, in that we both have a high sleep factor when it comes to borrowings.

Going forward, there are many options for the business to grow. We will not rule out expansion in dairying, as it is the business that we know and enjoy best. As the home farm is producing close to maximum capacity, the next move would have to be a stand-alone operation. In the future it is a distinct possibility that all farm machinery will be sold, (bar the quad), and all work contracted in. When calculated, the opportunity cost of owning machinery is huge. This would free up cash for investment in growth areas, while allowing staff time to focus on the important jobs of grass and cow management. We would also see quota purchase, at realistic prices, as making excellent commercial sense.

We would view continued equity investment as the core part of the strategy. Excellent returns over time, combined with liquidity and deferred taxation, make this form of business growth compelling.

We will make sure that any decisions we take will fit in with the overall strategic plan. We will continue to prioritize knowledge management, setting time aside to upgrade competence and skills.

When it comes to evaluating an opportunity, these decisions will be based on what we call the REST principal.

R RISK	Evaluate risk
E EQUITY	Benchmark return on equity
S SCALE	Look for scale
T TIME	Guard our time jealously.

Success for us is in achieving our goals. We strongly believe that if we adhere to these principals, we will, over time, achieve the personal and financial goals that we desire.

Breeding High Quality Forage For Sustainable Dairy Farming – A Multidisciplinary Approach

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At around £45 t^{-1} dry matter, grazed grass is about half the cost of grass silage and one-third the cost of concentrates. Reseeded swards containing improved modern ryegrass varieties produce dry matter yields approaching 15 t ha^{-1} over a grazing season. For a 250 day grazing season this amounts to an average grass yield of 60 kg $ha^{-1}d^{-1}$. At a stocking rate of around 2 cows ha^{-1} and with good grazing management, daily intakes of 15 kg DM per cow, are reasonable to attain and should be sufficient to achieve a daily milk yield of 18 litres. A potential target would be 20 kg DM intake per day supporting a daily milk yield of 30 litres. The maximum yield potential of ryegrass in temperate regions has been estimated (Cooper, 1969) as 29 t DM ha^{-1} for a grazing season - around 100 kg $ha^{-1}id^{-1}$. The best diploid ryegrass varieties on the current UK Recommended List produce annual yields of 17 t DM and in Ireland this increases to over 18 t. Under a 5-cut system with 350 kg N, some of the newest IGER ryegrass varieties produce as much as 25 t. It has been estimated (Humphreys 1999) that the average rate of genetic gain for dry matter yield in forage crops is 4% $decade^{-1}$ and therefore we should expect continued improvement in yield over at least the next 30 years. Past improvements have been aided by greater understanding of grass growth and development and by better measurement techniques, including the use of plot harvesters which enable rapid evaluation of sward performance rather than just relying on spaced plant measurements. In the future progress will be aided by better understanding of the genetics of important traits. Grass is a complex crop and in assessing its value, attributes other than total dry matter yield are important to consider. The overall measure of progress in forage breeding should be measured in terms of its impact on the production efficiency and quality of milk and meat and the sustainability of production systems taking into account animal welfare and the agricultural environment.

Breeding objectives

Initially grass breeding at the Welsh Plant Breeding Station, in common with other European breeders, concentrated on increasing dry matter yield and growth potential during the period up to flowering. Over-production of ruminant products from the early 70's onwards led to breeding objectives being targeted more towards increasing the efficiency of ruminant production in order to maintain farm profitability without increasing output. Good dry matter yield was still necessary, but traits like nitrogen-use efficiency (Wilkins et al., 1997), nutritive quality (Humphreys, 1995) and compatibility with white clover became increasingly important. Also from the mid 60's onwards there was a rapid decline in the use of species other than ryegrass and the situation at present is that over 90% of the grass seed sown in N.W. Europe comprises Italian, perennial and hybrid ryegrasses. As we start the new Millennium, there is increasing emphasis on sustainability in farming systems with on-farm produced feed assuming greater importance. A key element in the efficiency of these systems is to optimise the protein/energy balance in the rumen and associated input costs. The survival of livestock producers will be linked to the production from fewer, better quality animals giving a better quality product.

High quality forage for ruminant production

Forage crop breeders have made significant advances in improving the energy value of grasses through increased digestibility and sugar content but there is also a need to produce more on-farm plant protein. Increasing use of legume protein will help in this respect but sustainable systems of ruminant production are impeded by generally low utilisation of forage protein. Up to 40% of the protein in fresh forage may be lost as ammonia because of the inability of rumen microbes to capture the nitrogen released during the breakdown of plant proteins. If sources of readily available energy such as sugars are limited in the rumen, large quantities of ammonia may be absorbed before microbe assimilation into protein occurs. Significant improvements in

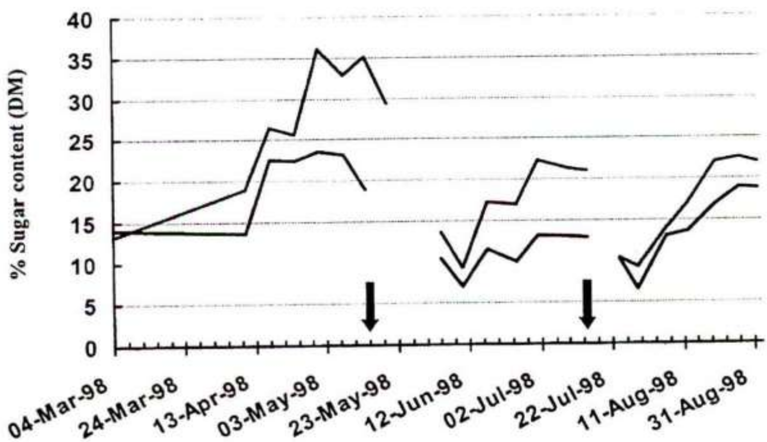

Fig. 1 - Grass sugar content (annual field data). The upper line is from a hybrid perennial ryegrass (AberDove) bred for elevated sugar content and is compared to the lower line from a normal (control) hybrid ryegrass (AberElan). Line breaks indicate where grasses were cut for silage (Data courtesy of L. A. Miller and J. M. Moorby, members of the LINK Sustainable Livestock Production sugargrass consortium).

the use of forage protein can be made by providing additional energy to increase the N capture by rumen microbes. Development of high-sugar grasses which accumulate 10-15% more sugars in leaves and stems (Figure 1) has achieved this (Humphreys, 1989). The benefits of feeding high-sugar grasses (which have only a slightly reduced crude protein (%CP) content) to dairy cows are evident in terms of milk production and milk protein content (Table 1).

Further potential to increase utilisation of forage protein by breeding to reduce the rate of protein breakdown may also exist. The important role that plant enzymes have in rumen protein degradation has only recently been appreciated (Theodorou et al. 1996) and breeding grasses to modify plant enzyme activity could therefore have far reaching consequences in terms of efficient use of N in animal production.

Table 1
Effects of water-soluble sugar content (WSC) of grass on milk yield and the protein content of milk (after Miller et al. 1999a)

	WSC %	CP %	Milk yield kg d^{-1}	True protein in milk g d^{-1}
High sugar ryegras	20.1	9.2	15.3	512
Normal ryegrass	12.9	10.6	12.6	417

Table 2
Effects of water-soluble sugar content (WSC) of grass on nitrogen partitioning into milk and urine (after Miller et al. 1999b)

	WSC %	CP %	N intake g d^{-1}	N output Milk	g d^{-1} Urine
High sugar ryegrass	20.1	9.2	268	82	71
Normal ryegrass	12.9	10.6	278	69	100

As well as direct nutritional effects, there are environmental benefits to be gained from incorporating high-sugar grasses into the diet of ruminants. Increasing the availability of energy in the rumen alters N metabolism and utilisation and reduces the partitioning of excess N into excreted dung and urine (Table 2). In turn this reduces the production of pollutants, such as ammonia volatilized from excreted urea and nitrous oxide produced from urine derived N, and in grazed swards reduces potential for nitrate leaching. Improving the efficiency of rumen fermentation with high-sugar grasses may also reduce methane emissions.

Supermarkets and consumers are increasingly dictating the quality of the product they require and both animal and plant breeders must consider traits which improve the acceptability and nutritional benefits of milk and meat. For example, ruminant nutritionists in IGER have shown that grasses, especially Italian ryegrass, contain high levels of poly-unsaturated fatty acids (PUFAs) which may be incorporated into ruminant products and help to reduce blood cholesterol levels in consumers. This is encouraging grass breeders to develop selection criteria for increasing the levels of omega-3 linoleic acid in their breeding material. Past breeding programmes have been successful in increasing the mineral content of forage (Moseley and Baker, 1991) but, undoubtedly, considerable potential remains to be exploited.

The value of extending grazing seasons

As stated earlier, increased reliance on grazed grass for milk production is a key element in reducing the costs and increasing the profitability of dairy enterprises. To facilitate this farmers can develop the infrastructure and management practices that allow them to extend the grazing season both in the spring and into the autumn. This may include the development of improved access to pastures with cow tracks; extra field entry points to reduce the impact of poaching; and systems of rotationally grazed paddocks with constant monitoring of grass cover to ensure a continuous supply of fresh grass in front of the cows. There is also considerable potential for grass breeders to produce new varieties to assist with this.

In spring, the main limitation to grass growth in the UK is low temperature as the amount of sunlight is relatively high. However in autumn, growth is more restricted by lack of light especially when there is also cloud cover. On average the daily sunlight level at the end of the growing season is 25% of that at the beginning. Potential for growth in late autumn and early spring is also conditioned by the developmental state of the grass. Initiation of flowering acts as a stimulus to leaf growth and early spring growth in grasses is often linked with early flowering. However an early heading date can be disadvantageous in terms of quality as digestibility is significantly reduced in stemmy as compared to leafy spring growth. Humphreys (1984) and Wilkins (1985) used crosses between early and late flowering plants from different parts of Europe to improve spring yield without an early heading date in perennial ryegrass and to improve the general consistency of yield throughout the year. This resulted in the development of varieties such as AberDart.

Italian ryegrasses also demonstrate a favourable relationship between spring growth and heading date in that although they generally have intermediate heading dates, spring growth is greater than in many early heading perennial ryegrasses. This characteristic has been exploited in tetraploid hybrids between Italian and perennial ryegrass (Jones and Humphreys, 1993) and there is increasing appreciation of the extent to which tetraploid hybrid ryegrasses such as AberLinnet can maintain productive swards during extended growing seasons. Hybrid ryegrasses combine good establishment and early growth characteristics from Italian ryegrass with greater persistence and tillering capacity from perennial. During the growing season, hybrids generally behave in a similar way to Italian ryegrass up to ear emergence after which there is a tendency to switch towards perennial ryegrass traits and a high tillering leafy regrowth is produced. This confers advantages both in terms of persistency and mid-late season nutritive quality. The first hybrid ryegrass tended to be more similar to Italian than perennial ryegrass. However, more intermediate types with a range of heading dates are now being developed to allow greater flexibility in cutting and grazing managements (Jones and Humphreys, 1999). There are also indications that the seasonal growth of swards may be improved further by growing mixtures of different hybrid varieties which express different degrees of Italian and perennial ryegrass characteristics and have a range of heading dates.

Potential for extending the growth of perennial swards into the autumn is generally associated with late flowering in perennial ryegrass but is also found in persistent tetraploid ryegrass hybrids which have intermediate heading dates. In order to reduce sward damage by grazing animals, grass breeding for late season growth should ensure that high tiller numbers are maintained in swards together with a prostrate growth habit and strong root growth. These characteristics are rather neglected in many European perennial ryegrass breeding programmes which tend to emphasise yield potential associated with reproductive development during the early part of the growing season.

This has tended to result in varieties with an erect growth habit which produce fairly open swards. Another major objective should be to maintain the nutritive value of grass at a higher level towards the end of the grazing season. The digestibility of perennial ryegrass declines during the late summer and autumn approaches levels of around 60% despite a high leaf content partly because of low sugar levels. Also as growth rates decrease in the autumn, the proportion of senescent leaves in grass swards increases. Therefore staygreen grasses with a high sugar content would be desirable breeding targets.

Environmental stress tolerance

As greater demands are made on swards in terms of production and quality over an increasing number of years, the importance of tolerance to diseases, climate and soil increases. Fortunately grasses occur naturally over a great range of environments and geographical areas and a large range of genetic variation for environmental stress tolerance can be found. While ryegrasses have many desirable attributes, in terms of nutritive value, seasonal productivity and response to nitrogen fertiliser, they are not highly adapted to cope with extreme stress conditions although a considerable range of ecotypic variation can be found. Fescues often have better persistency than ryegrasses when exposed to severe stresses but have major agronomic weaknesses including slow establishment, poor regrowth potential and low nutritive quality. Therefore, a combination of traits from ryegrass and fescue species could help to extend useful seasonal production and breeding from ryegrass x fescue hybrids is proving to be successful. Controlled introgression between ryegrasses and fescues has been successful in transferring good summer growth from meadow fescue into perennial ryegrass (Humphreys 1993) and drought tolerance from tall fescue into Italian ryegrass (Thomas et al. 1995).

Improved winter hardiness has also been transferred from meadow fescue into ryegrasses (Humphreys & Honne 1995).

Future opportunities for grass breeding using new genetic information

Genetic improvement through breeding depends on the extent to which breeders can identify and select desirable genes. Important agronomic traits are often governed by a number of genes whose effects merge into each other and which cannot be determined individually from normal measurements on individuals. However progress can be made on identifying individual genes through genetic mapping based on molecular markers, the identification of so-called quantitative trait loci (QTL) and the use of marker-assisted selection. The concept of genetic fingerprinting is now well established in many areas from forensics through to plant and animal breeding. It depends on being able to detect differences in the DNA composition of individuals through a variety of techniques and thus produce genetic markers which can be associated with genes of value to breeders. Such work is progressing with ryegrass in a number of countries including UK, France, Belgium, Holland, Japan and Australia. Some of this is being done as part of European projects such as EGRAM and NIMGRASS and also by collaboration in an International Lolium Genome Initiative (ILGI, Forster, 2000). At IGER good progress is being made in mapping genes associated with sugar accumulation in the leaves and stems of ryegrass. Marker selections are being made to confirm the value of specific genes in selecting for consistent expression of high sugar levels in leaves. Marker assisted introgression has also been used to monitor the transfer genes from fescues into ryegrass (Thomas *et al.* 1995).

Evidence of the benefits of grass breeding in practice

Demonstration trials to illustrate the benefits of improved varieties have been set up in various parts of the UK as part of a 'Practice into Profit' initiative supported by MAFF, MDC, MLC and a number of commercial organisations including Germinal Holdings. Results are emerging (Moseley pers. com.) which show that good utilisation of improved grassland can result in considerable savings in production costs. For example, the higher yields achieved from new hybrid and perennial ryegrass mixtures on dairy farms allowed sufficient silage to be made from 2 cuts rather than 3. This reduced the unit cost of silage from around £80 t^{-1} DM to £60 overall. New grazing mixtures have also proved very suitable for the extended grazing now being practised by some of the best UK dairy farmers. Sward growth rates in spring were up to 40% greater in areas as diverse as Cumbria in the North and Cornwall in the South and, on average, the farms turned out 33 days earlier. At Gelli Aur in Carmarthen they recorded an increase in milk yield of 1.5 l cow^{-1} d^{-1} and a reduction of 3.5 kg cow^{-1} d^{-1} in silage intake. The combined value of this was 56 p cow^{-1} d^{-1} and for the 100 cow herd total savings during spring was £1900. Mixtures of improved grasses together with appropriate management has, on average, increased milk yield from forage from 50% to 63% and yield from grazed grass from 30% to 43% while maintaining an average production of around 6500 l cow^{-1}. All this information provides strong justification for forage breeding as farmers receive considerable benefits from improved varieties at no extra cost.

Conclusions

It is clear that breeding high quality grasses for sustainable dairy farming is a complex subject which requires a multidisciplinary approach. Breeding work at IGER has benefited considerably from bringing together expertise in plant genetics and breeding with expertise in rumen microbiology and animal nutrition. This was a desirable consequence of the amalgamation, in the early 1990s, of the Welsh Plant Breeding Station with the Grassland Research Institute and part of the National Institute for Research in Dairying. The benefits of this are now emerging in work demonstrating the value of high-sugar grasses which serves as a model for future research. However investment in research on forage crops is increasingly viewed in an international context. Although forages (apart from maize and lucerne) are often regarded as low-profit crops by the international seed industry, they underpin ruminant livestock industries which account for a high proportion of national agricultural output in many western European countries, particularly the UK and Ireland. They are also important in Eastern Europe, Australia, South America, and S. Africa, vital to New Zealand and of increasing importance in developing countries seeking to improve human nutrition. International collaboration is vital to achieve the progress which is necessary and attainable. Forage breeders in Europe have a long history of collaboration through organisations such as EUCARPIA (European Association for Research on Plant Breeding) and it is evident that this is spreading beyond Europe. European projects such as NIMGRASS (Lower Nitrogen Losses in Dairy Farming through Marker Assisted Breeding for Nitrogen Use Efficiency and Feeding Value in Ryegrass) have arisen out of EUCARPIA and links have spread to other countries. For example, the International Lolium Genome Initiative (ILGI) is coordinated out of Australia and involves Japan and USA as well as several European countries. Breeder's privilege, which is part of Plant Breeders Rights legislation, ensures fairly free movement of genetic resources, although the impact of patents will need to be assessed in the future. With regard to work on ruminant nutrition there are good opportunities for further collaboration on grazing and forage conservation. Similarities in grassland utilisation between the west of the UK and Ireland makes them ideal research partners as the recent 'SWEETGRASS' Framework V EC proposal illustrates. Grassland is an extremely valuable resource and deserves to be treated as a proper crop. The nutrition it can provide ruminants in terms of energy and protein should be regarded in the same way as feed concentrates and its potential to support sustainable livestock farming should be fully exploited.

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Grazed Grass as a Feed for Dairy Cows

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The dairy industry in Ireland is facing a far more competitive environment than ever before. Driven by changes in the Common Agricultural Policy and World Trade Agreements, the industry is undergoing massive changes both nationally and internationally and faces many new challenges. Grassland is the single most important agricultural resource in Ireland and is the pivot around which the dairy industry revolves. Successful dairy farming in Ireland is due to a large extent to the efficient conversion of grass to milk. Grass when grazed efficiently is by far the cheapest feed available on the dairy farm (Dillon, Cliffe and Hurley, 1991). Grazing management should aim to provide a supply of nutritious herbage over the grazing season, at low cost, avoiding wastage and inefficient utilisation of herbage by the animal, and maintaining the productive capacity of the sward. The needs of both the animal and the sward need to be considered, and severe adverse effects on either should be avoided.

Our understanding of the feeding and management of the dairy herd has improved in recent years. Some of the changes that have occurred have been influenced by the application of the EU milk quota regime. Considerable changes in our thinking in relation to calving date, pasture quality and more recently in relation to the use of pasture measurement, have occurred. Likewise there is the realisation that the cow of today is not the same as that of yesterday. The blueprint for efficient milk production in Ireland recommended from Moorepark has changed to reflect this new reality. This paper attempts to highlight the most important issues in relation to grazed grass as a feed in Irish milk production systems. These include:

- ➢ Nutritive value of grazed grass
- ➢ Cost competitiveness in relation to other available feeds
- ➢ Potential production from grass
- ➢ Improving cow performance from grass

1. Nutritive value of grazed grass

Table 1 shows the nutritive value of well managed grazed grass for milk production.

Table 1
Chemical composition of grazed grass (g/kg dm)

Crude Protein (CP)	180-250
Neutral Detergent Fibre (NDF)	350-400
Acid Detergent Fibre (ADF)	180-250
Water soluble carbohydrates (WSC)	150-200

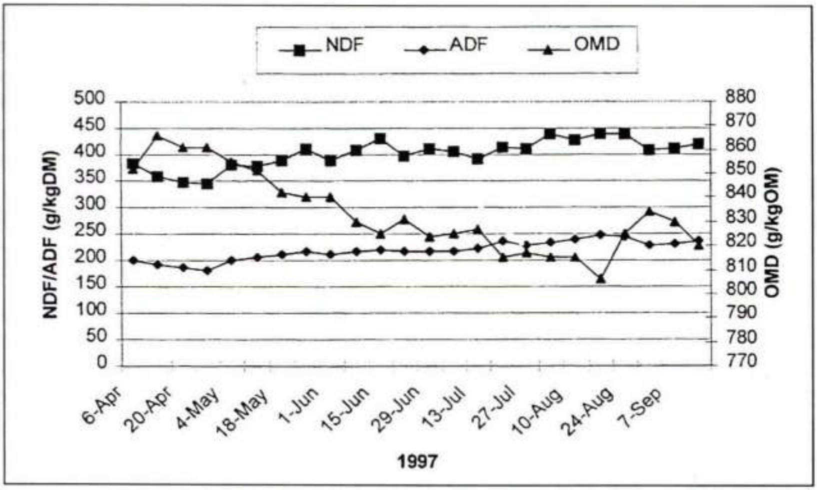

Fig. 1 - Chemical composition of grazed grass over a grazing season

Figure 1 shows the chemical composition of grass (pre-grazing samples above 4 cm) across the season for 1997 from a grazing experiment at Moorepark (Buckley, 1999). Digestibility is a key nutritive parameter and is a major determinant of the metabolizable energy content of grass. Control of grass digestibility and hence metabolizable energy content is a critical element of grazing management for milk production in Ireland (Stakelum and Dillon, 1991). This approach is very different to other countries (for example New Zealand and Australia) which also produce a large proportion of their milk from grazed pasture. Neutral detergent fibre concentrations of 50 to 60% are not uncommon in New Zealand and Australian pastures in mid-summer (Ulyatt and Waghorn, 1993). Mid season digestibility can be as low as 65% OMD (Ulyatt, 1980). This is mainly as a result of the high mid summer temperatures combined with moisture deficits. Pastures in these hotter environments also contain many sub-tropical species (Paspalum and Kikuyu as examples) which can be quite low in digestibility in summer. Therefore, animal production from grazed pasture in Ireland has a big advantage over those countries. It is possible with good grazing management to produce a feed of high quality over the whole grazing season. This feed is equal to, and at times superior to, the feed value of concentrate rations.

2. Cost competitiveness of grazed grass

Grazed grass has the advantage of being a low cost feed. Additionally, a low fixed cost system of milk production can be built around the utilisation of grazed grass. Both of these factors are equally important for the competitiveness of systems of milk production based on grazed grass. In recent years a number of attempts have been made to estimate the comparative costs of grazed grass, grass silage and concentrate feeds in Irish milk production systems (O'Kiely, 1994, Keady,1999, Sheehy,l999). O'Kiely (1994) showed that grazed grass was 66% and 40% cheaper than home grown barley and first cut silage, respectively. Keady (1999) estimated that grazed grass was 23% cheaper than a three-cut silage system while Sheehy (1999) showed that grazed grass was 50% cheaper than purchased concentrate at £140/tonne, while grass silage ranged from being 15% cheaper to being 23% more expensive. Looking to the future, the competitiveness of grazed grass should be maintained even if the intervention prices of cereals fall by 15%. However, increased silage costs due to increased machinery, labour and energy costs may outstrip concentrate costs.

The common conclusion of all these studies is that grazed grass is the cheapest feed available and will continue to be well into the future. Systems of milk production in Ireland in the future should continue to be based on grazed grass. Developments in grazing management cow type, labour use, farm infrastructure and milk harvesting technology should all facilitate this.

3. Potential production from grazed grass

The optimum production (per cow and per unit area) from any system of milk production across the world will depend on the constraints in which it operates. These include milk price regulations, cost structure and resources available. World wide we can see how different milk production systems have developed depending on these circumstances, e.g. California in the U.S., Waikato in New Zealand, Friesland in Netherlands etc. In all these environments there is an overall blueprint for the particular system of milk production that is considered optimum. Similarly for Ireland there is an overall blueprint that we consider optimum e.g. The Moorepark blueprint. Achieving high cow performance from grazed pasture is central to this system in Ireland. This high cow performance is achieved in conjunction with high rates of grass utilisation. Table 2 summarises the herbage allowance by herbage intake/milk yield relationship for a series of experiments carried out at Moorepark (Maher et al., 1997, 1998).

The results show that the optimum daily herbage allowance above 4 cm is 20kg DM for dairy cows with a RBI (95) of 110. The lower grass allowance (16 to 17kg DM) resulted in a very low post-grazing height. This in turn results

Table 2

Effect of daily grass allowance (kg dm/cow/day) on milk production, milk protein, grazing severity and intake of grass

	Grass Allowance (>4cm)		
	16-17	20	23-24
Daily milk yield	22.5	23.6	24.5
Milk protein %	3.33	3.37	3.39
Post-grazing sward height (cm)	4.5	5.5	6.6
Daily grass dmi (kg)	15.3	16.4	17.1

in reduced grass growth for the subsequent regrowth periods. High cow performance is achieved by maintaining a constant supply of grass for the herd on a daily basis. Weekly monitoring of farm grass cover has been shown to be essential in order to achieve this objective (O'Donovan et al, 1997).

Increasing the efficiency of production is essential in order to reduce the cost of food to the consumer. It is also important for the economic and physical sustainability of farming. Presently, output of milk is increasing at more than twice the growth in animal numbers (Cunningham, 1996). There are a number of issues in relation to the use of high genetic index sires in Ireland. These are as follows:

1. Their performance on grass based systems
2. Their suitability for seasonal calving
3. Issues in relation to genotype by feeding system interactions

Results from our studies so far indicate that the current high genetic index cows will achieve high performance in our grass based system. There is no indication of any genotype by concentrate feeding level interaction. Table 3 shows how much improved management and breeding has contributed to increased output per cow and per hectare since 1983 in controlled full lactation experiments at Moorepark. "Moorepark 1983" refers to the performance that was being achieved when the EU milk quotas were introduced in 1983. "Moorepark MGI" and "Moorepark HGI" refers to the performance, which is now achieved from cows of 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 separate precisely how much of this increase resulted from genetic improvement and how much from management plus feeding.

The maintenance requirement of the Moorepark cow of 1983 accounted for 44% of its total feed requirements. The figure for the HGI cow in these studies is 36%. This has resulted in an increase in feed efficiency of 16%. An increase

Table 3
Evaluation of the Moorepark milk production technology

		Moorepark 83 Pre Quotas	Moorepark MGI*	Moorepark HGI **
Milk Yield	kg/cow	5076	6585	7640
	gal/cow	1084	1407	1632
Stocking Rate	cow/ha	2.90	2.60	2.40
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

of 500 kg in milk yield without any changes in health and reproductive costs would increase margin per litre by 0.6p (3p/gal) in a milk quota environment. In a series of experiments, carried out at Moorepark, daily herbage intake was measured from late April to early September with spring-calving dairy cows. No supplements were fed to the cows during this period and the herds grazed to a post-grazing sward height of between 5.5 and 6.5cm. The production characteristics of the cows used in this study are shown in Table 4. The average total lactation yield was 5440 kg. The range in yields was from 3867 to 7366 kg. Multiple linear regression analyses showed that for each extra 1 kg of solids corrected daily milk yield, daily herbage intake increased by 0.41 kg. The analyses also showed that for each extra 1 kg of bodyweight that an extra 0.0176 kg of extra herbage was eaten each day (1.76 kg/extra 100 kg of bodyweight). This indicates that grass, as the sole feed, is adequate from late April to early September for herds of average total lactation milk yields of 5440 kg. This of course implies very good grazing management in order to achieve the required farm cover and post grazing sward surface height targets. We are presently defining these relationships for the higher index cows.

Table 4
Production characteristics of the cows used in the multiple linear regression analyses

	Mean	Range	SD
Days in milk	134	30-227	41.7
Lactation Number	3.51	1 -9	2.2
Bodyweight (kg)	541	399-694	53.5
Grass DM Intake (kg)	16.2	8.9-22.3	2.4
Daily milk yield (kg)	20.6	9-32	3.7
Total lactation milk yield (kg)	5540	3867-7336	785

4. Improving performance from grazed grass

Numerous experiments have been conducted around the world to examine the effects of concentrate supplementation on the performance of grazing dairy cows. Milk production responses (kg milk / kg concentrate) ranged from 0.32 (Leaver et al. 1965), 0.40 (Journet and Demarquilly, 1979) to 0.50 (Stakelum et al. 1988). However, most of these studies were carried out with moderate yielding dairy cows with milk yields in the region of 15 to 25 kg/cow/day. Very few studies have been carried out with cows yielding 30 to 40 kg/cow/day. It might be expected that cows with higher yield would partition a greater proportion of their extra energy intake towards milk rather than live weight. Also, it could be suggested that grass *per se* might limit potential intake with such animals. Because of the higher intake requirement of higher yielding cows, their optimum daily herbage allowance is higher than lower yielding cows (Butler et al., 1999). Therefore at equal stocking rates, higher yielding cows are at an effectively higher grazing pressure than lower yielding cows.

Table 5
Effect of level of concentrate input & genetic merit (milk yield) on the performance of springcalving dairy cows

	MM	HM	MM	HM
Conc. fed (kg)	695	695	1,340	1,340
Milk yield (kg)	6,576	7,632	7,221	8,142
Fat(%)	4.11	3.76	3.96	3.97
Protein (%)	3.39	3.37	3.45	3.41
Fat yield (kg)	266	286	285	321
Protein yield (kg)	222	257	249	277

HM = High Merit, MM = Medium Merit

Table 5 shows the total milk production for cows of high (HM) and medium (MM) genetic merit on two concentrate input levels (0.7 and 1.3 t/cow). All treatment groups were grazed to similar postgrazing sward heights in order to equalise grazing pressures across the genetic merit groups. The average response was 1.12 and 0.92 kg milk per kg of extra concentrate fed to the HM and MM cows, respectively. The MM cows in this study would be considered very high yielding cows in comparison to cows used in the studies referred to above. When pre-experimental milk yield was regressed on experimental milk yield, (ignoring genotype), similar relationships were found between pre-experimental and experimental milk yields for both concentrate feeding levels. The slopes of the two lines were identical (Figure 2). This indicates that the response to the extra concentrate feeding level was similar, regardless of initial milk yield. Milk production responses, similar to that achieved in this study, have been found in a more recent study at Moorepark. However the overall responses, of over a 1 kg of milk/kg of concentrate fed, is much higher than published previously. Hoden et al. (1991) suggest that the region for higher responses now, compared to the older data, is the substantially higher genetic merit of the cows. The technology of grazing, under experimental conditions at Moorepark, is more geared to achieving high daily intakes of grass. It is not at all clear why the immediate and total lactation responses of cows today, is higher than before. It would have been expected in situations where herbage intake was higher, due to advances in grass quality and grazing management, that responses should be somewhat less. Concentrate type is known to be important as a factor in determining both substitution rates and production responses (Stakelum and Dillon, 1990). Rumen overloading with ammonia due to the intake of excessive amounts of degradable herbage nitrogen may also be an issue. This can arise due to very high intakes of herbage of 24% crude protein of higher. Easily fermentable supplementary carbohydrates may be beneficial in alleviating this.

Higher levels of concentrate feeding may be an option on some dairy farms in the future where milk quota is not limiting and where a high stocking rate

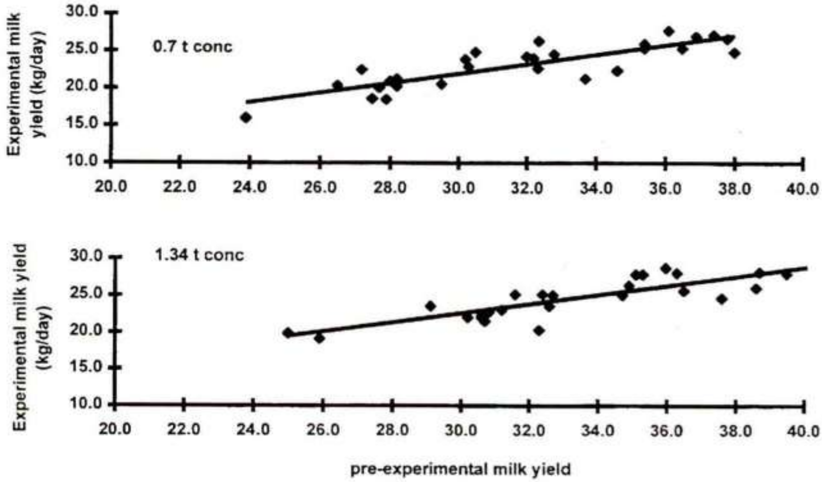

Fig. 2 - Relationship between pre-experimental and experimental

is carried in order to increase farm production of milk. The cost of purchased concentrates may be lower than present day prices. This may be a more competitive energy source than grass silage.

Summary

Grazed grass is and will remain the cheapest feed available to Irish dairy farmers. In Ireland it is possible to achieve high intakes of grazed grass over a long grazing season. This is equal to or better than most temperate grass areas of the world. The system facilitates the operation of a large herd size with relatively low fixed and labour costs. For future competitiveness, issues in relation to the cow best suited to this system of milk production will need to be addressed. Additionally, the production system will need to be compatible with the environmental constraints, which are likely to be imposed in the near future.

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Profitable Milk Production from Pasture

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"Only the most productive companies are going to win. If you can't offer a top quality product at the world's lowest price, you're going to be out of the game."

JACK WELCH, CEO, General Electric.

The New Zealand Dairy Industry owes its success to a continual improvement in the efficiency of milk production from pasture. However, this improvement has been driven by the need to increase productivity in order to maintain profitability in the face of low and declining milk prices. When adjusted for inflation, the rolling 3-year average Dairy Company milksolids (milkfat + milk protein) payout has declined from NZ$4.63/kg to NZ$3.74/kg over the last 15 years (LIC, 1998). Farm profitability has been maintained only because over this period milksolids production per hectare has increased by 40%, and total milksolids production per farm has increased by 85%. New Zealand dairy farmers have learned to produce milk at a fraction of the cost of other countries because they have been forced to.

Nevertheless, it is very unlikely dairy farmers in other parts of the world should attempt to duplicate the New Zealand pastoral system. Optimal farm systems depend on the milk price, and the relative costs of the land, feed, herd and labour resources available. Even within New Zealand, milk production systems have become increasingly diverse between regions and between farms. However, despite this diversity, the vast majority have the same purpose:

Maximising the margin between total income and total costs

In general, dairy farmers have maintained and increased profitability through a relentless drive to produce more milk per hectare, per cow and per labour unit. Many are ruthlessly efficient, yet they continue to strive to increase efficiency. Best practice seasonal dairy farmers have made remarkable improvements in productivity over the past decade. Some now achieve in excess of 1500 kg MS/ha/year, 400 kg MS/cow/year and 75 000 kg MS/person/year. The best farmers make economic farm surpluses (profit before tax, drawings and debt servicing) in excess of NZ$2500/ha (van der Poel, 1999). Rather than describe these various systems to you, I will discuss the principles of profitably producing milk from pasture. These principles are successfully imbedded within all profitable New Zealand farm systems. My challenge to farmers and their advisors at this conference is to consider how they might best be implemented to increase the profitability of dairy farming in Ireland. While in New Zealand these principles are usually applied to increase production, in Ireland it may be more appropriate to apply them to produce a given amount of milk at minimum cost.

What are we farming for?

New Zealand Dairy farmers generally have three common objectives (MacLean *et al.* 1997);

1) Increasing the profitability of their farm businesses.
2) Increasing the efficiency of labour use on the dairy farm.
3) Maintaining high standards of animal welfare and environmental protection.

Although all farmers will have different sets of personal and business objectives, all these objectives are inevitably underpinned by profitability (van der Poel, 1999). In contrast, the amount of labour necessary to operate a more profitable farm system may conflict with family and personal objectives. Labour requirements now often exceed that available from the farming family because the average dairy farm is now 91 ha milking 229 cows (LIC, 1999). Farmers are concerned with both the availability of good staff, and the complexity of farming systems when a significant proportion of labour is from relatively unskilled employees. Therefore, changes to farm systems to increase profit must now consider the implications for labour requirements, animal welfare and environmental sustainability.

Maximising milksolids income

Increasing production is virtually the only means of increasing income on dairy farms. Although the price received for milk is an important variable, in New Zealand little can be done by the individual to increase milksolids price other than maintaining high milk quality standards to avoid grading penalties. Nevertheless, increasing milk supply has not been totally unrestricted.

While we have no Government imposed milk quota, farmers have been required to own 2 dairy company shares for each kg of milksolids supplied. To increase production and supply additional milk, the farm must purchase additional Dairy Co-operative shares (a one-off, redeemable investment of about 60% of the value of the additional milk supplied). It has been signalled that the cost of extra dairy company shares is likely to increase markedly from now on. However, progressive farmers have continued to increase production to increase income and expand their businesses anyway, and they will continue to expand in future. Although the easiest way to increase production in New Zealand is to buy more land, I will concentrate on increasing production from an existing area of land.

Total annual milksolids production from a farm system is controlled by three key variables;

1) **The total amount of feed available to the milking herd over the year.**
2) **The proportion of this feed that is eaten by the milking herd.**
3) **The efficiency that feed eaten is converted to milksolids.**

In practice, if total milksolids production is poor, the cause will be related to one of first two factors. Efficiency of production is important, particularly from an economic point of view, but has somewhat less influence on yield per

Table 1

Some results from the systems for high milksolids production farmlet study conducted at No. 2 Dairy averaged over the three years of the trial

Farmlet	1	2	3	4	5	6	7	8
Stocking rate (cows/ha)	3.3	3.3	3.3	4.4	4.4	4.4	4.4	4.4
N fertiliser (kg N/ha/yr)	0	200	400	200	400	200	200	200
Feed supply (t DM/ha/year)								
Pasture grown	16.7	18.2	20.2	18.3	20.6	18.9	19.2	19.1
Maize grain						6.6		2.0
Maize silage							5.6	2.9
Balanced ration								1.6
Total feed suply	**16.7**	**18.2**	**20.2**	**18.3**	**20.6**	**2.0**	**24.8**	**25.6**
Milksolids (kg/ha/yr)	**1040**	**1208**	**1317**	**1190**	**1325**	**1785**	**1606**	**1800**

hectare than how much feed is available and how much of the available feed is eaten.

The importance of feed supply in determining total milksolids production was clearly demonstrated in the results of a three year farmlet study conducted at the Dairying Research Corporation No. 2 Dairy at Ruakura from 1995/96 to 1997/98 (Table 1). The trial was designed to investigate the economics of intensifying our pasture based dairy systems with inputs of nitrogen fertiliser and purchased supplements. The farmlets had different stocking rates, grew different amounts of pasture and compared three types of purchased supplementary feeds (Table 1). However, despite the wide range in management systems and feeding regimes imposed, total milksolids production was almost totally explained by the differences in the total feed supply (Figure 1). According to this relationship, the amount of feed that is

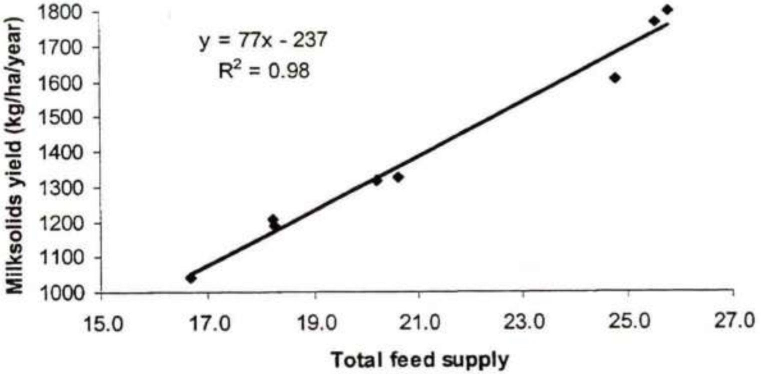

Fig. 1 - The effect of total annual feed supply on total milksolids production

required in a year to produce a given amount of milk (quota) could be predetermined. Maximising profits will arise from attaining this feed at minimum cost.

Maximising potential pasture growth

Once a pastoral dairy farm has been purchased, the pasture grown on that farm will always be the cheapest form of feed available to the dairy herd. The principles of achieving high levels of pasture production have been understood for many years. Soil fertility, the use of nitrogen fertiliser, soil moisture conditions (drainage and irrigation), and the pasture species present in the sward can largely explain the differences in potential pasture growth between farms within a region. If pastures are not growing as much as those on surrounding farms, the problem is usually one of these factors and there will be a straight forward solution.

Maximising future production within the system

The amount of pasture that is eaten by the herd, or harvested as conservation, has a large effect on the difference in apparent pasture production between different farms within a given region.

Pasture production, as discussed in relation to dairy farm research and management, is determined by the increase in pasture mass on ungrazed paddocks over time. For example, if the post grazing pasture mass of a paddock is measured as 2000 kg DM/ha, and the pregrazing pasture mass of that paddock is 3000 kg DM after 30 days regrowth, the growth rate would be calculated as 33 kg DM/ha/day.

$$\frac{\textbf{3000 kg DM/ha - 2000 kg DM/ha}}{\textbf{30 days}}$$

Annual pasture production is the sum of these successive growth rates over the year. However, it is imperative to understand that this method actually measures the amount of pasture harvested and only provides an estimate of true pasture growth.

Pasture is a short shelf-life product. Over time, new leaves appear from the base of the grass tillers, grow and then die and decay. In the spring a new leaf appears about every 7 days, and in the winter every 30 days. Each tiller can only support 3 leaves at any one time. Therefore, in spring leaves are turning over every 21 days, and in winter every 90 days. Evidence of this turnover of grass leaves can be seen as dead and decaying leaves through the sward. In moist conditions the dead leaves quickly rot away and disappear. During summer, the dead plant material often builds up in the sward as conditions become too dry to allow the material to decay.

All the available pasture must be eaten at each grazing to achieve high utilisation. Because of the dynamic nature of pasture, ungrazed leaves will often not remain until the next grazing. Rather, extra pasture that is left after grazing will simply increase the proportion of material that will die and rot. If we return to our understanding of pasture growth, the increase in pasture mass between grazings is the sum of new DM appearance, minus the old DM which is dying and rotting away:

Increase in pasture mass = New DM - Loss of old DM

If a high pasture mass of old material (> 21 days in spring) is left after grazing this will increase the amount that will die and rot, and therefore decrease measured growth rates.

The implication of this for dairy farmers is that the amount of pasture eaten by he herd has an enormous influence on apparent pasture production. In the extreme, if a pasture was never grazed, the pasture mass would increase until the amount of old material rotting away equalled the amount of new material growing. In essence, pasture production would be measured as nil.

Optimising feed utilisation

To maximise pasture utilisation, there must be enough cows to eat all the feed that is available each year. However, increasing the number of cows milked increases the amount of feed used for maintenance. Further, a high proportion of the variable costs of milk production is directly related to the number of cows being milked. Therefore, a stocking rate that maximises pasture utilisation is likely to be too high to maximise the biological and economic efficiency of the whole farm system.

It has been suggested from calculations based on farm systems trials, that the optimum annual per cow production to maximise biological and economic efficiency is currently 400 to 430 kg MS/cow in New Zealand (assumes 500 kg Friesian cows) (Penno, 1999). An important component of the increased economic efficiency from increased productivity per cow is the improved labour use efficiency.

Increased per cow productivity requires increased feeding levels. Recent calculations have suggested that to attain milksolids yields of over 400 kg/cow will require stocking rates of 80 to 85 kg LW/t DM. In traditional terms, for a farm with a total feed supply 16t DM/ha/year this stocking rate equates to only 2.7 cows/ha (500 kg cows), which is considerably lower than stocking rates that have been recommended in the past (Penno, 1999).

As yet these associations of lower stocking rates and higher levels of performance per cow remain largely untested. For this reason two major farmlet trials have been initiated. The first is with Friesian cows at the DRC No 2 Dairy, representing the climate typical of the Waikato, with mild winters and some degree of summer drought. The second is with Jersey cows at the Stratford Demonstration Farm in Taranaki, representing a cold winter, wet summer climate. Both trials have completed their first season of three. Data from the first year of the Stratford Demonstration Farm is contained in Table 2. The responsiveness of high genetic merit cows to reductions in stocking rate is already apparent. Based on the first year's results, the stocking rate for optimum milksolids production is as low as 85 kg Lwt/t DM. The stocking rate for optimum EFS is expected to be even lower.

It is important to remember these changes in stocking rate can be achieved

Table 2
First year's results from a trial to optimise stocking rate (kg Liveweight/t DM) for EFS

Farmlet	1	2	3	4
Stocking rate (cows/ha)	2.5	3.2	3.7	4.2
Stocking rate (kg liveweight/ha)	925	1150	1370	1550
Stocking rate(kg liveweight/t DM)	73	86	101	118
Pasture grown (t DM/ha)	13	13.3	13	12.1
Supplement bought-in (t DM/ha)	-0.4	0.1	0.6	1
Total available feed (t DM/ha)	12.6	13.4	13.6	13.1
Milksolids Production				
kg/cow	366	321	256	225
kg/ha	922	1019	946	923
kg/tDM	73	76	70	70
kg/kg Lwt	1.00	0.89	0.69	0.60

by reducing the number of cows per hectare, increasing pasture production, or introducing supplementary feeds. Often, if supplementary feed is available at a sufficiently low cost this may provide the best solution because it can be provided in the shoulders of the season to extend lactation, encouraging higher milksolids production per cow.

Maximising DMI at high stocking rates

To ensure high levels of pasture utilisation are achieved throughout the season, stock policy, grazing management and any supplementary feeding must ensure that at each grazing during the year the available pasture matches pasture requirements. The herd must be offered sufficient pasture to be well fed, but not leave a high post grazing residual full of clumps and ungrazed leaf material. High stocking rates alone are often cited as a reason for low per cow performance within pastoral dairying systems. However, survey data in New Zealand continually suggest that the farms with the highest stocking rates maintain the highest per cow performance. Within reason, it is likely that policy and management decisions have a greater effect on per cow performance than stocking rate.

Poor per cow performance is caused by low annual dry matter intake (DMI). Of course some farms are simply over stocked, and low performance per cow is simply a symptom the farm simply not having enough total feed available to feed the herd properly. However on the majority of farms poor DMI and animal performance is a result of a mismatch in the timing of feed supply and herd requirements during the season. The seasonal nature of pasture production means that even at optimum stocking rates, too much pasture will be available at some times of the year, while at other times insufficient will grow to feed the herd.

Manipulating herd requirements

The DM requirements of dairy cows are highest about 6 weeks after calving, and are at their lowest while the cow is dried off. At a given stocking rate, calving and drying off decisions have the greatest influence over the annual feed requirement pattern of the herd. Herds with high per cow performance generally have early mean calving dates relative to peak spring pasture growth to ensure peak DM requirements coincides with peak pasture growth. Because of the lag between calving and peak intake, the mean calving date of the herd should be about 6 weeks before the date when expected growth rates exceed herd requirements.

Drying off cows and removing cull cows from the herd can be used to reduce feed requirements after spring growth slows. In areas where autumn pasture growth is late or irregular this will often be more profitable than underfeeding the whole herd. The annual pattern of pasture production and quality necessitate high performance per cow in the first 150 days of lactation. This is even more critical in areas which expect a period of summer dry. Therefore, spring cow condition and pasture cover targets cannot be compromised by milking too many cows for too long in the autumn. Again, supplementary feeding may be justified if the costs are low enough, and autumn growth is reliable.

Manipulating pasture supply

Nitrogen fertiliser is one of the few tools available to increase the supply of pasture during the season. Under New Zealand conditions nitrogen responses in the order of 10 kg DM/kg N applied will generally be achieved when moisture is not limiting plant growth. Applications in winter and early spring can be a cost effective source of extra feed to fill spring feed deficits created by a high stocking rate, or early calving date. Autumn responses are more variable, particularly after a long dry summer period. Recent research has demonstrated the applications of nitrogen in late spring/early summer dry periods can be an effective means of providing extra feed for periods of summer drought (Penno, 1998).

During spring when more pasture grows than can be eaten by the herd, the surplus pasture must be removed from the grazing area. If pasture that is not required is left as a high post grazing residual, it will increase the amount which is wasted through death and decay, and reduce the quality of the pasture offered at subsequent grazings. Accurately identifying surplus pasture and harvesting high quality pasture silage can provide a high quality and cost effect supplementary feed.

Manipulating feed supply with supplements

Pasture grown on the dairy farm will not always be the cheapest form of feed available for milk production. Indeed, calculations which include the capital costs of owning land often make pasture look expensive. However, it must be remembered that once the farm has been purchased, and the pasture has been grown, this argument becomes irrelevant. Even at times when pasture

Table 3
Recent farm systems experiments investigating the use of supplementary feeds

Reference	Supplement	*Cows/ha*	Calving date	Milkfat (g/kg DM)	Protein (g/kg DM)
Clark 1993	Pasture silage	3.8	5/7	40	22
Penno *et al.*, 1996	Rolled maize grain	3.2	15/7	37	39
Penno *et al.*, 1996	Rolled maize grain	4.5	15/7	50	38
Thomson *et al.*, 1997	Concentrate pellets	4.2	20/6	76	58
Thomson *et al., 1998*	Maize silage	3.8	27/6	55	37
Penno *et al.*, 1998	Maize grain	4.4	12/7	51	40
Penno *et al.*, 1998	Maize silage	4.4	12/7	46	31
Penno *et al.*, 1998	Balanced ration	4.4	12/7	52	42
AVERAGE				**51**	**38**

cost more to grow than other feeds it must be utilised as and when it becomes available because of its short shelf life. Nevertheless, at times it will be economic and sensible to integrate feeds other than pasture into pasture based systems.

Table 3 contains a summary of five recent farm systems trials that have investigated the use of supplementary feeds. On average the use of supplements have increased milkfat production by 51g/kg DM, and milk protein production by 38g/kg DM. There is a trend for larger responses from concentrate feeds compared to maize and pasture silage. This is a result of the extra energy concentrates supply in each kg DM. There is also a trend for larger responses at higher stocking rates, and with earlier calving dates. The larger the feed deficit the larger the response to extra feed will be. The largest response that has been reported (Thomson et al,, 1997) was achieved by combining a high stocking rate with a very early calving date. In all these experiments gaining extra days in milk was a critical factor leading to good responses to supplementary feeds.

The response determines how much can be paid for the additional feed. The extra milk must be sufficient to pay for the purchase and storage of the feed, feeding out, the costs associated with extra days in milk, and the required profit margin. I suggest that because of the risks associated with biological production systems, a profit margin of 100% is necessary. Use the cheapest forms of feed first. In most cases this will be extra pasture grown with nitrogen fertiliser. In New Zealand maize silage and by-products are also sometimes cheap enough to allow their profitable use.

To effectively incorporate large amounts of additional feed into a farm system, key components of the system must change. If the feed supply and demand is in balance, introducing extra feed is likely to simply reduce the efficiency of feed utilisation. To maintain pasture utilisation extra demand for feed must be created. The most efficient way to utilise additional feed is to extend lactation length to improve per cow performance. Using extra feed to increase performance per cow reduces the proportion of feed is used for maintenance. Whether the extra days in milk should be in spring or autumn depends on the source of feed.

Conclusion

New Zealand dairy farmers have learned to produce milk cheaply by continuously striving to increase productivity per hectare, per cow and per labour unit. Our seasonal milk production systems are underpinned by growing and grazing large amounts of pasture. Total milksolids production is determined by the total amount of feed available, and the proportion of this feed that is eaten. Although pasture is not always the cheapest form of feed, it is a short shelf life product and must be eaten as and when it grows.

Feeds other than pasture can be successfully integrated into pasture based systems and will yield about 50 g milkfat and 40 g milk protein/kg DM offered. To attain large responses to supplements they must be considered as part of the total feed supply, and the stocking rate must be sufficient to utilise the total amount of feed available each year.

Stocking rates traditionally recommended in New Zealand may be too high to maximise the biological and economic efficiency of the whole farm system. Current recommendations are that under New Zealand condition stocking rates should allow Friesian and Jersey cows to attain 400 and 350kg MS/cow, respectively. Research suggests that whole farm efficiency is optimised at stocking rates of about 85 kg of herd liveweight DM of total annual feed supply.

Maximum profits will arise from producing as much milk as is possible at the least possible cost. In Ireland, where quota restricts total milk production, it is likely that profits will be maximised by maximising the proportion of milk production that is produced from grazed pasture, while minimising the number of cows required to efficiently utilise the total amount of feed required.

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Improving Milk Solids by Management

D. ANGLESEY

Tourin and Moore Hill Farms, Lismore, Co. Waterford

This paper describes how we at Tourin and Moore Hill farms try to achieve high milk solids production per cow. Tourin farms is owned in partnership by John Maxwell and Kristin Jameson. My career at Tourin began in 1975. Dairy stock from Northern Ireland were bought as the basis of a new dairy herd. Soon after their purchase 66% of these animals contracted brucellosis and were slaughtered. Replacements were bought from local stock (Shorthorn and other breeds), from this period we initiated our own herd register, since then the ancestry of each animal produced at Tourin can be traced. Our breeding programme in the herd has evolved through this register, proven bulls have been used except for one 3-year period. Irish bulls were used in 1982, New Zealand bulls in 1985. Since the early 1990's our breeding policy has concentrated on improving milk solids production. With Co-op payment systems now biased in favour of milk protein the rewards of our breeding policy have shown a return on investment. Improving milk solids is not an easy job, there are many issues involved in getting it right. The cow, her genetic make up, diet, calving date, drying off date, condition score, grass allowance, and finally how well she's managed are, I believe the main issues involved to increase milk solids.

Outline of farm and management

360 milking cows, 47% autumn calving (MCD 10 November); 53% spring calving (MCD 7 March)

115 ha Grass, 29 ha Maize, SR 2.5 cows/ha

Manager, 2.5 labour units, 1 Tractor driver. I have responsibility for the dairy unit, calf unit, heifer rearing and 1200 mid season lambing ewe flock.

Objective: To increase kg milk solids production per cow (primarily milk protein)

Management for milk protein

Cow - Breeding/Performance

The base of the herd has been bred from non-Holstein and Holstein bulls from (1980-1990). Bulls such as AFP, JCE, FSM, SRD and SAL. Since 1990 to the present day we have concentrated on breeding the herd to high milk solids bulls with reasonable milk volumes. Our present day herd consists mainly of INU, BGI, PRE, EBZ and ARN daughters. The percentage Holstein of the herd is now increasing which we may have to suppress. We have taken a policy decision to use some NZ semen on both herds. The selection of sires for the herd is for sires positive in milk protein %, milk < 700 kg and negative for milk fat %. Sires used on the herds for the past two years are;

Autumn herd - BGI, ICN, SKT, DTV, DRH, SPK, HZE and OYE

Spring herd - OUF, OYE, RFE, LYE, and WSE.

In any autumn/spring herd a percentage of animals are carried over from one herd to the next. Usually these are the better animals in the herd. We try to minimize this as much as possible however when it happens the animal is then inseminated to a beef bull. This avoids breeding replacements from carryover animals.

Calving date

The calving date in both herds is targeted to increasing the amount of grazed grass in the calved animals diet. The MCD (mean calving date) of the spring herd is currently March 7. Calving usually begins the 15th of February and finishes the 20th of April. Once calved the animals have access to grass initially for 2-3 hours until 1/2 day turnout and then full time turnout. Previously our spring calving date was slightly earlier i.e. (late January).

The MCD in the autumn herd is November 10. Calving begins in October and continues until mid December. This is slightly late by autumn calving standards and we plan to begin calving earlier. The majority of animals calve outdoors. These animals are grazed until mid December. Their winter ration is fed once calved. When grass is not part of the diet it is replaced by maize and grass silage. The grazing management employed with the autumn herd is flexible depending on weather, ground conditions and grass supply. A target grass intake of 4-5 kg grass DM is the aim while this herd is grazing.

Grass

Grazed grass plays an important role as a feed to both herds. With lower milk price and high input costs on the farm we aim to use this feed to our advantage. Our target for the future is to increase the amount of grazed grass to 80% of the spring herds diet. The autumn herds diet may be increased to 65-70% grass at a maximum. In the past we have managed pasture with little emphasis on feeding the cow. With the onset of work on grass allowance, post grazing sward height and farm cover we are now feeding our animals better.

It is worth noting that both herds are managed as two entities. The herds have separate grazing areas, grazing area crossover takes place during the drying off period or periods of excessive grass growth when the autumn herd may graze behind the spring herd.

We have learned to our cost about the absence of grass on the farm in the spring period. A lot of work is put into planning and implementing the closing strategy of the farm, setting it up for the spring. Closing begins in mid October and ends in mid December. Turnout takes place the latter days of February. Initially only for 2-3 hours. All animals are grazing by mid March. Investment has been made in the past year accessing more pasture with a network of farm roadways.

The entire land area of the farm can be cut for silage. This gives considerable flexibility in closing paddocks for silage. Surpluses can be harvested readily as they appear.

Grass allowance to the spring herd during the main grazing season averages 19-21kg DM/cow/day. The grass allowance to the autumn herd is much the same until mid June. This herd is then grazed on a strict allowance of between 15-17 kg DM/cow/day. Body condition score is usually good at this time so imposing a lower allowance keeps these animals from getting over fat. The autumn cows when dry are grazed on an outside farm for the months of August/September and part of October. This allows for grass supply to build up for the autumn on the home farm and can occasionally allow for a larger second cut to be harvested.

Grass supply in the autumn is always large i.e. the farm cover is high (1400-1500 kg DM/ha). The spring herd is usually supplemented from late September (irrespective of grass supply). Grazing with both herds continues until grass supply reduces. At this stage the autumn cows get preference to the main grass area on the farm. The spring cows clean up the paddocks as part of the closing programme. Housing of the spring herd takes place in late November.

Clover

Clover makes up a proportion of our grass swards (ranging from 30% to 5% on a DM basis). It is such a seasonal plant, one cannot rely on it to continually produce DM. Its is sown in the swards with tetraploid grasses so that it can establish. It establishes itself firmly in the swards in mid summer. We have reduced nitrogen input because of its presence in previous years, however this has not been a consistent trend.

Cow Nutrition

<u>SPRING HERD</u> *(Lactation length 290 days)*

Feeding regime

Maize silage plays an important role in the diet of the spring herd, until the amount of grazed grass increases 8-kg maize DM is fed. It is reintroduced in October when grass supply is declining (5 kg DM/cow). The concentrate mix fed to the spring herd is based on maize gluten, beet pulp and molasses, concentrate is fed to a maximum of 5.5 kg with maize silage in the diet. At pasture a mixture of molasses, minerals, cal mag and bloat guard is fed. This mix is supplemented when the herd is on grass only. Over the total lactation approximately 580 kg of concentrate is fed to the spring herd. In 1998 the spring herds feed input was 1.2t grass silage DM, 0.3t maize silage DM, and 4.6t grass DM (allowed).

The spring herd have a 25-30 day shorter lactation length than the autumn herd, the lactation length is mainly controlled by quota, monthly supplies in November and December dictate their drying off date.

AUTUMN HERD *(Lactation length 320 days)*

Feeding regime

The aim with this herd is to maintain total dry matter intake at a high level from the beginning of lactation. We find that this can be achieved with a mix of feeds - concentrate, maize silage, high DM grass silage, grazed grass and straw. A diet feeder is used to mix the feed. No in-parlour feeders are on the farm so the performances recorded are achieved with group feeding. Maize silage is a large part of the autumn herds diet (10.5-kg cow/day) this is an exceptional feed at maintaining high DM intake. Grass silage is offered at a level of 4-5 kg DM/cow/day. The concentrate mixture is designed to balance a diet based on maize silage containing 25% to 30% starch. Factors considered are protein solubility, sources of digestible fibre and sugars, absence of anti-nutritive substances, palatability and ingredient cost. The concentrate fed is as follows; Molasses 0.9 kg DM, Premix (Distillers, Soya, Rapeseed and Citrus pulp) 5 kg DM, straw (wheaten) 0.5, minerals 0.22. This concentrate can be offered at levels of 8 kg concentrate/cow/day during the full-time indoor feeding period. At grass post calving the autumn calvers are offered 80% of their total winter ration. On average over their total lactation the autumn calvers are offered 1000 kg of concentrate. In 1998 the total feed allowance of the autumn herd was 0.8t grass silage DM, 1.0t maize silage DM and 3.8t grass allowed.

Herd performance

Table 1

Milk yield, milk fat and milk protein (%), kg milk fat, kg milk protein and kg total milk solids for the spring herd

Spring cows	Milk yield (gals/cow)	Milk fat %	Milk protein %	kg milk fat	kg milk protein	kg total milk solids
1994	1305	3.82	3.38	233	207	440
1995	1314	3.59	3.39	221	209	430
1996	1469	3.64	3.37	250	232	482
1997	1512	3.92	3.43	278	243	521
1988	1455	3.70	3.48	252	237	489
Heifers						
1994	1230	3.95	3.38	227	195	422
1995	1042	3.81	3.34	186	163	349
1996	1128	3.91	3.59	206	190	396
1997	1253	4.05	3.43	238	201	439
1998	1186	3.84	3.49	212	192	404

Table 2

Milk yield, milk fat and milk protein (%), kg milk fat, kg milk protein and kg total milk solids for the autumn herd

Autumn cows	Milk yield (gals/cow)	Milk fat %	Milk protein %	kg milk fat	kg milk protein	kg total milk solids
1994	1427	3.63	3.27	242	218	460
1995	1448	3.63	3.33	246	225	471
1996	1490	3.87	3.35	263	228	491
1997	1646	4.11	3.49	317	269	586
1998	1711	4.26	3.52	341	282	623
1999	1717	3.99	3.54	321	285	606
Heifers						
1994	1138	3.77	3.26	201	174	375
1995	1215	3.77	3.34	214	190	404
1996	1237	3.90	3.43	226	199	425
1997	1372	4.11	3.57	264	229	493
1998	1424	4.24	3.51	283	234	517
1999	1401	3.97	3.50	260	230	490

Cow and heifer management

Cow condition score

We maintain our animals in a large body condition score throughout lactation. This can be achieved by calving them down in adequate body condition score. The targets which we try to reach with both herds are;

Calving 3.5 - 3.75
Breeding 2.9 - 3.1
Drying off 3.3 - 3.5

During the dry period if some specific animals (first calved heifers, older cows) are in poor condition 2.25 - 2.75. We split the dry cow mobs into two individual groups. We feed these animals then to improve their body condition scores.

Heifer weights

The majority of our heifers calve down at 22 - 24 months of age. We place particular emphasis on growing the heifers well to reach adequate weights at bulling and calving. We try to calve the heifers where possible at an average bodyweight of 580 kg. At these weights these heifers are not under as much pressure post calving in large herds which we run.

Stockmanship

The herdsmen employed at Tourin have a high level of stockmanship. This is something, which we are pleased about and is very difficult to acquire in these days of labour shortages on dairy farms. Sticks and kick bars, ropes etc are not used in the parlour. The animals while indoors have mats on their cubicles, which are cleaned twice daily. Lame cows are identified early and treated. We have a set of lame cow paddocks located near the parlour where the treated cows can graze. A key issue on the farm is to reduce the stress on dairy herd where possible. This policy has served us well thus far.

Summary and Conclusions

I have said previously in this paper that increasing milk solids cannot be achieved by alternating one element in the system. In our case at Tourin a number of key elements are in place, they are now having a positive effect on the milk production and composition on the farm. A brief outline of these elements are;

Breeding and genetics, long lactation length, adequate cow nutrition, maize silage and molasses, calving date and grazed grass, cow condition score, applying research results to improve milk solids, excellent advice, daily management carried out precisely and finally splitting the milk solids sample daily and testing it independently.

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Lessons from Kerry Agribusiness/Teagasc "Focus on Profit" Programme

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Introduction

In 1995, Kerry Agribusiness undertook a protein improvement programme on 35 monitor farms in co-operation with Teagasc. Both organisations have a common objective of helping farmers to improve their incomes. As there were no quota restrictions on milk protein, Kerry Agribusiness and Teagasc identified the potential for increasing the profitability and viability of Kerry farms through a programme aimed at increasing the milk protein from 3.20 to 3.40% by the year 2000. The programme also sought to reduce the costs of milk production by 5p/gallon over the same period.

Kerry Agribusiness milk suppliers are located in counties Kerry, Cork, Limerick and Clare. Milk supplies were restricted by the availability of quota; the high cost of production and, in many cases, poor farm structure and small scale.

Methods

The 35 farmers were selected to represent each category of milk supplier to Kerry Agribusiness. The factors considered for selection were scale of production, size of holding, soil type, farm management practices and farm location. Herds were milk recorded. Milk volume, protein and butterfat concentration, production costs, farm characteristics and management practices were monitored. Current information from research, on improving milk protein content and reducing costs, was communicated to monitor farmers by means of farm visits, farm walks, demonstrations, discussion groups, clinics, seminars, newsletters, booklet, press articles and the radio, by advisors and research personnel from Kerry Agribusiness, Teagasc, Munster Cattle Breeding Society, Department of Agriculture and New Zealand.

Grazing techniques

Several different grazing techniques were adopted in order to have grass in the cows diet in early and late lactation; these included paddock grazing, block grazing, strip grazing, back fencing, spokes of wheel, grazing from the back of paddocks, pre-cutting grass.

Information from research

Breeding

The breeding the relative breeding index (RBI) places three times more value on protein yield than on fat yield. High RBI bulls with a high positive predicted difference (PD) for protein % should be used when breeding to produce more milk protein. These bulls should be crossed with high protein producing cows to have sufficient good quality replacements. This will allow the culling from herds of cows producing less than 3% protein and 125 kg of protein and, if this culling could continue over a 3 year period, it would increase milk protein content by 0.15%.

Calving

Research data show that ,over a three year period, delaying calving from January 21st to March 15th increased milk protein by 0.17%. Mealing feeding was reduced by an average of 435kg. The margin per gallon of quota was increased by 8p.

Grass

Adding grass to a diet of silage and meals in spring increased milk protein by 0.11%. Likewise, grass in a silage diet lifted milk protein in the autumn by 0.24% compared to a silage only diet. Research data also show that increasing the amount of grass offered to a cow from 16 kg dry matter (DM) per day to 20 kg DM per day, milk protein increased from 3.24% to 3.30%, furthermore when the allocation was increased to 24 kg DM per day milk protein increased to 3.36%.

Intakes will increase by an average of 0.6 kg DM for every one-unit increase in grass digestibility. Digestibility is a key parameter and is the major determinant of metabolizable energy (ME) content. The difference in ME value between 70 and 80% DMD grass is 1 MJ/kg DM, however, the difference in intake is 3 kg DM/cow/day resulting in 2 gallons/cow/day more milk and a protein percent increase of over 0.1%. Increasing the energy in the diet increases the protein content of the milk.

Silage

The silage quality fed to lactating cows has a major influence on protein %. Research data show that if quality improves by 7 DMD units milk protein percent will increase by 0.1%.

Meals

Increasing the energy content of the diet with additional meals boosts protein by 0.05% for each 1 kg fed. The usual economical rate of meal feeding is 7 kg per cow per day while cows are fed indoors.

Results

Lactation length

Lactation length on the monitor farms was 260 days in 1995; however, this increased to 269 days by 1999. Cows must have lactation lengths of greater than 280 days to express their full genetic potential to produce protein. Cow numbers must be matched to available quota; this may mean reducing cow numbers. This provides an opportunity to cull low protein cows and to have more grass available for the remainder of the herd.

Grass allocations

Most farmers were willing to graze cows for 3-4 hours and bring them back to the yard, to avoid poaching, when the grass is grazed off. Monitor farmers also increased their grass allocations to cows from an average of 16 kg DM per cow to more the 20 kg DM per cow per day, particularly from early May onwards. This extra grass has a major influence on improving protein levels in milk. Twenty four hour allocation of grass rather than 12 hour allocation has become the practice on some farms as it allows cows with high demand for grass and shy feeders, such as first calvers, to increase their grass intakes.

Grazing season length

The number of grazing days on monitor farms increased from a 227-day average in 1994 to 256 days in 1999; 24 of the 29 additional grazing days were achieved in the spring (Tables 1 & 2).

Table 1
Number of days on which cows grazed grass - 1994 to 1999

	1994	1995	1996	1997	1998	1999
Average	227	239	248	258 2	51	256
Ranges	194-276	221-279	201-318	223-323	171-339	194-307

Table 2
Number of extra days grazing Spring 1994 - 1999

	1994 vs 1997	1994 vs 199	1994 vs 1999
Extra days	26	33	24
Range	0 - 66	13 - 68	0 - 65

Re-seeding

A number of changes had to be made on farms to achieve early grass and increase the number of days cows can graze. All the monitor farmers have re-seeded pasture since 1994. This has given earlier growth, higher yields, better quality, quicker recovery, a better response to fertiliser and later growth into the autumn. The monitor farmer with the lowest protein (2.97%) at the start of the programme has lifted protein to 3.27%; this meant an additional 6p/gallon from protein as a result of improving drainage, soil fertility and sward composition.

Table 3
Protein (%) as affected by reseeding

Date grazed	Old pasture	Re-seed	Difference
30/06/99	3.22	3.27	0.05
16/07/99	3.24	3.31	0.07
01/08/99	3.32	3.37	0.05
24/08/99	3.38	3.53	0.15

The data in Table 3 show the protein concentration prior to and after grazing re-seeds. The protein concentration increased by 0.05% and upwards when re-seeded pasture was grazed after an old sward. On each occasion, the composition of the sward grazed prior to the re-seeds contained over 50% perennial ryegrass.

Autumn and spring grass management

Closing off paddocks from mid-October enabled grass covers build up over the winter. Applying lime, phosphorus and potash improved the vigour of the swards. Nitrogen applications in early to mid-January boosted grass growth. All Terrain Vehicles (ATV's) were widely used to apply fertiliser on heavy soils.

Good roadways or cow paths are essential in order to graze grass in the spring. Access to drier areas of the farm helped monitor farmers to increase the grazing days in spring by over 20 which resulted in a saving of £21 per cow due to less meal fed and better quality milk.

Grass yields above 6cm and grass quality were measured on the next paddock to be grazed. Overall, both yield and quality varied considerably from month to month and year to year. However, variation was greatest in June and July and there was very little difference between the months. The data in Table 4 show grass yields for June.

Table 4

Average and range of pre-grazing grass yields (kg/ha) – 1996-1999

Year	Average	Range
1996	2631	892 - 4901
1997	2227	1026 - 3657
1998	2105	880 - 4122
1999	2381	1271 - 4224

The yield of grass suitable for grazing was between 2000 and 2500 kg DM/ha. The data in Table 4 show that the average yield was within that range for each year except 1996. Nevertheless, when the range of yields for 1999 varied from 1271 to 4224 kg DM/ha. The lowest yield (1271 kg DM/ha) was aftergrass; the highest yield (4224 kg DM/ha) was much too strong for grazing. Quality deteriorates rapidly as yield increases due to stem development and senesence at the base. Spring grass, up to mid-May, aftergrass and late autumn grass had digestibility values greater than 80%. Grass average DMD in June each year was consistently over 78%.

The data in Table 5 show a difference in digestibility of almost 10 units (from 74.8 to 84.5) in 1999. This difference was over 13 units in 1996. High digestibility grass is high in energy and also leads to high intakes. Milk yields and milk protein increased as grass digestibility increased. Milk protein was very much influenced by grass digestibility and intakes. Good grazing management in spring, i.e., grazing to 6cm maintained grass quality. Lax

Table 5
Mean and range of DMD-values (%) of June pre-grazing grass

Year	Average DMD	Range of DMD
1996	78.7	70.6 - 83.8
1997	78.1	73.3 - 81.9
1998	79.4	73.7 - 85.8
1999	78.9	74.8 - 84.5

grazing led to stem development; grazing too tightly lead to slow grass recovery, low intakes of poor quality grass and low protein in milk.

Cutting overgrown paddocks for silage and topping paddocks as dung pats, stemmy grass and weeds increase in the pasture, improved grass digestibility. Best results were got from topping when it commenced in early to mid-May and when grass was cut low at 6cm, and the tractor travelled slow and the flails were well edged. Nitrogen helped to increase the leaf content of swards particularly in mid season, applying small amounts of nitrogen gave more leaf than where no nitrogen was applied. These practices helped to maintain grass digestibilities at over 80% on monitor farmers.

Table 6
Protein percent by month

Month	1994 protein %	1999 protein %	Increase in protein %
January	3.06	3.28	0.22
February	2.91	3.29	0.38
March	2.86	3.08	0.22
April	2.95	3.06	0.11
May	3.09	3.17	0.08
June	3.13	3.26	0.13
July	3.18	3.29	0.11
August	3.22	3.34	0.12
September	3.40	3.52	0.12
October	3.60	3.68	0.08
November	3.47	3.70	0.23
December	3.21	3.52	0.31
Average	3.17	3.30	0.13

The data in Table 6 show that the average milk protein content was 3.17% in 1994 and had improved to 3.30% by 1999. The milk protein content was less than 3% in February, March and April of 1994. By increasing the energy content of the diet, i.e., more grass and better quality silage, the protein content improved by 0.38%, 0.22% and 0.11%, respectively, in these months by 1999.

The lowest increase in protein since 1994 (0.08%) was in May and October. However, the average protein content for May 1996 was 3.21% when grass growth and quality were good.

The average protein percent for 1999 was 3.30%. The range of protein content between the highest and lowest milk protein producer was 3.12% to 3.48%; this difference of 0.36% extra protein was worth 7.2p/gallon. Milk proteins level were less than 3% in February, March, April and May in the lowest protein producers. The difference between the lowest and highest milk protein producer was 0.90%, 0.63% and 0.62% in February, March and April, respectively. This extra protein was worth an extra 18.0, 12.6 and 12.4 p/gallon in February, March and April, respectively.

Table 7
Changes in mean weighted protein and fat contents, and in milk value

YEAR	1994	1995	1996	1997	1998	1999	Change
Protein (%)	3.17	3.19	3.22	3.25	3.28	3.30	+0.13
Butterfat (%)	3.52	3.56	3.57	3.64	3.76	3.76	+0.24
Protein/ 1000 gallons (kg)	148.3	149.1	150.9	152.3	153.7	154.5	+6.17
Fat/ 1000 gallons (kg)	164.7	166.6	166.9	170.3	175.9	176.1	+ 11.41
Milk value (p/gallon)*	94.72	95.43	96.24	97.51	99.24	99.59	+4.87

*Protein @ £4.11/kg and fat @ £2.05/kg

The data in Table 7 show that the weighted average protein concentration increased by 0.13% (from 3.52% to 3.76%) since 1994. Now, every 1,000 gallons of milk has >6 kg more protein and >11 kg more butterfat. Milk value increased from almost 95p per gallon to 100p/gallon.

Table 8
Number of farmers in different protein bands in 1994 and 1999

Protein bands(%)	1994	1999
3.45+	0	1
3.40 - 3.44	0	3
3.35 - 3.39	0	8
3.30 - 3.34	0	3
3.25 - 3.29	2	12
3.20 - 2.24	10	5
Total > 3.20	**12**	**32**
3.15 - 3.19	12	1
3.10 - 3.14	6	2
3.05 - 3.09	4	0
3.00 - 30.4	0	0
<3.0	1	0
Total <3.20	**23**	**3**

The data in Table 8 show that 12 of the 35 monitor farmers had milk protein content greater than 3.20% in 1994. However, by the end of 1999, 32 farmers had milk proteins >3.2%; 15 farmers had milk proteins >3.30% and 4 farmers had milk proteins >3.40%.

Table 9
Numbers of farmers with increased and decreased milk protein content

Protein % increase	Number of farmers
0.30 +	2
0.20 - 0.29	8
0.10 - 0.14	12
0.01 0.09	11
Total	33
Protein % decrease	
-0.1 - 0.09	2

Thirty-three monitor farmers increased protein %; 10 of these have increased milk protein by over 0.2% which has added 4p per gallon to the milk value.

Table 10
Meal and fertiliser costs (p/gallon)

Year	Mean & Range	Meal	Fertiliser	Total
1995	Mean	12.35	9.41	21.79
	Range	4.25 - 26.39	4.85 - 18.11	
1997	Mean	6.34	7.36	14.00
	Range	1.80 - 11.30	4.80 - 10.40	
1998	Mean	9.22	9.30	
	Range	0.02- 19.80	5.30 - 13.43	18.52
1999	Mean	9.94	7.34	
	Range	4.31 - 15.53	3.03 - 11.16	17.28

The data in Table 10 show the average cost of meal and fertilisers was 21.79p/gallon in 1995 with meal costing over 12p per gallon. However, by 1997 the cost of meal and fertiliser was 14p/gallon. The adverse weather conditions in 1998 and the Spring of 1999 increased the costs. Overall, the cost of meal and fertilisers in 1999 was 4.5p/gallon less than in 1995.

Conclusion

The main lesson from the Kerry Agribusiness -Teagasc "Focus on Profit" programme was that producing good quality grass and feeding sufficient amounts of this grass to cows, which have the genetic potential to produce high concentration of protein in milk, have increased the value of milk by 5p/gallon and reduced the cost of meal and fertiliser by over 4.5p/gallon.

Breeding Quality Cattle for Europe

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Market requirements

With almost 90% of beef exported it is important that the animals (or carcasses) produced are suitable for the highest priced markets. The highest priced markets available are in continental EU and the carcasses receiving the highest prices in these markets are those which are of good conformation and lean. For example, in the French market (Bord Bia, May 2000), steer carcasses grading U for conformation were priced at 26 p/kg (270 v 244) more than R grade, while the difference for bulls was 20p (259 v 239). Likewise, the difference in that market between carcasses grading R and O was 61p (264 v 203) for heifers and 50p (240 v 191) for cows. As breed is the main factor influencing conformation and leaness, it is important to make maximum use of the continental breeds which are superior for these traits. Thus, the aim is to produce animals (carcasses) similar to that of the purebred Charolais and Limousin herds in France.

Breed composition of the National Herd

A desirable feature of cattle breeding over the last 25 years has been the substantial increase in the proportion of the calf crop which were late-maturing breeds. Late maturing continental breeds increased from 6 to 8% of the calf crop in the late nineteen seventies to 52% in recent years. However, trends in breed usage in AI show that the proportion of late maturing breeds averaged only 36% in the period 1996 to 1998 indicating the greater reliance on natural service for continental breeds than with other breeds.

Calves from the dairy herd

There are 2.46 million cows in the National herd, 52% of which are dairy cows. Ninety-eight % of dairy cows are Friesian/Holstein and the most recent available data indicates that 46% are bred to Friesian/Holstein, 28% are bred to early maturing breeds and 26% are bred to continental breeds. Thus, approximately 300,000 from the dairy herd are late maturing breed crosses containing 50% continental breed genes.

Calves from the suckler herd

There are 1.18 million suckler cows in the country. The proportion of late maturing crosses in the suckler cow herd was shown to be 52% in 1998 having increased from 29% in 1992. Eighty-two % of the suckler herd are bred to late maturing breeds with the remaining 18% bred to early maturing breeds. Thus almost 880,000 calves from the suckler herd are continental crosses, 64% of which are three-quarters or more continental. Therefore, the important source of animals for the higher priced continental EU market is the suckler herd.

Bull breed comparisons

Sire breed comparisons have clearly shown that the late maturing breed crosses have higher growth rates, a greater proportion of muscle in the carcass, better carcass conformation scores and lower carcass fat scores compared to Friesians and early maturing crosses. As an example when compared to Friesians, Charolais x Friesian steers had 11% greater carcass weight for age, 18% more muscle weight at the same age, 44% better carcass conformation scores and 5% lower carcass fat scores.

Cow breed comparisons

At Grange, beef (Limousin and Hereford) x Friesian were compared with upgraded Charolais (at least 7/8 Charolais) as suckler cows. Charolais cows were over 100Kg heavier than the beef X Friesians. Based on intakes and weight changes it was estimated that the energy requirement of a 600 kg beef X Friesian cow during pregnancy is equivalent to that for a 660 kg Charolais cow. Colostrum yield was greater for the beef x Friesian cows than for the Charolais and as a result their progeny had higher immunoglobulin (1g) levels. Milk yields of the Charolais cows was only about two-thirds that of the beef x Friesians and as a result growth rate of their progeny to weaning was lower resulting in a liveweight difference at weaning in favour of the beef x Friesian progeny of 22 kg. The steer progeny of Charolais and Hereford x Friesian cows bred to Charolais sires were taken to slaughter at 2 years of age and the pistola (hind-quarter) of one side of each carcass was dissected into muscle, fat and bone. Carcass weights were marginally greater for the progeny of the Hereford x Friesian cows than for the Charolais progeny part of which was due to being 5 days older at slaughter (Table 1). Carcass conformation was better for the Charolais progeny than for the Hereford x Friesian progeny. When

Table 1
Liveweight and slaughter data for the steer progeny of Charolais and Hereford x Friesian cows

	Charolais	Hereford x Friesian
Weanling weight (kg)	304	328
Carcass weight (kg)	384	393
Age at slaughter (days	724	729
Kidney + channel fat (kg)	11.4	15.7
[1]Carcass fat score	3.8	4.1
[2]Carcass conformation score	3.7	3.4
Pistola (% of carcass)	46.8	45.6
Meat (% of carcass)	67.5	64.3
Fat (% of carcass)	15.3	18.1
Carcass value (p/kg)	194	181

[1]Scale 1 to 5 (5 fattest) [5]Scale 1 to 5 (5 best conformation)

expressed as a proportion of carcass weight, the pistola (higher priced cuts) of the Charolais progeny was greater than for the Hereford x Friesian progeny. The Charolais progeny had a greater proportion of meat and a lower proportion of fat than the Hereford x Friesian progeny. If the carcass is valued on muscle (meat) yield with pistola muscle valued at 454 p/kg, and fore quarter (and flank) muscle at 155p/kg then the carcasses of the Charolais progeny were worth 13 p/kg, or about £50 more for a 380 kg carcass than the Hereford x Friesian progeny. Similar calculations showed a difference in value of 20 p/kg of carcass between Hereford x Friesian and Charolais x Friesian steers.

Hybrid vigour

While the carcasses from the Charolais (almost purebred) were excellent, such a breeding programme obviously does not avail of hybrid vigour and milk production is low. Hybrid vigour (or heterosis) is defined as the superiority of the crossbred over the average of the two parent breeds for a particular trait. A summary of the available data shows that the overall advantage expected from using a crossbred suckler cow as opposed to a purebred in terms of kg of calf weaned per cow put to the bull is 13 percent. This advantage results from a combination of improved fertility, lower calf mortality and higher calf liveweight gain to weaning. In addition, the available data indicate that using a sire of a third breed increased the weaning weight by a further 8 percent.

Table 2

Ranking of top of AI beef bulls from different breeds based on growth rate

Breed	Bull name	Code	Growth EPD (kg carcass)	Conformation Score EPD	Fat score EPD	Killing-out % EPD
Charolais	Doonally Fabus	CF49	69	1.15 (7)	0.09	2.77
	Hara Kiri	HKI	62	1.18 (5)	-0.20	3.10
	Cavan Chap	IC27	52	1.23 (2)	-0.13	2.89
	Lisnalurg Ignot	LUI	52	1.28 (1)	-0.43	3.21
	Mogador	MDO	49	1.16 (6)	0.01	2.39
Belgian Blue	Tintin De My	TIY	41	1.20 (3)	-0.32	3.84
	Victorieux D Au Cheme	VDC	35	1.12 (11)	-0.68	3.79
Simmental	Ballagan Kelly	BKY	36	0.78	0.21	1.75
	Suir Con	SCO	30	0.83	-0.04	2.03
Limousin	Luttrellstown Gaynor	LTG	25	0.77	-0.14	2.95
	Enfield Big Bang	FL18	23	1.06	-0.12	3.55
Hereford	Clonakenny Fenton	CKT	27	0.61	0.79	1.50
	Rathcor Leo	RTE	18	0.53	0.59	1.12
Aberdeen Angus	Independence 117	RHD	16	0.87	0.45	2.33
Bohey Jasper		BJP	10	0.73	0.48	1.95

( ) Indicates ranking for conformation. Source: Irish Cattle Breeding Federation (2000).

Comparison of sires

In addition to substantial breed differences there are large differences between bulls within each breed for growth rate, carcass conformation and fatness and the incidence of calving difficulty. The Irish Cattle Breeding Federation (ICBF) have provided an across breed ranking of beef bulls which are available for widespread use in AI and on which full information is available. A list of the top bulls for growth is shown in Table 2. The "growth EPD" (Expected Progeny Difference) column shows the number of kgs. of extra carcass gain expected in steer progeny from the particular bull slaughtered at 26 months of age compared to progeny from standard Holstein/Friesian bulls slaughtered at the same age. For example the steer progeny of the best bull for growth, CF 49, would be expected to have 69 kg heavier carcasses with 1.15 higher conformation scores (scale E = 5 to P = 1), 0.09 higher fat scores and 2.77 percentage units greater killing-out percentage than the progeny of the standard Holstein/Friesian sires at the same age.

Bull progeny at 14/15 months of age

Bull progeny of HKI (ranked 2nd for growth and 5th for conformation in the ICBF list) and Simmental sires (used to provide replacements from within the herd) on Limousin x Friesian cows at Grange had carcass weights of 392 at 460 days and 357 kg at 439 days respectively. (Table 3) The spring born bulls were weaned on October 21 and received high quality grass silage plus an average of 4.3 kg of concentrates per head daily (total 968 kg) from weaning until slaughter on June 6, 2000. Daily gain from birth to slaughter for both groups exceeded 1.3 kg per day but the progeny of HKI had greater carcass weight for age (0.85 v 0.81 kg/day) due to a better killing-out percentage (59.5 v. 57.3%) than the Simmental progeny. Dissection of the pistola showed muscle yields of 78.1 and 75.2% for the HKI and Simmental progeny respectively. Despite high carcass weights particularly for the HKI progeny, carcasses graded very lean (average score 2.8 for HKI progeny) with mainly R for conformation scores. Preliminary results from a study carried in association with the ICBF and the Irish Charolais and Limousin Societies show a good relationship between scores for muscularity on the live animal and carcass conformation.

Table 3
Growth and carcass traits of bulls from mature Limousin x Friesian cows

	Charolais sire (HKI)	Simmental sires (to provide replacements)
Age at slaughter (days)	460	439
Daily gain to slaughter (kg)	1.32	1.31
Carcass weight (kg)	392	357
Carcass per day of age (kg)	0.85	0.81
Carcass conformation score	3.1	2.9
Carcass fat score	2.8	3.2

Future breeding policy

The suckler herd is the main source of the high quality animals (good conformation and lean) suitable for the higher priced EU markets. Suitable animals for these markets include purebred Charolais and Limousin such as produced in France. Similar breeding programmes could be achieved here by upgrading our present suckler herd. However, such a programme would lack the advantages of hybrid vigour and would result in lower cow milk production. Based on present information a more satisfactory approach would be to have a continental cross cow and where replacements are retained from within the suckler herd use a rotational breeding system involving breeds such Limousin (good conformation) and Simmental (milk production potential) with a third breed used as a terminal sire (eg Charolais on mature cows). These breed types are already widely available and it is suggested that certain herds should specialise in the production of suitable replacements i.e. herds with Simmental x cows use a Limousin bull, while those with Limousin x herds use a Simmental sire. First calving should be at 2 years of age (up to 3 years in purebred herds in France) with a known easy calving sire (e.g. Limousin AI sire) used for first calving. The terminal sire used on mature cows should provide progeny of high growth potential and good conformations. However, with cattle AI figures (excluding DIY) having declined from 1.03 million in 1992 to 0.72 million in 1999 and total AI to continental breeds only amounting 0.32 million (one-quarter of cows bred to continental sire breeds) the vast majority of continental calves are bred using natural mating. It is therefore important that in addition to improving the quality of sires in AI that the quality of continental bulls used for natural mating are also improved. Thus, the importance of linear scoring and providing BLUP values for bulls cannot be overemphasised.

Summary

* The highest priced markets require carcasses of good conformation which are lean and thus involves using continental breeds.
* The source of these animals is the suckler herd which presently provide almost 0.9 million continental cross animals or 3/4 of total continental crosses.
* Purebred Charolais (account for half the suckler herd in France) provide high quality carcasses but lack the advantages of hybrid vigour and have low milk production.
* Present information suggests that the suckler cow should be a continental crossbred with the terminal sire from a third breed.
* Based on meat yield 50 and 100 percent Charolais are worth 20p and 33p/kg carcass more than Hereford x Friesian.
* The top quality AI bulls for growth and conformation are now being identified by ICBF but as about 3/4 of breeding to continental breeds is by natural mating these bulls must also be of high quality.
* Payment for carcasses must be based on quality and the system of paying almost a flat price/kg does not provide any indication of market requirements.

Beef from Grass-Based System

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Grassland is Ireland's greatest renewable feed resource and it provides the main feed for ruminant livestock. Grazed grass, followed by conserved grass, are the cheapest renewable feeds available and as the majority of cattle are Spring-born, grazed and conserved grass are logically the basis for efficient beef production systems. Ireland has few competitive advantages, but its ability to grow grass does offer the chance to provide cattle (and sheep) with a relatively cheap feed source. The key to efficient beef production from grass, now and in the future, is to operate a flexible, adjustable grassland management programme, using factual information for prompt and appropriate decision-making purposes. The system operated must clearly match feed supply to animal requirements, putting the major emphasis on increasing the proportion of cattle diets that comes from grazed grass.

Cost of Grass production

a) Outside farmer's control

Grass growth is affected by a range of factors, some of which are outside the control of the farmer. Factors such as weather, geographical location and soil type have a major influence on grass growth and consequently on the cost of feeding livestock. Geographical location significantly affects the date of the start and end of the grazing season for example the grazing season in the south and south-west is at least 3 weeks earlier than the north and north-east. A time difference also exists at the end of the grass-growing season, where the south and south-west again have up to a 3-week advantage. These factors do affect the costs of producing grass. For the same soil type and level of inputs, the effect of geographical location means that grass yields can range from almost 16 t DM/ha to less than 10 t DM/ha. Translated into feed cost terms, the effect of location results in costs ranging from £37 to £52/t DMD (digestible dry matter). Weather, which can cause considerable variation in year to year annual grass production (i.e. + or - 20% difference from the long term average), can alter production costs from £42 to £63/t DMD. Excess soil wetness can result in production costs that range from £47 (dry) to £56 (wet)/t DMD.

b) Under farmer's control

The main factors controlling grass growth which are directly influenced by farming practices are soil fertility, nitrogen usage and grazing management. Now more than ever, farmers have to be cost conscious and each input has to be justified. For grazed grassland, fertilisers account for 80% of the input costs associated with grass production. It is an essential requirement that each farmer knows the soil nutrient status of their land. The decision to apply fertilisers to grazing grassland, especially phosphorus (P) and potassium (K), has to be made against the background of a knowledge of soil nutrient status. Nitrogen is the one major input at the farmers disposal which can be used to influence grass growth. An attractive response is achieved with the lower levels of nitrogen applied but grass production costs increased with each increment of nitrogen used.

Increasing nitrogen usage from 300 to 350 kg N/ha (270 to 310 units/ac) may increase yield by only 5% and the cost of this extra grass can be over £120/t DMD. Grass costs of this magnitude are very expensive and alternative purchased feeds could be economically more attractive.

Grange beef systems

(i) Suckler calf to beef system

Based on early-March calving, the current suckler beef systems finishes animals at 20 (heifers) and 24 (steers) month of age. The system is stocked at 0.84 ha per cow unit (cow + calf + year old + replacements) has a carcass output of 500 kg per hectare per year. This target is achieved by producing a steer carcass weight of 400 kg, heifer carcase weight of 300 kg and cull cow carcase weight of 400 kg. The target output (carcass/ha) is achieved from 10 tonnes of herbage dry matter (DM) plus a concentrate input of 820 kg/ha. Herbage production is based on 230 kg N/ha, and silage being harvested from 55% of the farm in late May, and 35% of the farm area in late July. Silage harvested in May is fed to the yearlings, while the July-conserved swards are offered to the cows. Cows and calves graze separately from the older cattle. Rotational grazing, with 10-12 paddocks per animal group, is practised.

Two-thirds of the lifetime gain for the progeny from the suckler system is produced during the grazing season. The liveweight gain during the first grazing season amounts to 220 kg (females) and 250 kg (males) or almost 60% of the animals lifetime gain. The indoor winter period accounts for one-third of the lifetime weight gains. The proportion of gain achieved by heifers is small in the second winter as animals are slaughtered early (at 20 months of age). However, almost half of the indoor liveweight gains are achieved through concentrate feeding. All of the liveweight gain achieved on the cows is derived from grazed grass.

(ii) Dairy calf to beef system

The present system involves purchasing March born calves (7 to 14 days old) from dairy herds and finishing them 24 months later. Both Friesian and Friesian/Charolais crosses are used. Calves are reared indoors for the first 10 to 12 weeks and go to grass in early May. Silage-ground is grazed in early Spring. Sixty percent of the farm area is cut for silage in late May, with a further 40% cut in late July. Animals are stocked at 0.45 ha/animal unit (yearling plus calf). Herbage production is about 10 tonnes DM/ha and together with a concentrate input of 2.2 tonnes/ha, produces 750 kg carcass per hectare. The concentrate input at 1 tonne per animal is made up by feeding 100 kg at the calf stage (including some at grass in the autumn), 150 kg during the first winter and the remainder during the second winter. A rotational grazing system is practised. Lifetime weight increases of 630 and 565 kg per head are achieved for Charolais x Friesian and Friesian steers, respectively. Fifty to 55% of the gain is achieved at pasture and a further 25% is achieved from forage indoors. A greater proportion (55%) of the weight gain is achieved during the second year at pasture when compared with the Suckler Calf to Beef System. Weight gains during the final winter are almost double those achieved during the first winter.

One of the main features of both Calf to Beef Systems is the high stocking rate achieved in the early part of the season. Both systems reach a peak in early June of 3000 kg liveweight/ha and this nevertheless results in high animal gains and provides sufficient areas to be conserved for winter feed. The longterm future of beef production systems in Ireland will depend on integrated Calf-to-Beef systems with a major proportion of the lifetime liveweight gain being derived from grazed grass.

Grazing management strategies

(i) General principle

The objectives of grazing management are to produce high yields of quality grass over a long grazing season and to manage both the cattle and grass so as to utilise the sward as efficiently as possible while getting high levels of animal intake and thus achieve high levels of animal output.

(ii) Utilising grass

Successful beef production from grazed grassland depends on having a planned management system which allows for flexibility as conditions change. As grazed grass is the main feed component, a knowledge of its growth pattern and stock-carrying capacity is important. Grass growth is seasonal and can change widely over short periods of time. However, one general trend is evident and that is that once mid-April is reached, grass growth increases rapidly, and during May values of 100 kg DM/ha/day are common. At that level of growth each hectare is capable of supporting up to 5 livestock units (2 LU/ac) assuming that each LU is offered 20 kg DM/day. Once mid-June has passed there is an inevitable decrease in grass growth, so that by mid-August pastures will only support half of the May stocking rate. There is nevertheless big variation between years and within years there can be a two to threefold differences in growth rates. Thus, for example, over a 3 week period in late-April to mid-May, grass growth can increase 10-fold but may drop to the third over the next four weeks.To fully exploit this changing grass supply, a flexible management system is required. A system that allows the farmer to see up-coming shortages as well as short-term surpluses needs to be practiced if grass is to be utilised efficiently and economically. A rotational grazing system offers the flexibility necessary to make these management decisions. As most farms are composed of a number of fields, which vary in size, the introduction of a rotational grazing system is not necessarily too difficult. Subdivisions do not need to be of equal sizes. The greater the number of fields or paddocks that are available, the greater is the flexibility introduced into the grassland management process. While keeping control on costs, a target of 10-12 paddocks (not necessarily of equal size) in the Spring-Summer period offers sufficient flexibility to manage grass in a variable supply situation.

The aim of each cattle farmer must be to maximise the intake of grazed grass by cattle in an efficient manner and to get maximum animal gains over as long a grazing season as possible. For efficient beef production from grassland, a balance is needed between the ability of grassland to support stock during the grazing season and the provision of adequate Winter feed. Inadequate Winter feed, especially in terms of quality, is still a serious limitation on many drystock farms. Inadequate stocks of winter feed means prolonged winter grazing, with little liveweight gains (indeed weight losses will occur) and damage to pastures. Late closing of swards as a result of uncontrolled grazing in Autumn/Winter means delayed Spring grass growth, so that when stock are turned-out early, through necessity as a result of Winter feed shortage, performance is poor and pasture production suffers as a result of over grazing. Early turnout to an adequate supply of Spring grass is highly desirable, firstly, in terms of improved animal gains, secondly to achieve a long grazing season and thirdly to reduce costs associated with the more expensive Winter period.

Knowing grass supply

A knowledge of grass supply at all times of the year is essential if informed management decisions are to be made. While issues such as rotation length and rest interval are of great importance to planned grassland management, a knowledge of pasture supply or pasture cover on a weekly basis (if not daily) is essential if the best use is to be made of grass.

All grassland farmers should have the skills to quantify pasture sward height and pasture yields (sometimes referred to as pasture cover). Tables which relate sward height (compressed heights) to yield have been produced at (Grange). An assessment of pasture cover may be obtained by frequently (once per week) walking the entire grazing area and measuring sward height. The measurement can be made with a sward stick, ruler or place meter. Eye assessment can also be used to estimate pasture availability. Once the technique of pasture cover measurement is mastered, it is surprising how quickly small changes in pasture supply will be detected.

Start of Spring grazing/Autumn closing dates

Late closing of swards as a result of prolonged uncontrolled grazing in Autumn/early Winter has a negative effect on Spring grass supply. Swards closed in mid-October compared with mid-December, can have yields in mid-March that are 70-80% higher Apart from less grass in Spring, there is a total loss to the system because the amount of grass grazed in the Autumn, as a result of the delay in closing, is less than the difference between the two Spring yields. It should be the aim of all livestock farmers to have some of the farm closed or rested from mid-October onwards to provide early Spring grass. A rotational grazing system facilitates an orderly closing of pastures in Autumn.

When pastures have a herbage mass (yield) of approximately 1000 kg DM/ha (in the grazing horizon) or a sward height of approximately 8 cm (compressed sward height), pasture supply should, in most years, be sufficient to support the full livestock grazing requirements on the grazing areas.

Grazing of silage swards

Any grazing of silage swards in Spring will reduce silage yields. However, provided that the final grazing is done before April 10, a reduction in silage yield of not greater than 15% can be expected. When the amounts of herbage consumed by the animals is allowed for, the net effect of Spring grazing of silage swards is likely to be less than 5%. Thus, grazed grass has replaced a more expensive winter feed (but the remaining winter feed may be more expensive). Recent Grange results have shown that in a planned grazing system, up to 3 weeks grazing can be obtained on silage swards in Spring. The earlier the sward is closed after grazing the smaller is the silage yield reduction. All silage swards should be closed by April 10 at the latest. In this situation, herbage mass (yield) on the silage swards was only 500-750 kg DM/ha in the grazing horizon (above 4 cm). Furthermore, a rotational grazing of silage swards, where paddocks are grazed only once, results in a series of Spring closing dates and thus a smaller yield reduction. At a pasture supply of 1000 kg DM/ha or greater in early April, silage swards should not need to be grazed because there is sufficient DM on the grazing land to carry the cattle.

Controlled grazing in Spring

The ability of well-managed grass swards to produce high yields of herbage and liveweight in April/June is underestimated by most livestock farmers. It is the stage where the greatest wastage of valuable feed takes place on farms. In most cases, the high yield of high quality herbage is not managed correctly and its true feeding value is not well used. The failure to adequately convert this valuable feed resource has a number of consequences. Firstly, while satisfactory animal gains are achieved in the short term (April/May), the performance for the subsequent months suffers as stock are grazing poor quality, stemmy, rejected herbage. Animals do not need to have huge masses of herbage (greater than 3000 kg DM/ha) in order to give satisfactory performance. Secondly, because of under-utilisation, which in some situations is less than 50%, pasture output is depressed for the remainder of the season. Thirdly, pasture quality is poor and swards which had a DMD value of 750 g/kg in mid-May (capable of producing a liveweight gain of 1 kg or greater/head/day) drops to around 650 g/kg DMD in June and July with the result that animal weight gains suffer. Fourthly, as pasture growth rates fall off, animals will be forced to eat into a stubble of very low quality with the result that gains in mid to late season will be poor, a phenomenon seen on many farms. This cycle of surplus grass growth early in the season and the inability to subsequently capture it in an efficient manner is repeated yearly on many farms.

Guidelines for grazing swards in Spring should centre on a rest interval of not greater than 24 to 26 days.

Rest intervals greater than these, while growing more grass, will lead to poor pasture utilisation and thus lead to swards of lower quality later in the season. Data from Grange show that grazing to a stubble height of 5 to 5.5 cm (compressed sward height) or a residual mass of 500 to 600 kg DM/ha during April to July, resulted in gains of over 1.1 kg liveweight/head/day.

Long grazing grass

With proper grassland management, animals can achieve a steady rate of gain over a long grazing season. Grange data shows that where pasture quality is maintained and when herbage supply and herd demand are matched, animals can grow at a steady rate from April through to November. Similarly, where overstocking took place in Autumn, performance was poor. Most pastures will only support 1200 to 1400 kg liveweight/ha from October onwards and for higher stocking rates a carryover of pasture from earlier in the season (August/September) is necessary. A rotational grazing system makes this approach more practical. Transferring grass from times of surplus to times of scarcity has been much discussed in recent years. There is surprisingly little scientific data relating to the practice of what has become known as extended grazing. Grange results over the past 3 years have shown that the grass, if available, can be carried as a standing crop in Autumn for 6 weeks or more with no advantage of a longer rotation, even though pasture quality (DMD) is maintained for periods of 9 to 10 weeks. However, from September onwards, on most beef farms herd demand matches grass supply, so that carrying feed supply for 6 weeks into October or November is unlikely to take place as there is not sufficient grass to do so. As provision of sufficient winter feed is a key issue in attaining high stocking rates, and conserving 35 to 40% of the farm in late July is an integral part of the management programme, the scope for surplus grass in the absence of omitting some second cut areas seems limited. However, on farms where most or all of the Winter feed comes from a single May/June harvest, the chances of carrying feed from August/September should be an option, but have yet to be assessed.

Overall comment

The optimal, rigorous management of Irish grassland is the route to a viable ruminant livestock industry in the future, assuming we will have to operate in a progressively more open economic marketplace but where there will be greater regulations regarding food quality, animal welfare and environmental considerations.

Fundamental to Ireland's ability to take full advantage of the opportunities provided by our grassland is a national, co-ordinated, focussed, comprehensive and fundamental research effort to understand grass production, consumption and conversion to quality beef – we must pursue the science of grass and beef.

This technology must be quickly transferred to beef farmers in the form of flexible, adaptable systems and management support mechanisms that will permit prompt and appropriate decisions based on accurate knowledge.

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Labour on Sheep Farms

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Labour in agriculture

The agricultural labour force in Ireland has been in continuous decline since the late 1950's, falling from 390,000 in 1960 to 135,000 in 1999. This is a feature of developing economies which results in increased employment in the industrial sectors with declining employment in the more traditional agricultural forestry and fishery industries. Agricultural employment in selected EU countries is shown in Table 1.

Table 1
Employment in Agriculture in selected EU countries 1997

Greece	Portugal	Ireland	France	Denmark	UK	EU
			% total employment			
19.9	13.3	9.9	4.6	3.8	1.9	5.0

Ireland still has the third highest percentage of its workforce employed in agriculture. Only Greece and Portugal has higher percentages engaged in farming. The northern European countries have much lower percentages, Belgium (2.7%), Germany (2.9%), Denmark (3.8%) with the UK having the lowest at 1.9%. The predominant feature of the agricultural labour force in each country, regardless of the percentage employed is its continual decline. The number employed in agriculture within the 15 EU member states has fallen from 11.9 m in 1980 to 6.9 m in 1997 i.e. a decline of 42% in less than two decades. The decline in the Irish agricultural labour force since 1970 is shown in Table 2.

Table 2
Ireland - employment in agriculture 1970 - 1997

1970	1980	1990	1999
	% of total labour force		
27	18	15	8

One of the main reasons for the exodus from farming has been the low financial rewards compared to returns from the industrial sector. Income survey data consistently show low or negative returns to labour management and investment in farming. In the past many continued in agricultural employment as there were no off-farm job opportunities or they preferred the life style associated with farming. However as economies become industrialised more off-farm job opportunities arise and this has led to the current situation where only 8% are employed and in agriculture in almost 50% of farm households either the farmer or spouse have off-farm employment.

There has always been underemployed labour on Irish farms particularly on small drystock farms. The 1999 National Farm Survey show 0.99 actual labour units "employed" on drystock farms, whilst the estimated labour requirement to operate the farm based on Standard Man Days was 0.50. It is not surprising therefore that output from agriculture has increased over the last three decades despite a falling labour supply. Investment in buildings, farm facilities and machinery have also replaced labour on farms.

Labour on sheep farms

Sheep number and flocks have been in decline over the last 5 years. One of the main issues raised by sheep producers in recent years has been the level of labour involved in running a sheep enterprise. The actual amount of time required to operate a sheep unit has never been quantified and this project is the first attempt to establish the actual position at farm level. Once the scale of labour required has been established then measures to improve efficiency can be researched and developed.

The objectives of the study were:

- quantify total labour used on sheep farms,
- allocate labour between farm enterprises and overhead tasks,
- quantify time spent on sheep tasks and variation in time between farms,
- to establish labour requirement of sheep and cattle on per LU basis,
- explain variation in labour requirements between farms,
- compare farm labour recording methodologies - detailed weekly v end of year estimates.

Thirty lowland sheep flocks producing mid-season lamb were selected by Teagasc sheep advisors and specialists. Flock size ranged from 150 to 1000 ewes with an average of 352 ewes. Detailed daily time sheets on labour use were kept by each farmer for the first week in each month over a 12 month recording period, commencing in September 1999. The amount of time devoted to each farm task was recorded and allocated to sheep, cattle, dairying or tillage as appropriate. Overhead farm tasks e.g. building/farm maintenance, office work etc. which could not be allocated to specific enterprises was recorded separately. Details on farm size, livestock numbers, farm buildings and technical performance were collected in a once off questionnaire which ranked buildings and handling facilities on a scale of 1 to 10.

Final records from participating farmers were received in mid-October so the results presented here are preliminary. The average size and stock number on the 30 farms is shown in Table 3.

Table 3
Survey farm details

Sheep (LU)	Cattle (LU)	Farm size (hectares)
95	31	63.9

Sheep were the predominant enterprise on the farms with average of 95 livestock units and 352 ewes. Of the 30 farms 13 had sheep only. The monthly time records showed an average of 2,867 hours worked on sheep farms with 2119 hours worked by the farmer whilst 649 and 99 hours were worked by other farm labour and contractors respectively. The farmer owner therefore accounted for 74% of total hours worked. The allocation of time to the different farm enterprises is shown in Table 4.

Table 4
Time devoted to sheep, cattle & dairying

	Sheep	Cattle	Dairying
		Average hours per LU per annum	
Routine tasks	26	25	66
Overhead tasks	6	4	17
Total	32	29	83
Total/ewe/annum	8	—	—

A total of 32 hours per livestock unit per annum was attributable to the sheep enterprise whilst cattle required 29 hours per livestock unit. This therefore contradicts the theory that sheep are much more labour demanding than cattle. A ewe requires 8 hours of labour input per annum, which is very similar to the Standard Man Day co-efficient which farm management practitioners have used over the last 3 decades i.e. 0.7 to 1 standard man day (SMD) per ewe depending on buildings and facilities. Of the 32 hours devoted to sheep 26 hours were spent at routine management tasks e.g. feeding, herding, dosing etc whilst 6 hours were spent on overhead tasks. The time spent on overhead tasks is much greater than expected and higher than that found in similar studies in the UK. There was only one sheep farm with a dairy enterprise in the study and the hours worked were much higher at 83 hours per livestock unit.

The variation in labour by size of enterprise was also analysed and as expected flocks with under 320 ewes average 37 hours per livestock unit whilst flocks with greater than 320 ewes averaged only 27 hours per livestock unit.

A more detailed analyses of variation ranked by hours worked per livestock unit of sheep is shown in Table 5.

Table 5
Hours per LU sheep - by labour input

	Low	Medium	High
Total hours - sheep/farm	2595	2738	3119
Sheep (LU)	123	84	74
Hours/LU Sheep	21.1	32.6	42.1
Ewes to ram	457	320	279
Weaning %	154	149	142
Stocking rate (LU/acre)	1.0	0.7	0.8
Farm size (acres)	133	190	151

The lowest labour input was associated with largest flock size. It is also interesting that those flocks with the highest labour input had poorer performance viz lower weaning and stocking rates. Over shepherding therefore does not result in better technical performance.

Detailed time records were kept on all tasks carried out by farm labour. A total of 79 different farm tasks were identified and the time devoted to each recorded in hours and minutes. A summary of time allocated to task groups is shown in Table 6.

Table 6
Time on major sheep tasks

	%
Lambing	19
Feed/forage	17
Herding	17
Veterinary	9
Marketing	5
Other	14
Overhead	19

Lambing, including checking ewes during lambing, accounted for 19% of total hours worked on sheep. Herding, which includes checking, counting, transport within the farm and changing internal paddock fencing accounted for 17% of all time input. Harvesting hay and silage, collecting bales, feeding meals and silage accounted for a further 17%. Veterinary tasks accounting for 9% (dosing, paring hoofs, dipping, scanning etc.) Overhead activities as previously discussed accounted for 19% of total time input.

The amount of time required to manage a sheep flock is affected by the quality of handling facilities and buildings. Sheep housing and handling facilities were ranked as poor average and good and the number of hours per LU associated with each group of farms is shown in Table 7.

Table 7
Labour input by housing and pens

	Hours/LU Sheep Poor	Average	Good
Sheep housing	35.1	24.8	25.7
Sheep pens	27.6	27.3	22.5

As expected farmers with good sheep housing spent on average 9.4 hours less per livestock unit than those with the poorest housing. Similarly those with good sheep penning spent 5.1 hours per livestock unit less than those with inferior penning. Good facilities are therefore important for efficient management of sheep flocks.

Paid farm workers contributed only 2.5% to total hours worked on sheep. Forty three per cent of farmers stated that they had difficulty in getting reliable labour whilst only 7% used the farm relief service.

Farmers were asked for their ideas or plans on how best to reduce the labour input to their sheep enterprise and their response is shown in Table 8.

Table 8
Ideas/plans to reduce labour input

	%
Improve housing	13
Veterinary - preventative	13
Improve handling facilities	10
Reduce feeding time in sheds	10
Compact lambing	7
Sheep dog	7
No improvement idea	37

Conclusions

Preliminary conclusions of this labour study are:

- labour requirements for sheep are similar to cattle and much lower than dairying,
- 20 per cent of farmer's time is spent on overhead farm activities, (farm buildings maintenance, fencing, meetings etc.)
- largest flocks have lowest input per ewe,
- high labour input per ewe did not result in superior technical performance,
- herding and feeding sheep accounted for 37% of labour, with lambing and

veterinary tasks accounting for a further 23%. Total amount of time on office work i.e. tax, farm planning, filling forms etc. was only 1.6% of total,

- farmers with good housing and handling facilities had lower labour input per ewe,
- farmers' views on improving labour efficiency were better housing/handling pens, illness/disease prevention, modernisation of indoor feeding and more compact lambing.

Acknowledgement

All the data presented have been provided by the 30 farmers participating in the study. I wish to acknowledge the amount of time, effort and co-operation given by these farmers in providing detailed weekly information on all their farm activities on an hourly basis over a 12 month period. Their commitment is evident in that of the 30 who started in August 1999, 30 completed the study in September 2000.

Financial Implications of Expanding or Reducing the Sheep Enterprise on Drystock Farms

P. MAHON

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Ewe numbers in Ireland increased from 1.55m. in 1980 to about 4.8m. in 1993 while numbers of farmers with sheep increased from 30,000 to 54,000 over the same period. This expansion in sheep was driven by the extension of the CAP for sheepmeat in 1980 and the introduction of various quota regimes. In June 1999 ewe numbers had reduced to 4.336m. This reduction in ewe numbers since 1993 has been mainly from the small flocks of under 50 ewes. (Table 1)

Table 1
Flock numbers and size (1994-1999)

	>50 ewes	51-100	101-500	500-1000	1000+
1994	21251	11909	15631	613	49
1999	16803	11269	14981	607	49

In 1999, of the 15,637 flocks of 100+ ewes, about 7000 are lowland flocks. It is projected that ewe numbers will decline by a further 900,000 in the period 1999 2007 (incl.) (Fabri-Ireland March 2000). Most of the expected reduction will occur in the smaller flocks, however, many farmers with large flocks will also be examining their future in sheep. The decision to remain in ewes, expand or reduce flock size will depend on many complex factors, including - labour considerations, financial, implications, constraints imposed due to off-farm employment, etc. Today I want to examine the financial implications of some alternatives open to the larger, more specialised and committed sheep/cattle farmer.

Table 2
Farm Income per hectare (1997 -1999)

	1997	1998	1999
Cattle - Rearing	£241	£229	£158
Cattle - Other	£230	£263	£169
Mainly Sheep	£220	£200	£164
			Teagasc N.F.S.

(Mainly sheep includes all types of systems and breeds)

Financial Implications of Changing Systems

In 1999 the gross value of cattle and sheep produced in the country was £1034m. and £153.5m. respectively. Premiums and headage added a further £456m. to cattle and £122m. to sheep output. Net income from cattle and or sheep varies from about £150 - £370 per hectare (£60 - £150/acre) with a few drystock farmers capable of reaching up to £200 income per acre (income as defined on profit/loss account). In general, average income from cattle/sheep farms is in the region of £170 - £200/ha. (£70 £80/acre).

When the margin for mid season fat lamb is compared with margins from cattle systems the results generally indicate that the gross margin and net income from mid-season lamb is at least equivalent or better to returns from cattle (Table 3).

Table 3
Gross margin per hectare for mid-season lamb and cattle (1996 - 1998)

	1996	1997	1998
		£/hectare	
Mid-Season Lamb	541	519	474
Cattle - All Systems	441	431	401

N.F.S. Teagasc

Overhead costs on cattle and sheep farms (excl. conacre) average out at around £170/ha. Indicating a net income of about £320/ha. (£129/acre) for mid season lamb as against £260/ha. (£105/acre) for cattle.

So, on average while the income from mid-season lamb is equal to or better than that of cattle, the investment required for sheep is about 50% of that required for cattle (£1700 v £3300/hectare approx.).

Results from the more intensive and efficient producers over the period 1997 to 1999 indicate that the margin of advantage remains with the mid-season lamb system (Table 4).

Table 4
Gross margin per hectare for top 25% of producers

		1997	1998	1999
Single Suckling	– Weanling			£475
	– Store	£661	£649	£475
	– Finish	£507		
Other Cattle		£771	£691	£618
Mid-season Lamb		£932	£876	£770

N.F.S. Teagasc

Changing your system - Financial Implications

A frequent question asked by many sheep farmers is not "should I expand ewe numbers" but "if I get out of sheep will I make more money and have an easier life". Clearly, the improvement in cattle premiums, slaughter and extensification, etc. available to the cattle farmer looks very attractive compared to the stagnant ewe premium. Excluding headage, a suckler farmer selling finished animals could collect around £370/ha. (incl. Extensification) compared to £155 or so for ewes, at similar stocking rates (2001 premium rates).

The individual farmer should not of course change their system on the basis of average or top 25% returns but on the basis of their own individual situation. The financial impact of changing a sheep and or cattle system basically depends on:

- WHERE ARE YOU COMING FROM - WHERE YOU WANT TO GO
- i.e., Level of physical efficiency of sheep and cattle enterprises
- Expected prices and premiums - New Investment required versus capital released
- Labour Requirements and personal preferences.

Basically, if net income from cattle and sheep are more or less similar and the investment requirement for cattle is double that of sheep, the financial implications of changing are obvious.

Two examples are used to illustrate the impact of changing on:

- Net Profit - Cash Flow
- Net Worth Change when examined at roughly comparable levels of efficiency for the cattle and sheep enterprises.

Case 1

Farm 60 ha.	–	No Headage
40 sucklers	–	progeny to beef
272 ewes	–	mid-season lamb
Good facilities, etc.		
Term Loan £20,000		

Some Alternative Systems

1. Reduce ewes to 100 - increase sucklers to 60.
   Extra Investment £23,000 + £8,000 extra working capital.
2. Reduce sucklers to 26 - increase ewes to 395.
   Reduced Investment £3200.
3. Reduce sucklers by 6 and join REPS.
   Reduced Investment £6500.
4. Reduce ewes by 55 and join REPS.
   Reduced Investment £1700.

Summary of Financial Returns

1. Profitability

	Present £	Alt. 1 £	Alt. 2 £	Alt. 3 £	Alt. 4 £
Gross Receipts	63780	68522	61919	64059	65793
(of which premiums)	(16430)	(19918	(15190	(16249)	(17633
REPS	–	)	)	(4800)	)
Cash Expenses	42414	-	39414	(4800)	
Net Cash Income	21366	47411	39846	24645	40334
Depreciation	4000	21111	22074	4000	2459
Net Income	17366	5000	4750	20645	4000
		16111	17325		21459

2. Cash Flow

	Present	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Cash Balance for Living Expenses	17382	15834	18408	20390	20454

3. Net Worth Change (Assume £15,000 personal drawings etc. tax)

	Present	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Net Worth Change	+556	-194	+588	+2859	+3443

Clearly the additional investment required for Alt. 1 and replacing ewes with cattle, places a big strain on cash flow due to increased loan repayments, while minor reductions in either cattle or sheep would qualify the farm for REPS and also extensification premiums at the low rate.

The All Sheep Farm

Case 2 looks at a sheep farm at a high level of efficiency and the financial impact of changing to 50% sheep: 50% suckling system.

Details:- 60 ha. – No Headage
635 ewes – mid season lamb
£20,000 Term Loan

Alternative

350 ewes + 50 sucklers selling weanlings
Extra Investment £58,000 - over 10 years at 9%

Summary of Financial Returns

1. Profitability (£)	Present - All Sheep	Alternative 50%: 50%
Gross Receipts	63169	70,080
(of which Premiums)	(9525)	(14958)
REPS	(4800)	(4800)
Cash Expenses	38481	46295
Net Cash Income	24688	23785
Depreciation	4000	5800
Net Income	20688	17985
1. Cash Flow		
Cash Balance for Living Expenses	19685	15280
2. Net Worth Change (assume £15,000 personal drawing excl. tax)		
	+2859	+1267

Summary

There is little difference in net income per hectare between cattle and sheep at comparable levels of efficiency. However, the investment cost of most cattle systems is roughly double that of sheep which swings the financial advantage in favour of sheep. Generally, changing enterprise mix is more or less akin to readjusting the deck-chairs with no great change in income and a probable worsening of annual cash flow. Qualifying for REPS (which is relatively easy from the stocking rate criteria in a cattle/sheep system) has a bigger impact on profit, cash flow, etc. than adjusting enterprise mix at comparable levels of efficiency.

The individual farmer, however, must examine their own situation and not base decisions on averages, top 25% or whatever. Each situation is different - the level of efficiency of each enterprise may vary, existing resources are variable, borrowing requirement and repayment capacity will vary and personal likes and dislikes may influence change over and above the financial considerations.

Appendix I Background Budgets

Case 1

Stocking Rate	–	1.15 acres/LU approx.	
Steer Weight	650kg		95p/lb
Heifer Weight	525kg		94p/lb
Meal Input	–	Steers	700 kg
	–	Heifers	450kg

Ewes 150% weaned

Sale price £43.70 per lamb

Overhead costs (excl. Interest and Depreciation) £9550 (base)

Investment Costs	
Suckler Cow	£750
Suckler Quota	£300
Replacement Ewes	£60

Case 2

Ewes 1.6 lambs/ewe weaned

Suckler Weanling Steer	320 kg	(£512)
Weanling Heifer	290 kg	(£348)

Overheads £11650 (excl. interest and depreciation)

Worm Parasite Control and 'New' Technology: A Fresh Approach

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Introduction

It is widely recognised that gastrointestinal parasites have a negative impact on the health, welfare and productivity of sheep. In cases of heavy infections that go untreated the result may be fatal (Coop, Graham et al 1985; Parkins & Holmes 1989). Current parasite control measures have an excessive reliance on anthelmintics with insufficient attention to judicious pasture management. The threat of anthelmintic resistance coupled with growing consumer concerns over chemical residues in meat and in the environment, which is resulting in longer withdrawal periods, means that we must re-examine the approach to parasite control on farms. Pivotal to any efforts to control parasites is a sound understanding of the epidemiology of the parasite as it interacts with the host under specific management and production systems (Barger, 1999).

Epidemiology

The life cycles of the major gastrointestinal nematodes are similar and can be described as direct in so far as only one host (i.e. sheep) is invaded during a single cycle of the parasite's life history. The adult female worm produces eggs that are passed out on to the pasture in the host's faeces. Given suitable conditions of warmth and moisture the eggs will hatch, complete two free-living feeding larval stages (L1 to L2) to become a non-feeding infective third stage (L3). In contrast to L1 and L2 stages, L3 (surviving on their lipid reserves) are best equipped to survive adverse conditions and are able to survive for many months at low temperatures and can overwinter. When ingested by a suitable host, the infective larvae (L3) mature to become adults and females produce eggs. The length of time between larval ingestion and the appearance of eggs (known as the prepatent period) in faeces is about 3 weeks. Peculiar to *Nematodirus,* all development to L3 occurs within the egg and a period of cold exposure as a stimulus to hatching is required. As a result summer/autumn hatching is largely inhibited and a mass hatch of *Nematodirus* eggs will occur in late spring early summer of the following year. Among other parasites which may be found in the abomasum and intestine of sheep (Table 1), the most ubiquitous parasites found in sheep in Ireland are *Teladorsagia (Ostertagia spp)* and *Nematodirus.*

In addition to an infective larva's (L3) ability to survive for many months at low temperatures, two factors which affect the normal parasitic life cycle and which ensure their continuation to the next season are arrested larval development within the host and the periparturient rise in faecal egg counts. Arrested / inhibited larval development can be described as the phenomenon

Table 1
Roundworm parasites found in sheep and their location in the gastrointestinal tract

Abomasum	Small intestine	Large intestine
Teladorsagia (Ostertagia) spp	*Nematodirus spp*	*Oesophagostomum venulosum*
Haemonchus contortus	*Cooperi spp*	*Chahertia ovina*
Trichostrongylus axci	*Trichostrongylus vitrinus*	*Trichuris ovis*
	Bunostomum trigoncephalum	
	Capillaria spp	
	*Strongyloides papillosus**	

*Infection occurs through skin as well as orally

whereby there is temporary cessation in development of the nematode. By remaining sexually immature in the host until more favourable conditions return, the parasite ensures its chances for survival. Not all nematodes have the same disposition for arrested development (Urquart, Armour, Duncan, Dunn & Jennings, 1996). Developmental arrest of larvae can occur either in response to the acquired immune status of the host or as a result of a seasonal stimulus (such as the increasingly colder temperatures experienced in autumn/winter).

The periparturient rise in faecal egg counts observed in ewes around parturition and in early lactation is a result of a temporary relaxation in immunity. The source of the high egg count could be three fold the maturation of arrested larvae (arrested because of host immunity), from an infection (overwintered infective larvae) picked up on the pasture or the increased fecundity of an existing adult worm population (Urquart *et al* 1996). The importance of this rise in faecal egg count is that it occurs at a time when there is an increasing number of susceptible hosts thus enhancing parasite survival.

The level of parasitism acquired by the grazing animal at any one point in time is determined by a number of factors. These factors may include the effects of seasonal conditions which determine the availability of both infection and pasture, husbandry system, grazing behaviour, nutrition, previous experience of infection (leading to immunity), physiological state of the host (notably in relation to the breeding cycle of the ewes) and the genetic make-up of the host. To a susceptible host the major epidemiological variable that influences the worm burden is the number of infective larvae ingested from the pasture each day (Barger, 1999). There is also clear evidence for genetic variation in the host's response to parasites (Barger, 1989; Stear and Wakelin, 1999; Hanrahan and Crowley,1999; Good, Hanrahan and Crowley 2000).

Lambs are the most vulnerable in the flock because they have no experience of infection. The ability of a sheep to mount an effective immune response is acquired over time, in response to parasite exposure. When and how effective the acquired resistance is depends on the species of parasite. For example

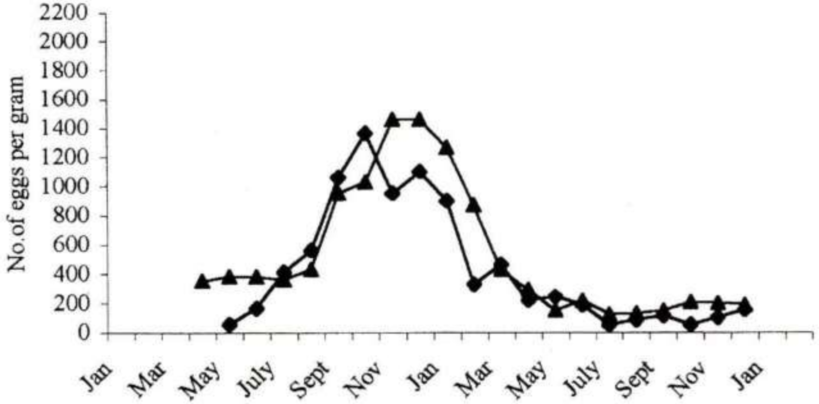

Fig.1 - Pattern of faecal egg count in undosed ewe lambs / hoggets (Kearney 1966-8)

young lambs acquire good resistance against *Nematodirus spp* after 2 to 3 months of grazing infected pastures, whereas 8 months may be required to develop resistance against *Teladorsagia (Ostertagia)* and *Trichostrongylus colubriformis* (Gruner, 1991). The pattern of faecal output in naturally infected untreated lambs seen in Kearney's study (Figure 1) reflects this acquisition of immunity over time. In response to the increasing level of pasture contamination over the grazing season the natural pattern of faecal egg counts in young lambs continued to rise until resistance began to develop and a subsequent reduction in faecal eggs was observed.

Pre-weaning spring-born lambs are confronted with two sources of infection: residual over-wintered larval population and the larval population that is a result of the ewe's increased faecal egg output around parturition and early lactation. Figure 2 highlights the effects of dosing ewes (lambed late

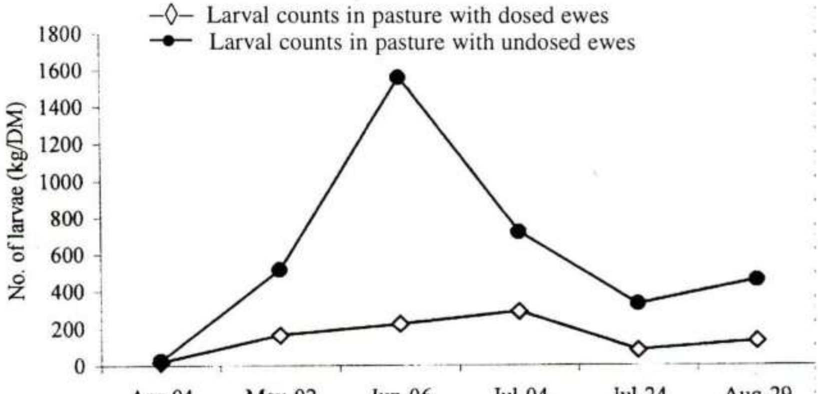

Fig. 2 - Number of infective larvae counted per kg/DM observed on pasture where ewes were dosed or remained undosed

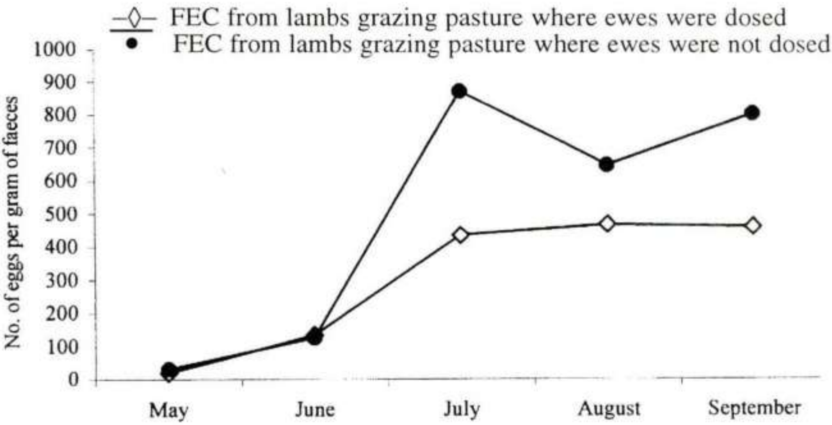

Fig. 3 - Faecal egg counts observed in lambs whose mothers were either dosed or remained undosed

March and dosed prior to going out and 5 weeks post lambing) on the subsequent numbers of infective larvae observed on pastures. A lower level of pasture contamination was observed on pasture where ewes were dosed (Figure 2) and this was reflected in the lower faecal egg count observed in lambs from those pastures (Figure 3). Post-weaning, and as a result of acquiring infection from the above two sources, lambs will be exposed to an increased source of infection derived from their own contamination of the pasture.

Parasite control measures

With the ability of some parasites to arrest within the animal or overwinter on pasture, the ideal of a completely parasite-free pasture is unrealistic. The essential aim therefore, is to minimise the level of pasture contamination thus reducing the intake of larvae by the lamb during the critical pre- and post-weaning periods. The availability of highly effective broad-spectrum anti-parasitic drugs has led to a chemotherapeutically dominated approach to parasite control in many sheep farming practices. However, anthelmintic resistance threatens this chemotherapeutic approach to parasitic control in sheep (Jackson, 1993; Coles 1997). Anthelmintics can be grouped into three classes based on their main chemical composition and mode of action (Table 2). Resistance has been observed for all 3 broad-spectrum families. Evidence from studies in Europe indicate a slower rate of emergence to that seen in the Southern Hemisphere (Waller, 1994; Jackson & Coop, 2000). There is little evidence that reversion to anthelmintic susceptibility occurs following an absence of the anthelmintic so once resistance is established it remains (Jackson, 1993). Recommendations to delay the onset of resistance include minimal chemoprophylaxis, maximal drug efficacy (correct dose and proper administration) in conjunction with judicious grazing management (Coles & Rouche, 1992).

Table 2
Anthelmintic groups and mode of action

Group	Class of anthelmintics		Mode of action
1.	Benzimadazoles & Probenzimadazoles	1-B	Disrupts parasites metabolism-leads to starvation
2.	Imadazothiazoles & Tetrahydropyrimidines	2-LM	Causes muscular paralysis and rapid expulsion
3.	Avermectin & milbemycins	3-AV	Causes flaccidparalysis

To take on board these recommendations a fully integrated approach to parasite control is needed based on epidemiological knowledge and grazing management practices so that severe pasture challenge is avoided by the most susceptible part of the flock. An appraisal of when to and why to dose is needed. On-farm DIY technology from New Zealand for determining faecal egg counts at farm level (FECPAK®) offers a potentially effective tool to enable the rational use of anthelmintics in conjunction with good grazing-management practices.

Faecal egg counts are an indirect and the only practical method available to measure parasite burden. To obtain a faecal egg count for a flock the FECPAK® method involves collecting samples from a representative number (about 20) of fresh faecal deposits to make a composite sample. This sample is subsequently mixed and processed and the results expressed as the number eggs per gram of faeces. Factors such as weight, nutrition, time of year, age of animals, clinical signs and seasonal appearance of particular parasite species are all considerations when interpreting the faecal egg count result. Monitored over time the information from composite faecal counts can be used when making decisions regarding the timing and use of anthelmintics. Faecal egg counts will also be indicative of how fast and to what extent a particular pasture is becoming contaminated. In addition to making informed decisions about anthelmintic usage, the use of this technology will also enable an assessment of drug efficacy. Performing post drench checks after dosing will achieve this. If eggs are observed this may reflect incorrect dosing practices that in itself will encourage anthelmintic resistance (e.g faulty dosing equipment, not dosing according to the heaviest in the mob) or that anthelmintic resistance is already present to the particular drug used.

Ultimately the use of FECPAK® technology will provide a dynamic flow of information on parasite status of sheep, give producers the choice of making informed decisions on when to dose, provide information about how optimal their dosing procedures are or indeed the efficacy of the drugs used. Moreover the results obtained from monitoring faecal egg counts on a regular basis can be interpreted in terms of pasture safety and incorporated into pasture management strategies on farms.

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Quality Lamb Partnership Programme

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A unique quality lamb production partnership offering full traceability from farm to fork has been established in Mayo. The South Mayo Quality lamb producer group have teamed up with Dawn Meats, Ballyhaunis, Teagasc, Bord Bia and the local Leader Company to form an alliance aimed at delivering an independent quality assured and fully traceable product to the consumer.

Background

South Mayo Quality Lamb Producer Group was set up in 1986 and from an initial 50 members delivering 2500 lambs per annum it has steadily expanded to 180 members and 25,000 lambs annually.

Quality has always been its hallmark. From early on it forged close links with Teagasc in the form of local drystock adviser Gerry Murphy. Its ties with the local Leader Company enabled it to venture into areas that might otherwise have been difficult to finance. Leader provided funding in the following areas:

- Mobile weighing facilities placed strategically throughout the area.
- A computer programme designed to monitor lamb throughput and performance both of individual farmers and the group.
- An independent assessment by a trained Teagasc grader of 18,000 group lambs and the training of group co-ordinators in assessing lamb quality.

Premiums towards the purchase of top quality terminal sires by individual farmers. The group has continued this premium ram scheme through industry sponsorship leading to over 500 top quality rams being introduced to the flocks in the past 8-10 years. Dawn Ballyhaunis and its predecessors have actively supported this effort.

Into the future

It is little wonder then that the next natural progression for this group would be in the area of quality assurance and traceability. Farm food assurance is now a key component of farm food production and marketing. Consumers require assurance in relation to food safety, animal welfare, environmental protection and traceability. Producers must demonstrate that the highest possible standards have been observed at all stages of production. These objectives can be best achieved by participation in a Farm Food Assurance Programme.

However the group felt that many of the current attempts at providing quality assured/traceable food products were window dressing with little really tangible to offer the consumer. They decided to strive towards a fully independent quality assurance scheme. Discussions and negotiations ensued involving Teagasc, Dawn Meats, Bord Bia and Leader which culminated in the launching of the Quality Lamb Partnership Programme at Ashford Castle Equestrian Centre by Minister for Food Mr. Ned O'Keefe recently. By offering more than the minimum demanded by the marketplace this pro-active partnership is ahead of its time but the hope is that they will be able to carve out a premium niche for the product and be repaid with a premium price. A steering group representing group, Teagasc and Dawn and chaired by the very experienced Michael Deeley, Bord Bia will oversee its implementation.

Programme Outline

The project will operate at two levels - a general programme for all participating farmers in the Dawn Meats area involving individual consultations, performance analysis and advice. Secondly, a targeted scheme for the South Mayo producer group will have a strong emphasis on the three key elements of farm assurance and traceability, animal breeding and production systems. All breeding ewes and factory lambs will be individually tagged, and this is regarded as critical to traceability. A food assurance plan will be drawn up for each participant who will have to complete a food assurance programme delivered by Teagasc. Participants must comply with a code of practice covering animal feed and medicines, health and disease control, animal welfare, livestock quality, environmental protection and farm records.

This whole package was developed by the group together with Adviser Gerry Murphy, Gerry Scully, Chief Sheep Adviser, Teagasc and Tony Petit, Teagasc Specialist in quality assurance.

The Quality Assurance/Traceability element

Quality Assurance

Each farm is visited by Teagasc Adviser, Gerry Murphy who examines the farm under the foregoing headings and agrees on a quality assurance plan with the farmer. A quality assurance course will form part of the requirements.

Traceability

Each farmer has his own individual member number. All breeding ewes and factory lambs are individually tagged. The tag used was sourced in the UK (Ketchum tip tag). It is a closed plastic tip tag. The tag contains the logo S.M.P.G. - the farmer identified number and an individual number for each animal. Ewes carry a yellow tag and factory lambs a white tag on the right ear. From previous experience with the tag by group members the loss rate was minimal. The cost per tag was approx 15p/head.

Upgrading of existing systems within the factory will enable individual lambs to be traced through slaughter and into the chills.

Reaction to the tagging has been positive and already farmers have found that information on kill out % and breed type for the lambs is very useful while individual ewe information regarding mating, lambing time, difficulties etc. are an aid to good management.

Obviously continued positive reaction to tagging will hinge round the successful outcome to the marketing efforts measurable in terms of a premium price to the farmer.

Traceability and Quality Assurance

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The Sheepmeat Forum was established by the Minister for Agriculture, Food and Rural Development in February 1998. The objectives set by the Minister for the Forum were:

i) to evaluate the future direction of the sheepmeat sector; and

ii) to assess how the industry can address existing constraints and future challenges

The Sheepmeat Forum issued its report in October 1999 when it highlighted a range of issues requiring attention for the sustained development of the sheep industry in this country. Representation on this committee was wide ranging and included Teagasc, Bord Bia, IFA, UFA, ICMSA, ICOS, Macra na Feirme, IMA, Kepak, Slaney Meats, ICM, UCD and the Department of Agriculture Food and Rural Development. In November 1999, Minister Joe Walsh set up the Monitoring Committee of the Sheepmeat Forum with the responsibility of furthering the implementation of these recommendations wherever possible. The report contains some very important recommendations that if not implemented quickly will almost certainly leave us without a place to sell our lambs. I as its Chairman will do what I can to facilitate the recommendations contained in the report.

Sheep traceability

Amongst the many items recommended, sheep traceability and quality assurance were major discussion items and are the two for discussion under this session of your meeting today. It was clear to the membership of the forum that the development of an effective sheep traceability system will become an important advantage to Ireland in maintaining access to its markets, especially in France, and could help build market share elsewhere. Everybody accepted the need to provide an assurance to the consumer that lamb can be traced from purchase back to its farm of origin and in this way give a guarantee that the meat is safe and wholesome. Consequently the membership recognised the need for a sheep traceability system and gave its support to its introduction in 2000.

The urgent need for change

Few if any of the membership realised then the speed with which the need for a credible QA and traceability system for sheepmeat would become if we are to have a sustained viable industry. In relation to these two topics we cannot afford to ignore what other countries have done recently and indeed the discussions that have taken place at European level in recent weeks and months. These discussions are ongoing and undoubtedly will result in changes that we will have to implement if we are to stay in business.

The need for tagging should never be looked on in isolation but as part of a comprehensive package, which will have as its core the need for a transparent traceability, and quality assurance procedure that will give the necessary guarantees that the consumer demands and rightly deserves. The current proposals from the Department of Agriculture Food and Rural Development together with the development of a QA scheme recently committed to by An Bord Bia, which if implemented, will go a long way towards achieving the necessary objectives.

Is tagging essential?

In the EU directive of 1992, Directive 92/102/EEC, there is a requirement for sheep identification back to a flock basis. In this there was some potential flexibility given in relation to branding, tattoo or tag. However, events have moved faster than even the most committed of us would ever have contemplated. The EU commission is now more interested in ID/QA and in spite of what some of us might think, it has been documented that our current system is unreliable and unacceptable. We urgently need to change this perception of the Irish lamb export product. There is now the momentum in Europe to have a harmonised system of ID for all member states. In recent weeks, senior veterinary staff from EU member countries met and agreed that the ID system should be tag based. Such a recommendation is unlikely to be ignored by the Council of Ministers.

Unlike the New Zealanders, many of us Irish sheep producers appear to lack long-term commitment to our industry. As the second largest exporter of lamb meat in Europe we are extremely vulnerable to the vagaries of the marketplace. Consequently as producers, we should be proactive rather than reactive; when it is clear that something needs to be changed we should get out there and do it fast. So volatile is the situation now that we must degrade political point winning to second place and all work together so that an income for the 43,000 sheep producers in this country can be guaranteed.

For my own part I have never supported the idea of doing anything where there is a cost involved unless it is financially rewarding. The most important reward at the moment is that we will continue to have a place to sell our lambs. Imagine what would happen in Ireland if access to our export markets was blocked for a month in say July or for a lot longer! Even at this point, apparently some potential buyers have gone elsewhere for their lamb and orders have been cancelled just because we do not have a credible QA/ID system in place.

Time is not on our side and if we think that we can wait until the Minister Joe Walsh delivers a better deal for the sheep farmers in Europe, we are not at the races. Unlike in 1992, the pressure for identification and traceability is now coming from the consumer, in addition to much more intense pressure from Brussels. We have no choice but to live within current and future EU rules in this regard.

Vulnerability

Ireland is not a scrapie free country and this together with the fears of scrapie and BSE/CJD across Europe is generating new fears. Incredibly for a major exporting country, by Jan 2001, Ireland will be the only major sheep producing country within the EU without an acceptable sheep ID system. By January next, the UK will have a scheme in place, the French and Dutch have opted for individual number tagging of all animals and the Spaniards have an ID/traceability system in place. Of their own free will, all countries have opted for tagging.

If we want Minister Joe Walsh to negotiate the best for us in Europe, we will be giving him a stronger hand if we are seen to be abiding by the current and giving a commitment to future EU legislative rules. We must put a system in place that not only identifies the animals on the farm but allows for this information to be carried through to the carcass and even onto the cut carcass.

Members of the Sheep Monitoring Committee and others are continuing to discuss this extremely important issue aimed at putting a system in place that (i) is acceptable within EU rules, (ii) will take on board the fears of producers and in addition, (iii) will help to give us a marketing advantage for a quality product.

There are many details still to be worked out but with the commitment of all, the momentum is there to do it. Personally I feel we can get a marketing advantage in France by individually numbering all our lambs and combining this with a national QA programme. In effect I believe that this is something which is essential, something which should have been put in place yesterday rather than tomorrow so to speak, although I would not see it as being practical that individual numbers would be read at the abattoir level.

Currently the UK and Ireland are the only major sheep producing countries within the EU without an individual number on the breeding ewes. Having lambs individually numbered would confer management advantages for improved efficiencies, including better record keeping of the occasional drug treatment etc. We need to give this level of guarantee to the consumer that we are committed to producing a quality product and have a scheme in place that stands up to any scrutiny.

Any scrapie monitoring/testing programme will necessitate individual numbering and we are likely to see much more of this even in the short term. We should set ourselves up for this now and not be forced to change later. I ask you – is individual numbering too high a fence to jump now? I believe that Ireland should lead the way and let the other countries take a leaf from our book rather than the opposite way around.

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