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ELEVENTH RICHARDS-ORPEN MEMORIAL LECTURE

1. The Production and Utilization of Grass for Grazing and Silage

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I wish to sincerely thank the trustees of the Richards-Orpen Memorial Trust for inviting me to deliver Part 1 of this lecture; I share the honour with Dr. Mayne of Hillsborough. The work of Moorepark in the development of grassland based systems of milk production goes back to the era of M. Walshe and D. Browne at the foundation of An Foras Taluntais. The invitation to me is a recognition of Moorepark's role in this area and a tribute to the production research endeavour of the Dairy Husbandry Department over that time.

The first grazing experiment at Moorepark in 1960 was a comparison of rotational versus set stocking systems of grazing management. There were no concentrates fed and nitrogen input was 22 kg/ha on grazing ground and 44 kg/ha on silage ground. Milk yield per cow and per ha was 2504 kg and 5147 kg, respectively, at a stocking rate of 0.49 ha/cow for the rotational grazing treatment. Thirty years later at Curtins farm with a nitrogen input of 375 kg/ha and a stocking rate of 0.34 ha/cow with very little concentrate (125 kg/cow) a yield of 5393 kg/cow and 15862 kg/ha has been achieved. This is a three-fold increase in milk output per unit land area. This increase is mirrored by great technical improvement at farm level and concurrent changes in the structure of milk suppliers. There is a core of dairy farmers who are now very receptive to technological efficiency which is based on research information. Production research at Moorepark and its associated stations has provided this information and given dairy farmers the confidence to adopt new practices.

This paper is an attempt to outline the present state of knowledge with regard to grassland systems for milk production, to describe the more recent research results at Moorepark and to identify some of the more important areas where major gaps in knowledge exist and where research work should be focussed over the next number of years.

Introduction

The value of total agricultural output in Ireland from grassland based farming enterprises is shown in Table 1. Ruminant based enterprises (cows, cattle and sheep) represent 87% of livestock output and 77% of gross agricultural output. Total agricultural exports accounted for approximately £3.335 billion in 1989 which was about 23% of the total exported value.

Land use in Ireland reflects this predominance of livestock farming and more specifically grazing livestock. Table 2 shows a breakdown of land use in Ireland

Table 1
Output of animal product (1989) (Punts in Billions)

	Value
Cattle	1.208
Milk + Dairy Products	1.189
Sheep + Wool	0.179
Total Livestock*	2.949
Gross Agricultural Output	3.358

*Includes horses, poultry, eggs and pigs

(Finlgeton, 1990)

Table 2
Land use in Ireland

Million Hectares	Type		
6.89	Total		
5.67	Utilised		82%
2.97	Pasture	}	
			75%
1.26	Hay and Silage	}	
1.00	Rough grazing		17%
0.44	Tillage		8%

(Finlgeton, 1990)

by major category. A total of 75% of the utilised agricultural land is pasture for grazing and conservation. Tillage accounts for less than 10%.

Over 90% of annual feed requirement of a spring calving dairy cow and 95% for a beef animal comes from grazed grass and conserved grass products such as silage and hay. Food production from arable crops is energetically more efficient than any form of animal production (Van Es, 1979). In Ireland, however, arable crops would be no alternative to grassland because of limitations such as unploughable land, drainage and climate. Economic conditions also make it more profitable to use grassland for livestock production rather than arable crops.

Figure 1 shows the various losses of energy which occur when grazed grass is eaten by ruminants. Herbage growth is the difference between the growth of the new plant and material losses due to decay. These losses which occur during sward growth development are also effective during the grazing period. Grazing effects such as trampling and contamination by faeces render some herbage unavailable or more inaccessible to the animal. The residual herbage after grazing can partly be used in succeeding grazing periods. A proportion of the energy in the herbage eaten by the animal is lost in faeces, urine and methane. The energy of ingested herbage less these losses gives the metabolizable energy (ME) which is converted into heat and energy in animal products. The most

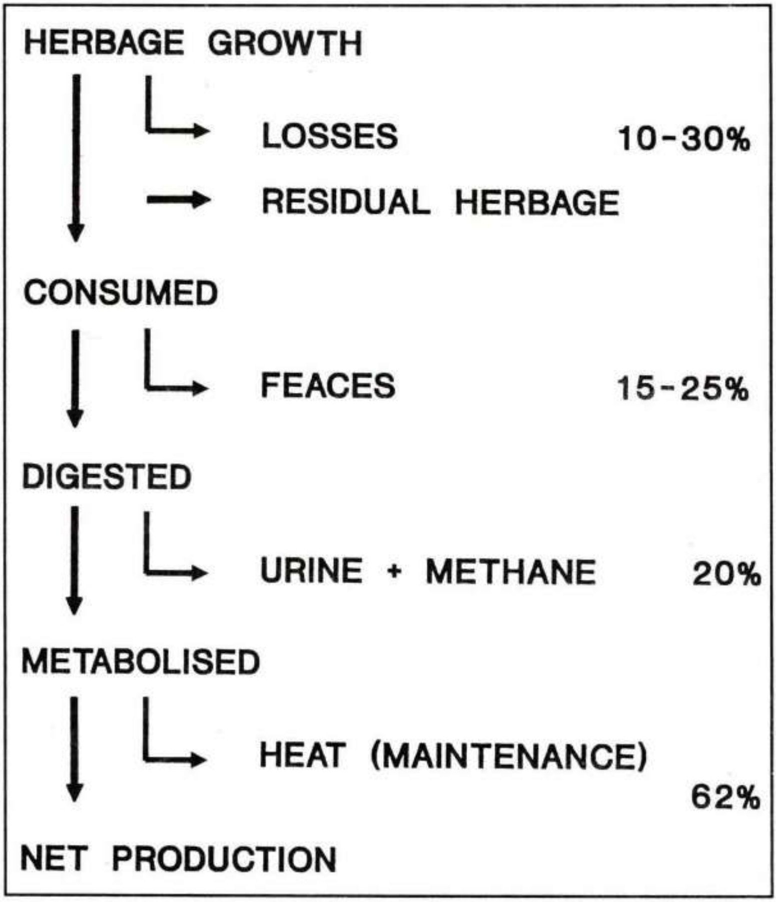


Fig. 1 – Sources of energy loss in the utilization of graded pasture by dairy cows

important energy loss within the animal is heat. Part of this represents energy that is needed for maintenance. The remainder arises from inefficiency in the use of ME for either maintenance or production of milk and tissues. The efficiency of utilization of ME for maintenance and for production of milk appears not to vary much and is close to 62%.

Faecal energy losses are variable because they are related to diet digestibility and this can vary considerably in relation to intake, herbage species, climate and stage of maturity.

The same principles apply to silage production and utilization in that losses in the field allied to in silo and feeding losses all combine to give accumulated inefficiencies. Herbage utilization rates under cutting regimes are higher than that for grazed grass (Richards, 1977). Gordon (1988) has reviewed the losses associated with the different silage harvesting systems.

Grassland and grazing research aim to find an optimum compromise between individual animal performance and output from the farm or per unit land area. Optimum efficiency of grassland utilization is not always compatible with optimum nutrition of the grazed animal. An understanding of the various elements in Figure 1 and the controls and influences which alter the various processes is the long term goal of grazing research. Many different biological and statistical sciences are involved from botany and pasture ecology to animal biochemistry and physiology.

Systems of milk production

The system of milk production adopted in Ireland is basically the conversion of grass to milk at the lowest possible cost. The system is based on high-stocking rates, early turn-out to pasture, 300 Kg N/ha and rotational grazing with two cuts of silage. Early and compact calving 6-8 weeks prior to turn-out in spring has been adopted for spring-calving milk production systems. McCarthy (1979) reviewed the 21 years of grassland and grazing work at Moorepark from which the system has been developed. Crosse (1988) describes a management blueprint for dairy farming on free-draining and wet land based on the linking of key decisions to calendar dates. The calendar approach was necessary because of lack of organisation of both farm facilities and managerial ability. Winter feed requirement was identified as a fundamental restriction to intensification. This strategy outlines a management approach to achieving those targets consistently. Dairy farmers were encouraged through this approach to maximise farm output by keeping as many cows per ha as possible. Output per cow was secondary in pre-quota days to output per ha. When the stock carrying capacity of the farm was reached further increases in output were achieved by increasing individual output per animal. Costs of milk production were not a central theme then. Efficiency was measured by gross margins/ha or as output/ha. They ignored the fixed costs factor. Today, with the imposition of quotas and super-levies, the efficiency of dairy farming is measured as the cost per gallon and dairy farmers should be concerned with reducing this cost of production.

Dillon and Stakelum (1990a) have shown the costs of milk production of efficient and less efficient dairy farmers in the Cork area. Grassland management on dairy farms is the key element for making the process of milk production more efficient both in terms of herbage utilization and cost. The principal issues relating to grass production and utilization for milk production and how they relate to a simple low-cost system will now be examined.

Grass production

Maximum yields of 27-30t DM/ha/annum based on theoretical potentials can be produced from grass swards under our conditions (Keife, 1978). Moorepark cutting trials with plots receiving optimal N, S, P, and K and cut every 4 weeks have produced yields of 13.75t DM/ha over 9 years (Dulon & Stakelum, 1988/89). The range was from 83 to 134% of the average, depending on the year. These values compare with similar values (McCarthy, 1984) found under intensive grazing conditions.

There are many factors affecting grass production and it would be impossible to deal exhaustively with them in this paper. Some excellent reviews are available (Holmes, 1989). Some of the more important primary factors affecting production are soil type and nutrients status, climate and location and species composition. All of these factors interact with each other. The production of herbage is also affected by management factors as imposed by the farmer such as method of utilization (e.g. cutting and grazing), rest interval, method of grazing (e.g. rotational versus continuous) and stocking rate.

In farm practice it is not feasible to operate at biological optima. Many compromising restraints set limits such as the economic optimum. Additionally, there are issues of animal welfare and environmental considerations as well as milk quota restrictions.

Stocking rates and nitrogen input

These two factors are the most important ones directly under farmer control which will determine the efficiency of grass utilization and maximization of farm output. The average stocking rate in acres per cow for Ireland is 1.6 and in the mainly dairying category it is 1.5 (Fingleton, 1991). By soil class the figures are 1.4, 1.6 and 2.1 acres/cow for soil class 1 to 3, respectively. Nitrogen usage is 85 kg/ha on dairy farms with 107 kg/ha used on silage ground (Murphy and O'Keeffe, 1985). This indicates a gross degree of understocking on dairy farms nationally. Table 3 outlines the average N input by farming system. The input of 12 and 21 kg N/ha on drystock and mixed dry stock/dairy farms speaks for itself.

Table 3
Nitrogen usage (kg/ha) by farm enterprise

Enterprise	Amount
D	85
D + DS	21
D + DS + T	58
DS	12
DS + T	91
HS + DS*	47
For Conservation	
Silage	107
Hay	60

(Murphy & O'Keeffe, 1985)

Priority use of nitrogen for dairying is as follows: (1) nitrogen for silage; (2) nitrogen for early grass; (3) nitrogen for grazing. Grazing experiments which compared the responses to applied nitrogen for milk and beef production used various low nitrogen treatments. Some were zero N or N for silage only while others used N for silage and early grass. Gately et al. (1984) reviewed N by stocking rate experiments at Moorepark and Johnstown Castle carried out by

Table 4
Increase in stock-carrying capacity

	Nitrogen (kg/ha)		
	BL	NH	% Change
Dry Land	202	365	19
Wet Land	64	240	32

(Gateley et al., 1984)

Browne, McCarthy, McFeely, Gately and Stakelum from 1967-1980. Table 4 shows the mean percentage change in stock carrying capacity on freely and imperfectly drained sites used in the studies. The percentage change appears much higher for wet soils. This is because the N levels studied were in the more responsive range. Analysis of the data showed that the maximum change in stock carrying occurred on both soil types in all years at 300 kg N/ha. There was considerable variation in the change in stock carrying capacity from year to year, i.e lowest in Year 1 and highest in Year 3 of the experiments in question. The changes above 300 kg/ha were small. McCarthy (1985) found a 4% increase in milk output per cow and per hectare at a stocking rate of 3.1 cows/ha by increasing annual N input from 270 to 390 kg/ha. This is very close to that predicted by the model of Gately et al. (1984).

The growth of grass over the season is unevenly distributed and utilization must be achieved by both the grazing animal and conservation. The integration of the cutting and grazing areas constitutes a grazing system. Extra nitrogen provided in a system will increase the overall output of the pasture and hence the stock-carrying capacity. However, the response to extra N will be uneven across the growing season and will therefore also have an effect on the components of the system such as the optimum area to close for the various conservation cuts, the start of the grazing season, use of supplementary feeds, etc. Increasing herbage output in a situation where a system is operating at maximal utilization could be expected to increase output per animal and per area if the system continues to operate at that level of efficiency. The questions which arise in relation to this are:

1. How well is the efficiency of a grazing system known?
2. Have the various output of pasture by stocking rate experiments operated at optimal efficiency throughout the grazing season?
3. Would the responses achieved have been different under different levels of defoliation or by using different systems or criteria?

Milk production based on perennial ryegrass/white clover pastures

In view of the low rates of N used on dairy farms nationally (much higher N rates are used on intensively managed dairy farms) and the low stocking rates, white clover based pastures would seem to have a place in milk production in Ireland. Ryden and Garwood (1986) estimated that leaching, denitrification and ammonia losses were 8, 10 and 12 times higher in grazed ryegrass swards receiving 420 kg N/ha compared to a grazed ryegrass/white clover sward receiving zero N. In the high-N sward, 160 kg N/ha was leached annually.

Various estimates have been reported for the N-fixing ability of white clover. Murphy (1987) found a range from 94-194 kg N/ha while Frame and Newbold (1986) found values of 80-280 kg. The fixing ability of white clover swards is highly dependent on the clover content of the sward (Marriott and Rangeley, 1984) which is in turn adversely affected by the level of applied nitrogen fertilizer. This is illustrated in Figure 2 from Frame and Boyd (1987). The average response of a white clover/ryegrass sward to extra nitrogen is 8-9 kg DM/kg N (Frame and Newbould, 1986) compared to a response of 25 kg DM from a grass sward in the range of 0-300 kg N/ha/annum (Frame and Newbould, 1984). Figure 3 shows a generalised effect of increasing N on grass and grass/white clover swards. The fertilizer nitrogen equivalent value for the white clover swards (the amount of N which needs to be applied to a grass sward to achieve the same yield of DM as from a white clover/grass sward receiving zero N) is between 175-200 kg N/ha/annum.

An evaluation of white clover swards for milk production between the years 1967-1980 at Johnstown Castle and reviewed by Ryan (1986) showed an average response of 30% in milk output/ha. This translates to 40% when fitted to the model of Gately et al (1984). The clover percentage in the sward where measured in these trials ranged from 2-18%. Five years of research (Ryan, 1988) with a Cropper/Francis/Huia sward receiving zero N on grazing ground and 386 kg N/ha on 33% of the farm containing Italian ryegrass has been compared to perennial ryegrass sward receiving 361 kg N. The Italian cut was 3-4 times each year and slurry seeded each autumn. The extra stock-carrying capacity occasioned by the extra N was 20%. Clover decreased from 50% in first year to 20% in the last year. Bryden et al. (1990) found in a trial comparing zero N white clover and ryegrass swards (N=350 kg/ha) that the zero N swards had invariably less (70%) herbage

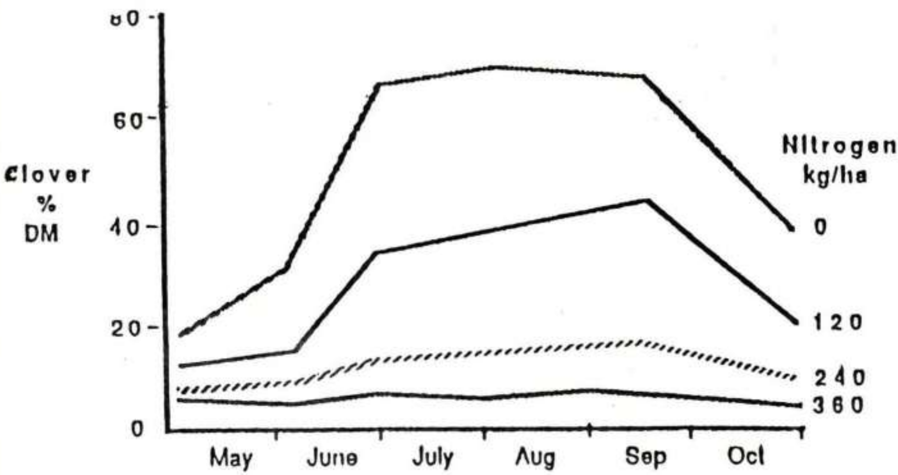


Fig. 2 – Effect of fertilizer N rates on white clover content (Frame and Boyd, 1987)

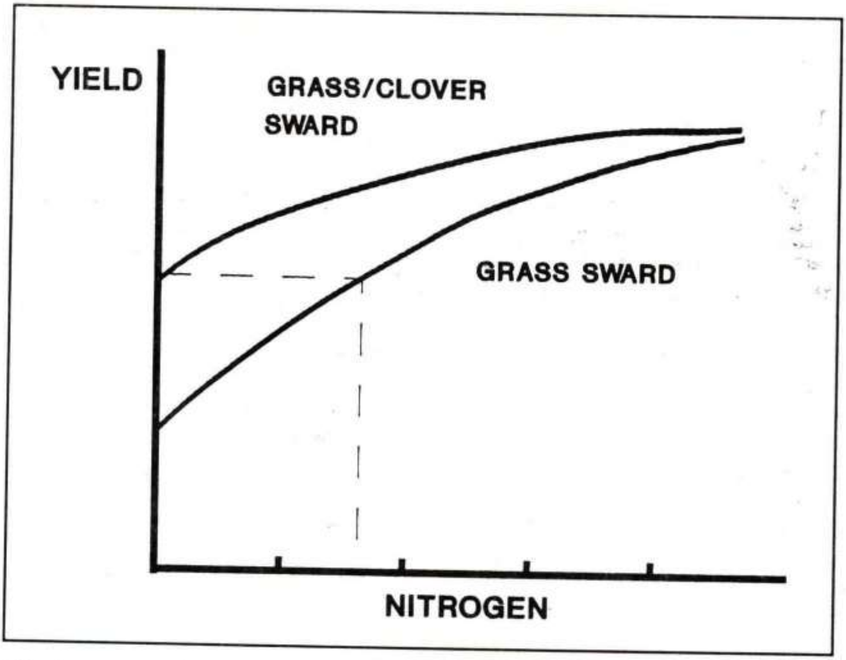


Fig. 3 – Generalised effect of N application on yield (Frame and Newbould, 1984)

than the N swards, but consistently higher OMD levels. Bax (1989) fed an extra 300 kg of concentrate to cows with zero N on white clover/ryegrass pastures to maintain the same milk yield as cows on the N sward. The effective stocking rate was 2.25 cows/ha on both swards.

It would seem, therefore, that while output per hectare is some 20-30% lower with white clover at a given stocking rate, at a lower intensity output could be equivalent. The uncertainty of pasture output from year to year is a major problem. Also seasonal production of herbage is altered especially in spring by relying on atmospherically fixed N. Murphy (1987) examined the effects of spring N application (50 kg/ha) on N fixation levels and DM production. A response of 10 kg DM/kg extra N (5%) was achieved. N fixation was reduced by 29 kg and 52 kg by urea and CAN, respectively. This indicates a much higher inhibitory effect by CAN compared to urea.

Research priorities for white clover

It seems that white clover may play a more significant role in the future in grassland based animal production systems especially due to the possible environmental restrictions which may be enforced on stocking rates and N usage. At present, the favourable milk price/nitrogen price ratio still favours N usage. At circa 300 kg N/ha, N will contribute 3-4p to the cost of production of 1 gallon of quota. However, certain priorities in research for the future are necessary.

There is no clover work now in progress since the Grassland Programme in Johnstown Castle was terminated.

(1) ***Varieties***

Breeding objectives of white clover are based on improving yield and reliability, improving spring growth and cold tolerance, and disease resistance. Yield and persistency under severe grazing is important for Irish conditions. Selection for seed yield (shortage of seed is a problem with the newer more desirable varieties) potential is also a consideration. An improvement in N-fixation ability and a certain N tolerance is an advantage for dairy farming systems especially where early turnout is feasible. Non-bloating clover, too, is important.

The most obvious problem with white clover is its incompatibility with perennial ryegrass. Conditions which lead to vigorous growth of the grass will have an adverse effect on white clover. Tetraploids are more compatible than diploids with no difference between early and late ryegrass varieties. The co-adaptation concept (Burdon, 1983; Harper, 1967) where both components are selected from coexisting genotypes offers prospects for compatibility and production. Evans et al. (1985) showed a yield of total herbage from S23/white clover sward of 7.4 t/ha (5.1 t/ha for white clover component) where clover was 69% of the sward. The production from the co-adapted species was 10.3t/ha for total herbage (7.1t for the white clover component) and the clover remained at 69% of the sward.

(2) ***Establishment***

There are firm guidelines laid out for the establishment of white clover swards. Management guidelines refer to methods of sowing, depth and time of sowing, etc. Of more importance, however, is the introduction of white clover into existing pastures or where white clover has become depleted. Drilling the existing sward after a heavy silage crop with the use of an herbicide is recommended. More information is needed for the different circumstances which could prevail.

(3) ***Grazing management***

The optimum grazing management for efficient utilization and high digestibility in pastures is 6 cm post-grazing sward height (Stakelum and Dillon, 1988). Is this optimum for white clover maintenance? A height of 7-9 cm is recommended for rotational grazing with cattle. There is an obvious conflict here. Hay and Baxter (1984) in New Zealand suggest that continuous grazing in spring and rotational grazing in summer may be the ideal system. French methods (Pflimlin, 1984) for cattle favour 4-5 week rest intervals in early season and 6-7 week intervals in late season.

White clover is much more tolerant of longish rest intervals and cutting regimes than once believed. A silage sward based on clover/grass can produce 70% of the yield of a grass sward receiving 300-350 kg N/ha/year (Roberts, Frame and Leaver, 1989). The incorporation of a silage cut has a beneficial effect on white clover in a sheep grazing system (Curll and Wilkins, 1983). The construction of a management system integrating silage and cutting may be difficult where a two sward system is adopted because of necessity rather than choice.

Strategic use of N in a way which does not diminish white clover content in the sward could be used to make up the shortfall in spring and autumn growth. Nitrogen use in spring is more detrimental than autumn applied nitrogen.

Conclusions

The contribution of white clover to pasture production at low N rates at farm level is most certainly much lower than that found at experimental level. The reasons are likely to be many and varied. The evaluation of managements designed to optimise white clover performance are very different to what pertains on farms. There are many other priorities in production systems other than sward management for white clover encouragement or maintenance. A system which can maintain clover at 30-40% of the sward year in year out is the task which research in this area has to solve.

Reseeding pastures

In Ireland, about 130,000 ha are reseeded annually. Many methods of reseeding exist from spring and autumn seeding with full cultivation, undersowing cereals or arable silage crops to various forms of overseeding and direct drilling. It is not the intention here to review the various reseeding techniques but to discuss the place of reseeding in animal production systems in Ireland.

Pastures are reseeded for a number of reasons. The productivity or output of the existing pasture may be considered too low due to a poor proportion of highly productive grasses like perennial ryegrass. In that context, the present utilization rate should be optimum and the boost in production which ensues should be utilised fully in order to justify reseeding. In the context of existing low production levels from pasture it should be clearly identified as to what factors are inhibiting production. Soil nutrient status and levels of fertilizer inputs may be sub-optimal for the desired production. A change in grazing strategy by increasing the level of herbage removed at individual grazings will have a very beneficial effect on pasture composition over a few years. In situations where tillage is an integral farm enterprise or where land reclamation is carried out, reseeding pastures may be necessary as a normal or necessary farm operation. It is in the area of silage production, especially on two-sward systems, where silage yields are insufficient to meet winter feed requirements, that reseeding has its most important role to play in dairy production.

Comparisons of permanent and reseeded pastures

A general point is worth making at the outset. Comparisons of reseeds and permanent pastures suffer notably from the fact that "permanent pastures" can mean anything from a ryegrass dominated pasture to something with a zero ryegrass. Many observations on the differences lack any quantification of the composition of the permanent pasture.

The outstanding attribute of perennial ryegrass is, as its name implies, persistency over a range of management techniques. Yield levels are higher than for the Poas, Holcus lanatus and the Agrostis species (Table 5). These are

Table 5

Herbage yields of different grass species (TDM/ha)

	Fertilizer N (kg/ha)		
	240	480	OMD
PRG	9.7	13.2	0.80
HL	8.8	11.5	0.76
AS	8.6	10.5	0.71
AT	8.0	10.0	0.70
PT	6.8	8.8	0.75

Frame, 1983

common grasses in permanent unimproved old pastures. Also, the digestibility and growing season are higher and longer respectively than those grasses and it has higher ensilability characteristics. Higher intakes at similar digestibility levels are also a feature of ryegrass due possibly to palatability effects.

The inferior grasses, however, are not outyielded to the same extent by perennial at more modest N input levels (Table 5.) Smith and Alcock (1985) showed that when pastures contain mixtures of species which vary in yield potential, the output reached is higher than the mean for the species present and similar to that of the highest-yielding component (Table 6). Hopkins et al. (1990) concluded that while reseeds (Melle) were more productive in the year after sowing, many permanent swards are capable of high levels of production and that reseeding to a ryegrass sward cannot always be justified, particularly for grassland receiving low or moderate inputs of N. Figure 4 outlines data extracted from this experiment across 16 sites in England and Wales and at two N input levels. It shows a large response in Year 1 and small or negative responses to 300 and 150 kg/N/ha, respectively in the 2 subsequent years. The permanent pastures were mostly over 20 years and contained less than 30% ryegrass. Quality (fibre) assessments indicated a small advantage to the reseeded swards. Figures 5a and 5b, from the same experiment show the production averaged for years over a range of N inputs for the 3 subsequent years from the seeding year (Figure 5a) and including the production in the seeding year (Figure 5b). At N levels up to 150 kg/ha or greater the response to reseeding, if the establishment year was ignored, was relatively constant. With the inclusion of the establishment year, the response disappears. This emphasises the need to use sowing techniques

Table 6

Yields qf sward types at 300kg N/ha

	t DM/HA
PRG + WC	12.6
Mixture	12.9
Mean of monocultures of mixture	10.5

(Smith & Allcock, 1985)

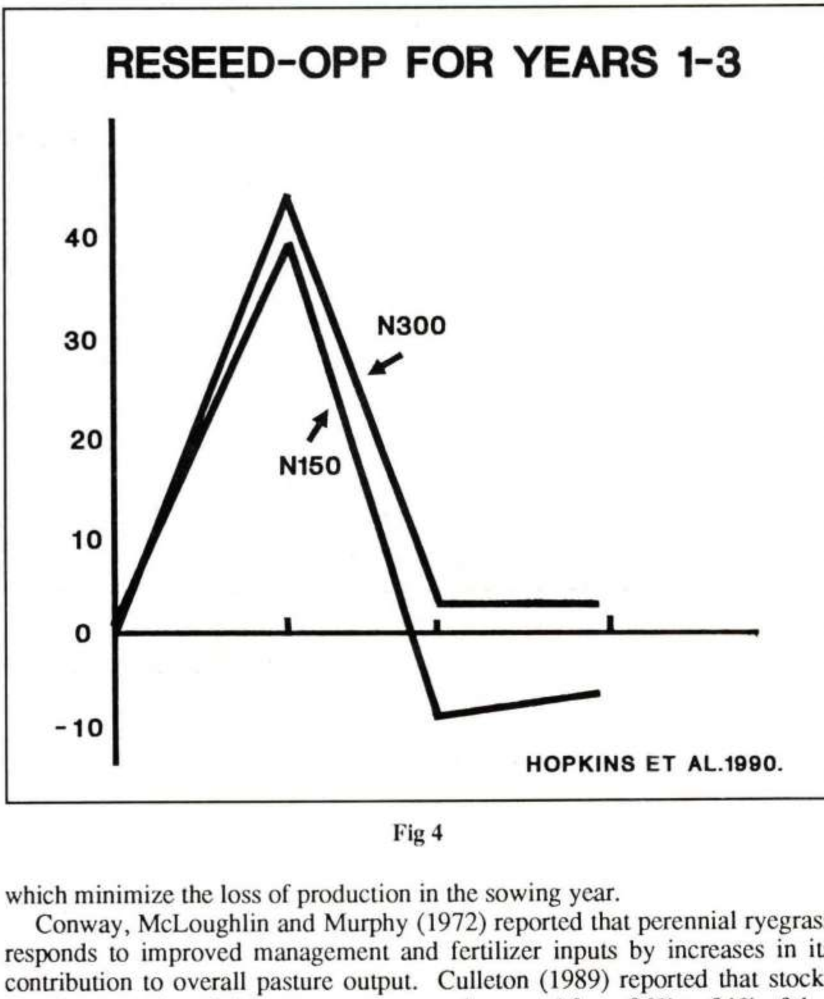


Fig 4

which minimize the loss of production in the sowing year.

Conway, McLoughlin and Murphy (1972) reported that perennial ryegrass responds to improved management and fertilizer inputs by increases in its contribution to overall pasture output. Culleton (1989) reported that stock-carrying capacity of old permanent pasture increased from 86% to 94% of that of a reseeded sward (Melle) in the third year when measured by liveweight gain of grazing steers. This increase was associated with an increase in perennial ryerass content in the sward from 3% in Year 1 to 32% in Year 3. The yield improvement under a cutting regime, however, for the old permanent pasture while it increased from 9.3 to 10.8 t DM/ha was not associated with an increase in ryegrass in the first 2 years. The reseeded swards under the same cutting regime (Talbot) decreased from 14.9 to 13.6 and 12.2 t DM/ha in Years 1, 2 and 3, respectively. This was associated with a decrease in the ryegrass component of the sward from 99 to 75% in the first 2 years. The yield advantage was 60, 33 and 13% in Years 1 to 3, respectively in favour of the reseed. The comparisons were carried out on a three-cut silage system. The author concluded that

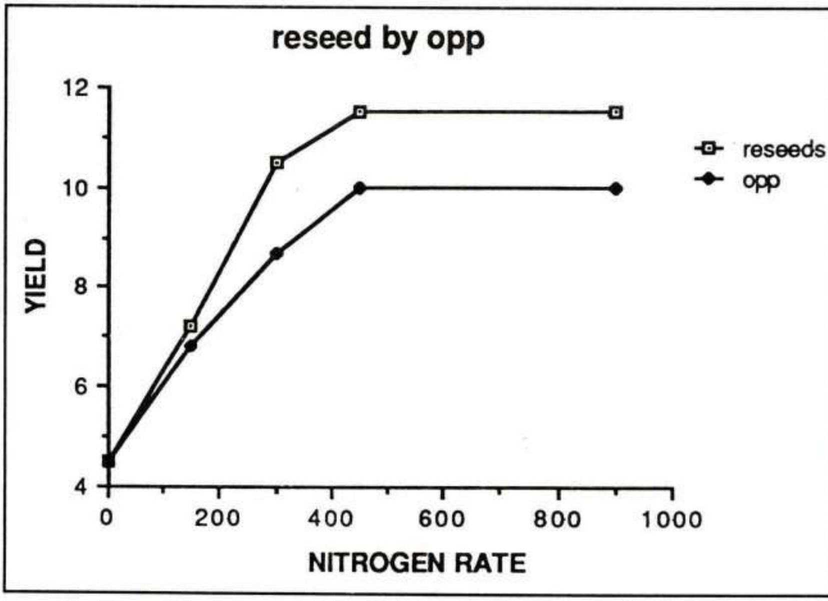


Fig 5a

Yield of reseed and opp at a range of N levels (Hopkins et al., 1990)

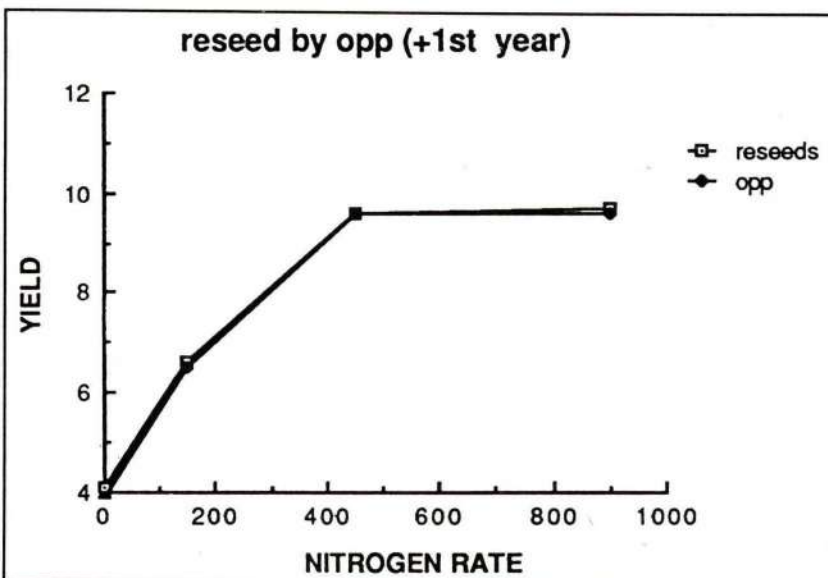


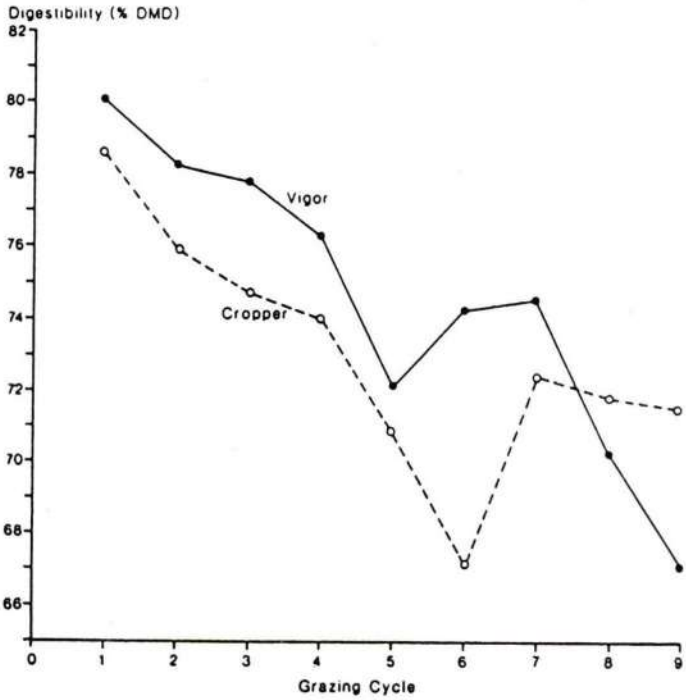
Fig 5b

reseeding of old pastures gave increased liveweight gain under grazing for the first 2 years and by Year 3 the advantage was small due to improvement in yield and animal performance on the old pasture due to increased ryegrass content. Under silage the yield advantage was maintained over the duration of the experiment but the reseeds tended to deteriorate in spite of adequate nutrition and management.

McCarthy and Cullinane (1982), working on a whole-farm comparison of reseeded and old permanent pasture for milk production reported an overall 10% increase in silage harvested over 3 years in a two-cut regime. The yield advantage was 20% for the first cut (6.7 versus 5.6 t DM/ha) and –3% for the second cut (4.5 versus 4.6 t DM/ha). The milk production response to reseeding was 3% and 8% at low and high stocking rates, respectively. The differential response illustrates the point made earlier that responses to increased pasture output depend on the level of utilization achieved. Poa Trivialis predominated the old pastures at 36% by tiller count followed by Agrostis species at 29%. The perennial was 7% and other grasses were 29% and were comprised mostly of Holcus lanatus and Festuca Rubra. The major change in composition of the old pasture over 4 years was a decrease in P. trivialis from 38 to 22% and an increase in ryegrass from 7 to 17%. The major change in the reseeds was an increasing density and an invasion of unsown species particularly P. trivialis.

Keating et al (1989, 1990) found that carcass gains and carcass output/ha were substantially higher on Italian and perennial ryegrass silages than old permanent grass silages. The carcass gains/day were 0.59, 0.57 and 0.54g for 1987, and 0.54, 0.44 and 0.38 for 1988 for Italian, perennial and old pastures, respectively. The quantities of silage harvested in the first year showed a substantial advantage in favour of the Italian ryegrass (16.9 tonnes/ha for 5 cuts) compared to 14.3 and 14.0 tonnes (from 4 cuts) for the perennial and old permanent pastures, respectively. In the 2nd year the quantities were identical for all swards. In Year 1, all material had broadly similar digestibilities and preservation. In Year 2, however, the Italian and perennial silages preserved well and had high digestibilities (>73%). The old pasture preserved more poorly and had lower digestibility (67%). While there was no advantage in intake and daily liveweight gain in Year 1, there were large differences in liveweight gains (0.92, 0.76 and 0.67 kg/day for Italian, perennial and old pastures) and intake (7.4, 6.6, and 6.5kg DM/day for Italian, perennial and old pastures) (7.4, 6.6, and 6.5kg DM/day) in Year 2. The results showed that carcass output/ha for finishing steers was higher for the reseeded pastures compared to the old pastures in each of the two years.

Translation of dry matter production responses under cutting to grazing situations is not correct for many reasons. Most comparative response work to different ryegrass cultivars has been done under cutting and therefore the influence of the animal in terms of treading, pattern of defoliation, recycling of nutrients, etc. is ignored. There are problems associated with the evaluation of ryegrass cultivars under grazing, not least being their different heading dates and seasonal production pattern. This raises issues regarding their managements in that optimum output may be achieved with one cultivar with a specific grazing management system, the optimum output might be achieved with another cultivar with a different system. Gately (1984) examined cultivars of Melle (vigour) and Cropper for milk production over 5 years in a grazing trial at two stocking rates. He found a 9% advantage to Melle at low stocking rate and a –7% disadvantage to Melle at high stocking rate in terms of milk output per hectare. This interaction between cultivars and stocking rate raises a central point in grazing management for milk production, i.e. in situations of undergrazing digestibility declines and intakes and hence performance deteriorates. Gately (1984) showed (Figure 6) a substantial digestibility decline in mid-season with the early-heading variety compared to the later one at low-stocking rate. The author suggested on the basis of no stocking rate effect with the early ryegrass that still further improvements in output per hectare could have been achieved with further increases in stocking rate. What is implicit is that management or defoliation severity was not optimum. The author also drew attention to the fact that the seasonal production pattern of the early ryegrass may be more suited to the appetite requirements of the spring-calving cow.



Mean digestibility for each grazing cycle at the low stocking rate in 1981

Fig. 6 – Mean digestibility for each grazing cycle at the low stocking rate in 1981 (Gately, 1984)

Cow factors affecting output from grazed pastures

The question is often posed, "What is the potential of our cows to produce milk given the elimination of restraining factors such as feed composition, management influences, etc?" The question really needs to be put in a different context. Given a genetic merit for milk production, what is that potential in relation to pasture feeding conditions and how does it compare to silage and concentrate rations? Is grass as good given optimum quality and quantity as indoor diets?

Stakelum, Gleeson and Murphy (1985) compared at Moorepark two systems of milk production in order to answer this question. System 1 was based on all-year-round indoor feeding with high-quality silage ad-libitum, 3 feeds of a high-energy density ration daily, in addition to one feed of beet pulp nuts at mid-day. System 2 was an optimum grazing treatment. The cows grazed aftermaths during the entire grazing season at a daily allocation of twice their intake requirement. The cows received fresh pasture every day of 3-4 weeks regrowth interval. Table 7 shows the performance of the two groups. Milk volume and protein yield was 9 and 5% higher respectively for the indoor group The pasture fed group had higher fat and protein content and equal fat yield compared to the indoor group. In all, the aggregate yield of the milk fat and protein was similar for the two groups. The intakes of the indoor group was substantially higher (circa 18 kg OM/head/day) than the grazing group (14-15 kg OM). The liveweights at the end of the grazing season were 644 versus 556 kg for the indoor and grazing group, respectively. The results indicated that higher feed intakes achieved by dietary regimes indoors were channelled into large body weight gains. The cows lacked the ability to produce extra milk constituents. The potential of the cows would be expressed by a diet of grazed grass liberally supplied with its quality controlled. The experiment at Curtins reported by Pat Dillon in this issue has shown that in a systems framework under tight grazing and low concentrate inputs where cows calve onto grass, comparable yields as found here can be achieved.

Assuming that the genetic potential of the Moorepark herds represents the national average, the yield of 387 kg of fat and protein on pasture can be considered an optimum. Increasing that yield through genetic selection for milk production (or fat and/or protein content) would lead to higher yields per

Table 7
Potential milk production from pasture

	High intake	Pasture
Milk Yield (kg)	6091	5596
Fat %	3.32	3.64
Protein %	3.17	3.27
Fat Yield (kg)	202	204
Protein Yield (kg)	193	183
Fat + Protein (kg)	395	387

(Stakelum, Gleeson and Murphy, 1985)

individual animal if feed sources did not present a barrier. Increases in milk yield occasion higher intakes per cow. The equation A and B shown below are simple and predict intake reasonably accurately for groups of grazing dairy cows from milk yield and liveweight.

Equation A: TDMI = 0.1MY = 0.025LW (Caird and Holmes, 1986)
Equation B: TDMI = 0.2MY = 0.022LW (Neal, Thomas & Colby, 1984)
(TDMI, Total Dry Matter intake; MY, Milk Yield; LW, Liveweight, all in Kgs)

More complex equations using herbage allowance, stage of lactation and supplementary feed can provide more accurate predictions of individual animals. Stakelum and Connolly (1987) found that 91% of the variation in herbage intake between cows could be described by a multiple regression relating intake to milk yield, liveweight, the interaction term of milk yield and liveweight and quadratic liveweight term. Inclusion of surface area measurements, fat score, and the calving date did not add significantly to the descriptive model. Figure 7 shows a graph of intake against average bodyweight over the lactation for five yield categories of cows. The milk yield is the average yield from April to October for early February cows. The curves demonstrate that intake increases as milk yield and bodyweight increases. Daily dry matter intake increases by between 0.41-0.45 kg per 1 kg extra FCM (3.6% fat) per day. An extra 100 kg bodyweight in cows necessitated an extra 1.5 to 2.2 kg of herbage DM intake daily. Table 8 shows in tabular form intakes extracted from Figure 7 for two

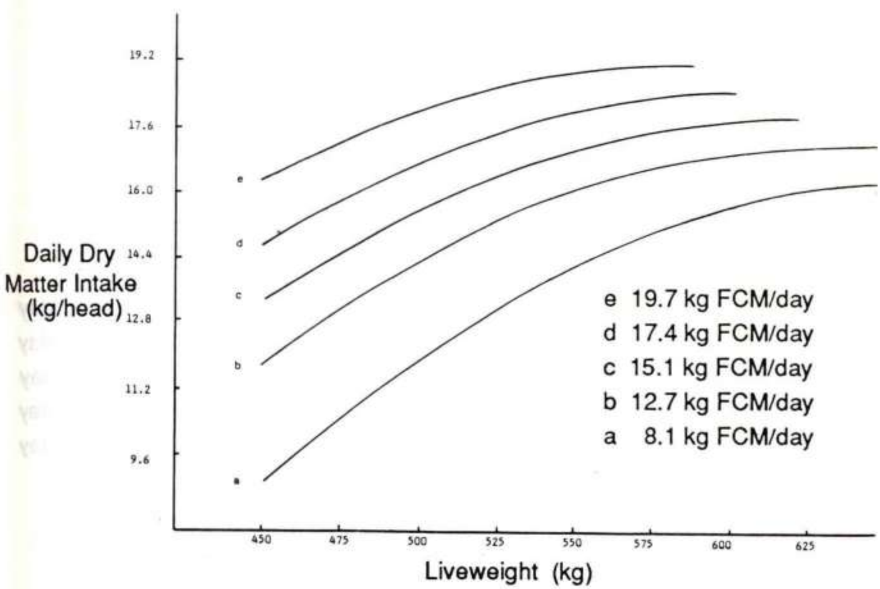


Fig. 7 – Predicted daily dry matter intake for cows of different liveweights and daily fat corrected (3.6%) milk yield during the experiment (Stalelum and Connolly, 1987)

Table 8
Liveweight and milk yield effects on voluntary DMI of fresh grass by dairy cows

Milk yield kg/day	500 kg	600 kg	Kg DM/Extra 100 liveweight
08.3	11.5	15.36	3.71
12.5	14.15	16.57	2.42
15.0	15.66	17.30	1.64
17.5	17.16	18.03	0.87
20.0	18.66	18.76	0.10
Kg DM/kg milk	0.60	0.29	

(Stakelum and Connolly, 1987)

weight categories of cows. The salient point here is that at low to moderate milk yields, the extra body size of cows is expensive from a feed point of view. At the higher end of the milk yield scale extra size causes only a small extra feed demand.

The gross feed efficiencies calculated as daily fat corrected milk yield (kg) per 100 MJ of digestible energy intake is shown in Figure 8. The data from Figure 8 is used to calculate these data sets. Highest gross efficiencies are always at the higher milk yields while smaller cows are more efficient than large cows. However, the decrease in feed efficiency with increasing size is small at higher yields and large at lower yields. Holmes (1988) draws attention to the quantity

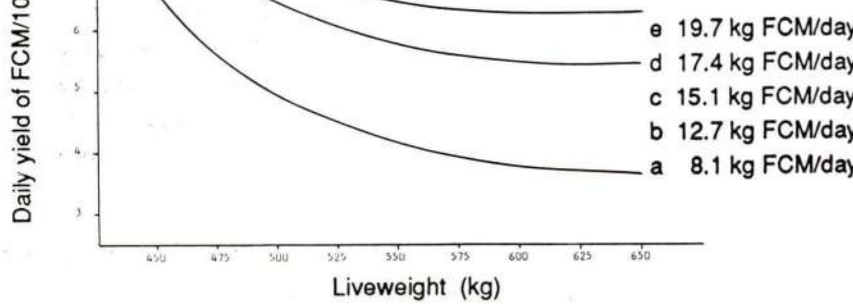


Fig. 8 – The relationship between gross efficiency of milk production (kg of daily fat corrected (3.6%) milk yield per 100 MJ of digestible energy intake) and body weight for different levels of milk production (Stakelum and Connolly, 1987)

of nutrients needed to maintain a cow. Clearly, the higher the output of milk the higher the gross efficiency because of the dilution of the maintenance requirement. This is aptly illustrated by Figure 8.

This definition however, of cow efficiency is too narrow. It ignores fluctuations in body tissues gain or loss. A simple input : output relationship can encompass inputs and outputs defined as physical, biological or financial. They can be measured over a full productive cycle of an animal or system or over the lifetime of an animal. Young cows are less efficient than older cows within a lactation cycle. Lifetime efficiency increases with succeeding lactations because the fixed costs of rearing are diluted. Ostergaard et al. (1990) drew attention to the term residual food intake which takes into account estimated energy in food minus estimated energy in products (milk, gain/loss, foetus) and for maintenance. The ratio of the two terms is feed efficiency.

The effect of genetic selection for milk yield on feed conversion efficiency can be estimated from 5 experiments (Bryant, 1981; Bryant and Trigg, 1981; Grainger, 1981; Pearson et al., 1981; Weinberg, Wilk and McDaniel, 1981; Grainger, Davey and Holmes, 1985; Gibson, 1986). Holmes (1988) estimated in a review of these works that over a 25-30 year period, that the genetic improvement is represented by the following differences:

Milk fat yield	+19%
Liveweight	– 1%
Intake	+ 6%
FCE	+13%

The data show that the increased yield caused an increase in FCE similar to that outlined above. There was no evidence of changes in digestive or metabolic efficiency and no effect on maintenance requirement. There was increased body weight loss or decreased liveweight gain during lactation. This is an importrant issue. The loss or mobilization of body tissue helps the cow overcome limitations in intake in early lactation. However, the restoration of liveweight loss must come from the diet late in the lactation cycle. Estimates of net efficiencies of milk production from dietary sources is around 62-66% while the efficiency based on the utilization of bodystores is 82-84%. Liveweight gain in lactating animals is performed at an efficiency of utilization of ME close to lactational efficiency (62%) which is much higher than for non-lactating animals.

Comparisons of HBI and LBI in New Zealand with both Jerseys (Bryant and Trigg, 1981) and Friesians (Grainger, Davey and Holmes, 1985) showed that the HBI cows produced higher yields of milk, fat and protein than their LBI counterparts. Milk fat content was not different. During lactation, the HBI cows lost more weight than the LBI cows when body condition score at calving was >5.5. Where body score at calving was close to 4 the HBI cows gained less weight during grazing. Bryant (1984 and 1985) demonstrated in a large grazing experiment over 3 years that HBI cows were more efficient convertors of feed to milk. They produced 19% more milk, 23% more fat, and 19% more protein. The differences were comparable to the 25% difference in breeding index. The feed intake was 14% greater than the LBI cows. The HBI cows were more competitive graziers and grazed their pastures more uniformly.

Experiments at Moorepark and its stations examined grazing strategies for the preferential treatment of high yield cows. The high yielding cows may benefit from selective grazing ahead of the low yielders in the herd. Conversely, the lower yielders it could be argued, are more timid graziers and might benefit also from preferential treatment. A two year experiment ('85-'86) was carried out to examine the interaction between dairy merit and grazing strategy as leader/ follower (Crosse and Fitzgerald, 1988). There was no interaction between dairy merit and system of grazing. The leaders increased their milk yield by 10% (regardless of merit) compared with the combined herd but the followers (also regardless of merit) were reduced by 9% in yield eroding any possible overall benefit to the system. This is in agreement with another study carried out at Moorepark in 1987 (Crosse and Fitzgerald, 1988) and by others (Archibald, Campling and Holmes, 1975). Mayne, Newberry and Woodcock (1988) found a 26% increase in milk yield by high yielders as leaders and only a 12% reduction in yield by followers compared to similar groups in a combined control group during the experiment. The net effect was a 9% overall benefit to the L/F system. However, the total lactation yields were increased by only 4% by the L/F system.

Supplementary feeding at pasture

It is beyond the scope of this paper to give a detailed review of this topic. Phillips (1988) has reviewed supplementatry feeding of grazing dairy cows with forage. A more general review is published by Siebert and Hunter (1982). Leaver, Campling and Holmes (1968) reported an average response of 0.33 kg milk per kg concentrate fed. More recently, Journet and Demarquilly (1979) found a response of 0.40 kg milk. Stakelum, Dillon and Murphy (1988a) examined the range of Moorepark experiments on this subject from 1976 onwards. The response ranged from 0.13 to 0.98 kg milk with an average of 0.53 kg. Generally, responses to concentrates are poor and in very many cases, uneconomic. Substitution of concentrates for grass occurs and its effect is very large when daily herbage intake is high (i.e. when grazing pressure is low/ herbage allowance high). Additionally, if the herd is milking close to its potential very little if any milk production response will be got.

Our experiments at Moorepark recently have focused on the effects of different concentrate types on substitution rates, milk production responses and rumen fermentation pattern. Well managed grass swards are very high in digestibility and offer a very different set of circumstances with regard to concentrate feeds compared to silage. Two indoor feeding experiments were completed in 1987 and 1988 (Stakelum and Murphy, 1988b; Dillon, Stakelum and Murphy, 1989) to compare the effects of fibrous versus starchy concentrates when fed to lactating cows with fresh herbage. Figures 9 and 10 outline the rumen fluid pH and L-lactate levels over a daily cycle for a grass only and a grass plus either 3 kg of barley or molassed beet pulp nuts (Dillon et al., 1989). The decreased acidity at 1.5 to 4.5 hours after concentrate feeding coinciding with peak lactate levels on the barley treatment indicates a fermentation pattern which is highly undesirable and was associated with a much more depressed level of herbage intake compared to the herbage only and molassed beet-pulp supplemented group. The herbage intake data showed a substitution rate of 0.80 compared to 0.4 kg/kg of concentrate fed for barley and MBP, respectively. The L-lactate levels were identical to the D-lactate levels for all treatments both in their absolute levels and in their pattern of change over the day. This result is supported by previous studies at our Centre (Stakelum et al., 1988b) and confirms the results of a grazing trial with high yielding dairy cows at Moorepark where barley supplementation at high daily herbage allowances gave substitution rates of 1.4 compared to 0.7 and 0.40 kg/kg concentrate beet pulp and molassed beet pulp, respectively (Stakelum and Dillon, 1988). The significance of a substitution rate greater than zero is of enormous importance. It means a negative effect on total intake. In this experiment, the conditions were such that the digestibility of the herbage selected by cows was comparable to that of the concentrate itself and it indicates that quite clearly starchy cereal grains under those conditions are unsuitable as a supplement. A more recent experiment (Dillon and Stakelum, 1990b) confirmed that both molasssed beet pulp nuts and

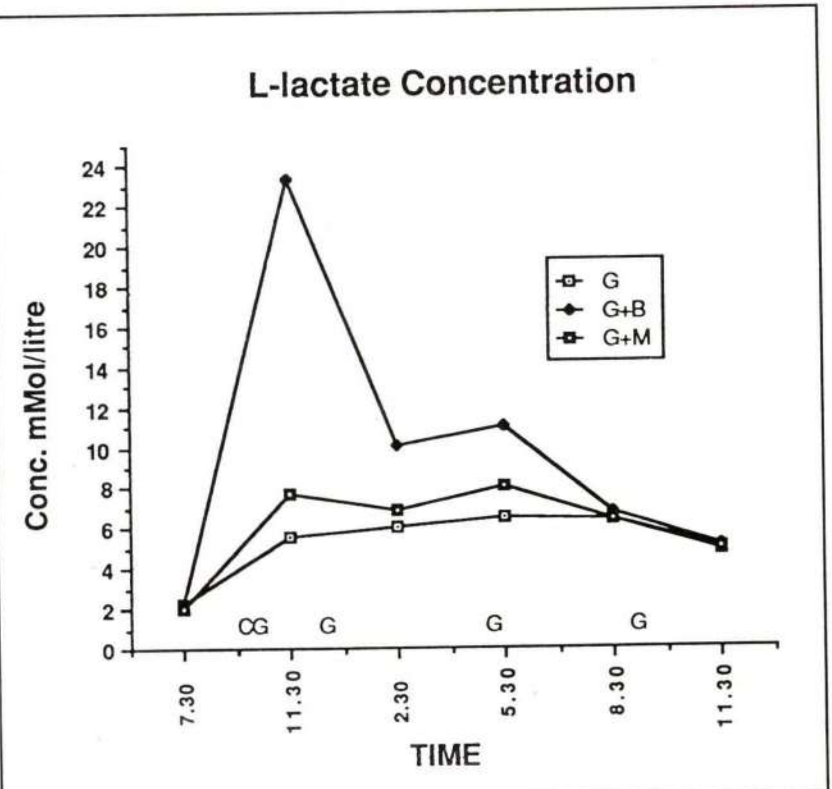


Fig. 9 – L-lactate concentration in rumen fluid of cows receiving grass (G), grass + barley (G+B) or grass + molassed beet pulp nuts (G+M). C and G indicates time of concentrate and grass feeding on a horizontal axis (Dillon et al., 1989)

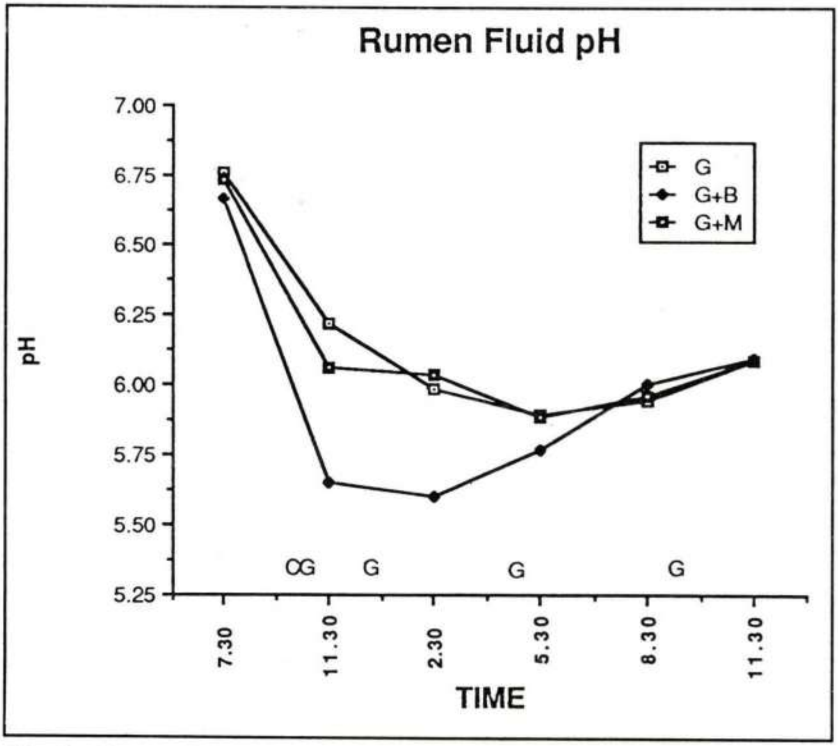


Fig. 10 – Rumen fluid pH of cows receiving diets shown in Figure 9 (Dillon et al., 1989)

brewers grains gave a much higher milk production response than barley in a simulated farm level study. Gleeson (1981) reported responses of 0.80 kg/kg of concentrate fed in whole farm system comparisons. The responses found were higher in late lactation than early lactation coinciding with reduced herbage availability.

Quite clearly, concentrate type and level, quality and quantity of herbage on offer, stage of lactation and appetite capacity and dairy merit will determine the magnitude of the response. In short-term experiments the carry over effect of supplementary feed on condition score and the persistency of the milk production response is also of importance. If a milk production difference continues after the concentrate is withdrawn the response calcuated over the feeding period will very much understate the actual benefit. Additionally, a benefit may also be translated into the next lactation (particularly at high stocking rates not as yet used under Irish conditions) whereby the condition of the cows is improved at the next calving. Journet and Demarquilly (1979) quoted a response of 0.40 kg milk/kg of concentrate. The residual effects over the next winter were large enough to give an overall response of 1 kg of milk/kg concentrate. Burstedt (1983) also found responses in late lactation to feeding concentrates during the grazing

season. Residual responses of 1.6-4.0 times the direct response were found in a number of studies. This has great practical significance for late calving spring cows. The time of concentrate feeding, viz-a-viz the cyclical change in pH during the day may also be important.

The most obvious effect of feeding concentrates at pasture is to alleviate the grazing pressure. This means, where other factors remain constant, that more herbage will be left behind on the pasture after grazing. This is a direct result of substitution rate. It means that even at high grazing pressures where herbage intake is restricted, feeding concentrates will still cause some increase in the quantity left grazing. Concentrate feeding can be used therefore to allow for higher stocking rates than would be normally used. Also, with the advances in our knowledge of grazing management, silage quantity on farms is not now as big an issue as say 10 years ago. Silage surplus to winter requirements is very much a spin-off benefit from grazing management strategies based on post-grazing sward surface heights. The integration of this forage into a defined system is an issue requiring more research especially in mid-season and late-lactation. The possibility of much cheaper concentrates under the CAP reforms could render them competitive with second and third cut silages and obviously again raise the issue of their use in grazing systems. The clear definition of the degree of pasture deficit which would necessitate the introduction of supplementary feed is not yet defined.

Herbage intake at pasture

The level of herbage intake achieved at pasture is an important determinant of the level of animal performance achieved under a set of circumstances. In this regard, industry supported research for production experiments usually falls short of allowing scientists to pursue aspects of research aimed at understanding the complex mechanisms involved in the grazing process. A fuller understanding of a process allows some prediction of the effect of a treatment or a range of treatments and in the context of production based experiments facilitates the extrapolation of results to other situations. Our knowledge of the grazing process and grazing systems in general had proceeded without any precise and accurate data on individual animal intake at pasture. Many techniques have been used and are still in use which have bias and major inaccuracies. Techniques based on sward cutting (herd estimates of intake) demand special grazing conditions to facilitate the technique that render the relevancy of the experiments rather questionable in some cases.

However, advances in this area have been dramatic since the mid-80s. Since the publication of the first work by Mayes, Lamb and Colgrove (1986) on the use of herbage an dosed alkanes to measure herbage intake with indoor fed sheep, the progress in this area has accelerated. Many experiments have been conducted at Moorepark since 1987 (Dillon and Stakelum, 1988, 1989, 1990c and d); Stakelum and Dillon, 1990) to examine the use of this technique for dairy cows under rotational grazing situations. We now use it routinely at Moorepark and Curtins in our grazing studies. Data sets are now being assembled which will begin to answer some of the questions regarding the gross efficiency of different cows in their conversion of grass to milk and herbage intake pattern of cows under different grazing conditions. This has been a wonderful development in grazing research and was supported by the Farmers' Journal Trust Fund and the Management of Teagasc. Work is continuing in this area.

Sward quality

The context in which quality is used here refers to the digestibility of the material on offer or selected rather than the botanical composition of the sward. In most of the grazing experiments done in temperate regions the independent effects of reduced digestibility in a grazed sward on animal performance has not been examined. This is in spite of the many references in the literature to the possible deleterious effects of lenient grazing on the accumulation of stem and dead material in grazed swards.

Our knowledge of how the sward reacts to different defoliation treatments has developed greatly over the last number of years (Robson, Parsons and Williams, 1989). Swards are not managed under grazing in order to maximise growth rates of the swards. Additionally, neither are they managed to sustain optimal animal performance in the case of dairy cows. Maximum grass growth rates are achieved under conditions of lenient defoliations. However, tissue death is also maximal in this situation. Net production of herbage, which is the difference between gross production and death is optimised under grazing management where grass production is well restricted. Very severe grazing can lead to a reduction in all three components.

The control of the development of the inflorescent tillers in the spring is a major consideration in grazing management. The use of rigid rotational grazing can lead to substantial under-grazing of paddocks in the April-June period. The use of sward height, as a simple and effective method of judging the severity of grazing is now accepted as a means of achieving an efficient herbage utilization rate throughout the season and a control of herbage supply. Experiments in Moorepark since 1986 have focussed on this aspect of grazing management and have been described in some detail by Stakelum and Dillon (1991). Using 2.5 cows/acre (during the 1st silage conservation period in April to June will, given an average growth rate of herbage for that time, graze the pastures to 6 cm. The effect of this will be to create a green leafy sward for the remainder of the grazing season, to maximise the amount of silage which can be harvested from the 1st cut at the end of May and to avoid excessive per cow depressions in milk production in the early half of the grazing season. The sward structure and morphological composition which exists from mid-summer onwards is eminently more 'grazible' and promotes higher intakes of higher digestible material than more laxly grazed swards. The significance of these broad findings are of enormous importance to grazing management practices for dairy cows.

Because growth rates fluctuate very widely within seasons from year to year it is important to develop and evaluate flexible management approaches to grazing in order to avoid surpluses and react to deficits. The degree to which the deficits should be tolerated is also a very big question but to achieve a relatively constant grazing height of 6 cm in the first half of the grazing season necessarily implies a large degree of flexibility. The optimum height for grazing later on in the season needs to be identified in relation to previous management. The very many environments in which milk is produced in Ireland creates many different starting points and conditions at the commencement of the grazing season. These range from the early March to late April turn-out and a spectrum of soils with different degrees of drainage. The later-turn-out areas present a particularly difficult situation with regard to controlling quality.

The digestion of fresh grass

When fresh grass is ingested by the cow, bacteria in the rumen digest the carbohydrate fraction (the fibre and soluble sugar component) to volatile fatty acids (VFAs of which acetate, propionic and butyrate are the major components). This causes a major downward shift in rumen pH especially when concentrates are fed (see previous section). When the pH falls below 6.0, fibre digestion will be impaired. This is a major reason for the depression in grass intake when starchy concentrates are fed at pasture (see previous section).

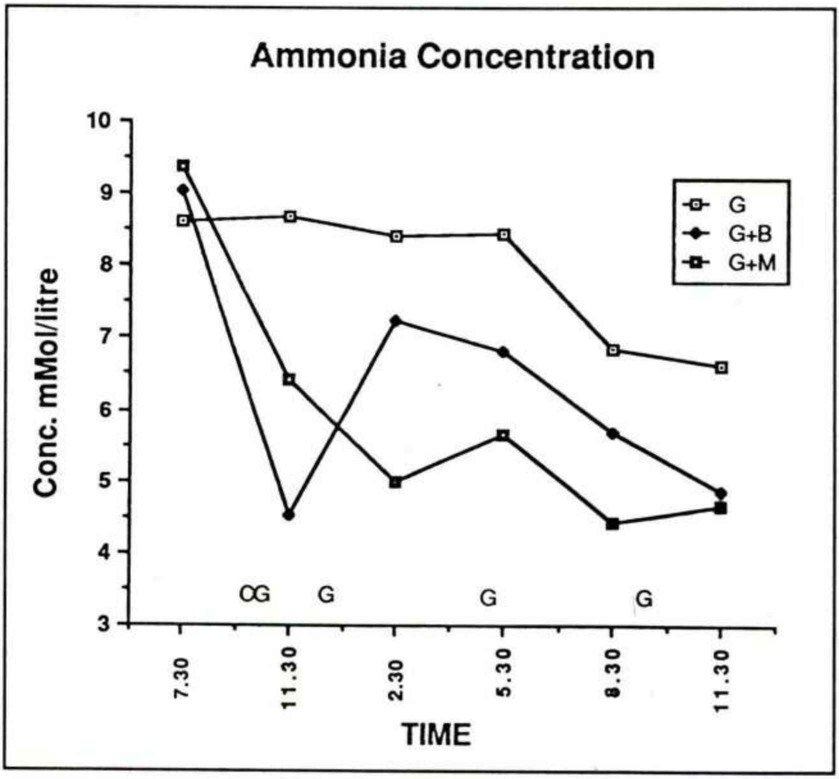


Fig. 11 – Rumen ammonia concentration of cows on grass (G), grass + barley (G+B) and grass plus molassed beet pulp nuts (G+M). Time of feeding indicated (Stakelum and Connolly, 1987)

The crude protein fraction of fresh grass (total-N) consists of protein and non-protein material (NPN). The NPN component can range from 15-50% of total N and consists mainly of amino acids and peptides (short chains of chemically bonded amino acids). Most of the NPN is soluble and quickly fermented. The protein fraction can be either soluble or insoluble and this will determine their degradability characteristics. The protein of grass is extensively degraded in the rumen. The high rumen ammonia levels following degradation is indicative of this . Figure 11 shows the reduction in rumen ammonia with energy supplementation of grass fed cows from an experiment at Moorepark (Dillon et al, 1989). The starch supplement (barley) gave a transitory reduction while the sugar/fibre supplement (molassed beet pulp) gave a persistent reduction. The imbalance of energy to protein ratio in highly digestible grass is not as large as with silage but is still not ideal. Samples of herbage representative of that selected by grazing cows were found to have a rumen protein degradability of around 77% (Stakelum et al., 1988). The apparent loss of N between the rumen and duodenum on fresh grass diets high in nitrogen has been described by Beever and Siddons (1989) and represents a major inefficiency of N utilization. Table 9 shows some data from Beever and Siddons (1989) to illustrate this point. Three diets ranging from 100% ryegrass to a 50 : 50 ryegrass/white clover mixture were fed to cows. There was a loss of 84, 87 and 147 g N/day between the rumen and the duodenum on the three diets. Also, over 50 g/day ammonia-N was lost on all three diets by outflow from rumen to duodenum. This is probably facilitated by a rumen pH well below 7.0 when highly digestible forage diets are fed. However, microbial protein synthesis, expressed as g of microbial N/kg organic matter apparently digested in the rumen is considerably higher with fresh forages (33-58g) than silages (13-28g) (Gill, Beever and Osbourne, 1989). Microbial N constitutes over 70% of the duodenal non ammonia nitrogen fraction on perennial ryegrass diets.

The efficiency of utilization of absorbed amino acids by an animal is partly dependent on the ratio of amino acids relative to the reaqirements for specific aminoacids and the relative proportions of proteins which need to be synthesised for milk or meat production. There is ample evidence to show that the provision of extra protein to animals on forages with high levels of digestible crude protein can improve their performance. Rogers et al. (1980) reported a 15% increase in milk yield from feeding 1 kg/day of formaldehyde treated casein. Ad-libitum

Table 9
Nitrogen digestion (g/day)
Ryegrass : white clover mixture

	100 : 0	75 : 25	50 : 50
N intake	519	604	693
N to SI	435	517	546
Duodenal ammonia flow	55	51	58

(Beever and Siddons, 1986)

feeding of ryegrass or white clover resulted in a 30% increase in milk yield on the white clover diet (Rogers, Porter and Robinson, 1979). The causes and mechanisms for these responses are poorly elucidated. Dillon and Stakelum (1990b) found a response of 0.58 kg milk per kg of protected soya compared to 0.16 and 0.24 kg milk per kg of barley and unprotected soya, respectively, for grazing dairy cows in late lactation. An increased outflow of protein from the rumen to the small intestine may be the cause of the responses thereby correcting an amino acid shortfall or imbalance. It may however be related to an increased level of DM intake as occurs for example on clover diets. O'Mara et al. (1991) reported a 7% and 3.5% response in milk yield to protected soya and fishmeal to grazing cows compared to a similar level of beet pulp nuts. Both these diets contained similar levels of UDP. Experiments are ongoing at Moorepark to examine the effects of providing supplements with ryegrass on microbial protein synthesis and duodenal nitrogen flow rates.

Conclusions

In the more applied area of grass utilization, work needs to be focussed on the area of whole season utilization of herbage encompassing such issues as early and late season management, regional and soil type limitations and a flexible approach to grazing management. These studies need to be extended to include aspects of dairy and genetic merit of cows. Use of white clover in grazed pastures is an important subject requiring experimentation. Much is known but many factors need study in production systems. Low cost reseeding techniques need continual work. This is particularly relevant for dairy farmers operating at high levels of efficiency. The evaluation of newer grass varieties for milk production under the various conditions of farming practices is also of importance for intensive systems.

On the more basic levels, we need an active programme on patterns of selection by grazing cows under rotational grazing, detailed studies on tissue turnover in grazed and cut pastures, use of alkanes to measure diet composition of grazing animals, rate of decomposition of dung pads and utilization and digestion of ingested herbage. Additionally, studies on the factors which cause sown swards to revert over time to mixed compositional sward are central to our understanding of how perennial ryegrass and other grasses grow and survive under various managements.

Our grassland farming practices are now operating under much more restrictive constraints such as quotas and environmental factors. Allied to these are issues of animal welfare and ethics which are quite important in Europe. The political and economic environment is not supportive of production research now to the extent it once was. It is unlikely if the many issues of research priority outlined above will be possible under the present major cut-backs in the Teagasc resources. Farming groups need to recognise this and become more supportive of production research aimed to greater farm efficiency.

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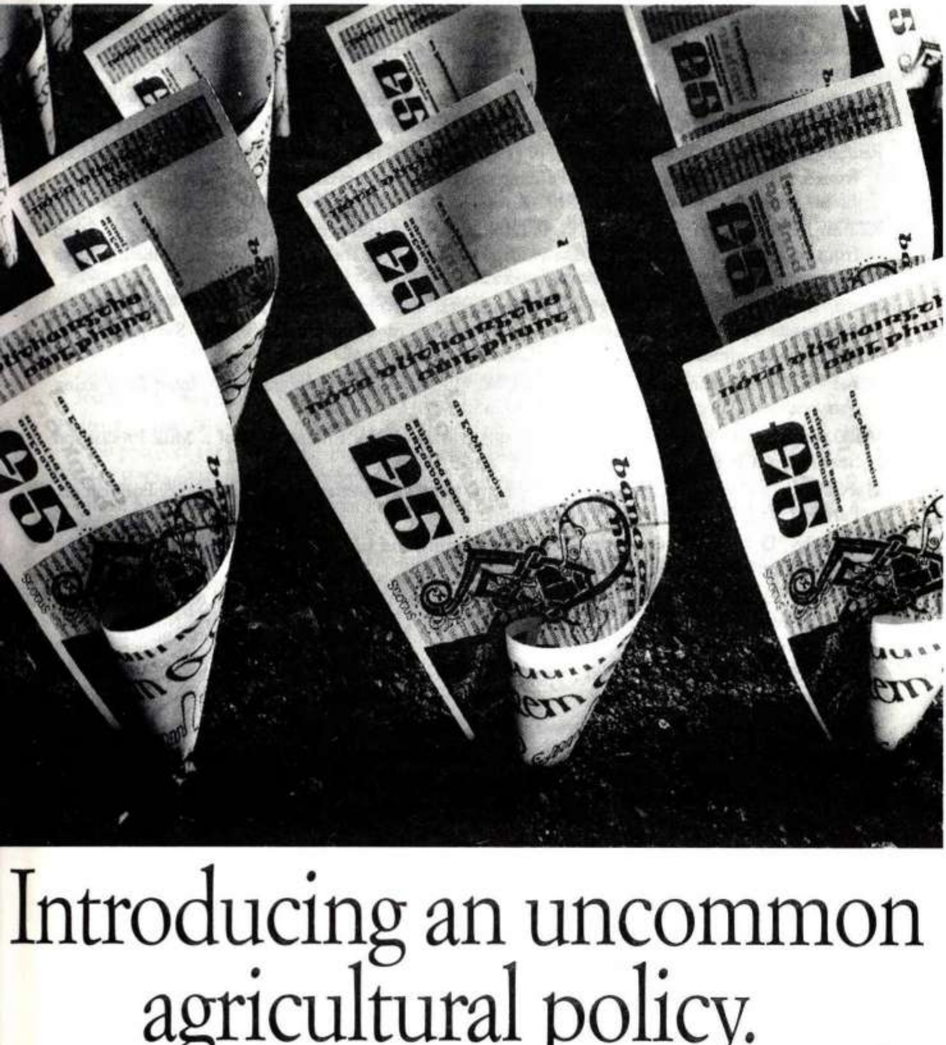

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ELEVENTH RICHARDS-ORPEN MEMORIAL LECTURE

2. Silage Intake – A Major Constraint to Low Cost Milk Production?

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At the outset I would like to thank the Irish Grassland Association for their invitation to address this Conference as one of the Richards-Orpen Memorial Lectures. It is indeed an honour to be associated with the memorial to someone who made such a tremendous contribution to the Irish Grassland Association and to grassland farming in Ireland.

Introduction

With increasing pressure on dairy farm incomes arising through constraints on milk production in the form of milk quotas, reductions in milk prices and rising input costs, it is imperative that the lowest cost combination of resources on the farm are used to produce each litre of milk. Under the prevailing climatic conditions in Ireland and western parts of the United Kingdom, this inevitably necessitates a high reliance on grass, either in the grazed or conserved forms. Whilst current discussions within GATT (General Agreement on Tariffs and Trades) and the CAP (European Common Agricultural Policy) may result in lower grain prices throughout the European Community, the competitiveness of milk production on the western fringes of Europe will ultimately depend on the full exploitation of the milk production potential of grass.

One of the major obstacles limiting milk production from grass in these areas is that, on average, utilization through grazing is only feasible for between 6-8 months/year.

Production from forage for the remaining period is dependent upon conserved forage – primarily in the form of grass silage. However, many previous reviews (Gill *et al*, 1988; Harris and Raymond, 1963 and Reeve, 1989) have highlighted the low intake characteristics and lower nutritive value of grass silage compared to grazed grass. Indeed as early as 1963, Harris and Raymond in their review stated that "the value of silage as a ruminant feed may be limited at present either by low digestibility or by low intake if it is of high digestibility. If high digestibility and high intake can be combined, silage should provide a feed of much higher animal production charcteristics than is often now accepted". The purpose of this review is to examine recent information on the limitations of grass silage and to highlight possible opportunities for overcoming such limitations.

Changes during ensilage and effects on intake

The major changes which occur during the ensilage of grass are the fermentation of grass sugars by lactobacilli bacteria to form lactic acid and the

Table 1
Typical composition of fresh grass and silage (after Wilkinson, 1981)

	Fresh grass	Grass silage
Water soluble carbohydrate (g/kg DM)	150	10-20
pH	6.0	3.8-4.0
Fermentation acids (g/kg DM)	0	100-150
Crude protein (g/kg DM)	160	160
Non protein nitrogen (g/kg total N)	180	500
Ammonia nitrogen (g/kg total N)	3	80

breakdown of true protein to form non protein nitrogen. The end result is a marked change in chemical composition as shown in Table 1 (Wilkinson, 1981). The ultimate consequence of these changes in composition are a marked reduction in the intake potential of grass as compared to grass at ensiling. In one of the most comprehensive studies on this topic Demarquilly (1973) evaluated a range of 45 grasses and 87 silages through sheep and observed that, on average dry matter intake was reduced by 33% following ensilage, with a range from 1-64%.

However, as indicated above, the extent of the reduction in intake is extremely variable, and whilst several studies have indicated that part of the variation may be attributed to fermentation end products (Wilkins *et al*, 1971 and Gill *et al*, 1988), in particular the level of acetic acid produced (Tayler and Wilkins, 1976), results of recent studies indicate that marked differences in intake characteristics can occur, even in the absence of changes in fermentation pattern (Gordon, 1989; Mayne, 1990 and Keady and Steen, 1990).

One of the major difficulties involved in examining effects of specific silage parameters on dry matter intake is the risk of confounding animal effects with silage *per se*. For example Rook *et al* (1991) attempted to produce a prediction model to account for variations in silage intake in situations where silage was offered *ad libitum* and concentrates offered on a flat rate basis. The model derived from a comprehensive data set accounted for 63% of the variation in silage intake in early lactation or 58% in mid lactation. However animal factors including factors such as yield of fat plus protein, post calving liveweight and week of lactation were the major factors in the model. Only two factors associated with silage, digestibility and ammonia nitrogen content were found to be important.

In order to evaluate the critical silage factors which influence intake, animal effects need to be eliminated. This can best be achieved by screening a diverse range of silages through a single species of animal under a constant nutritional regime.

Implications of reduced silage intake on animal performance

Providing a satisfactory fermentation is achieved during ensilage, ensiling does not directly affect the digestibility, metabolizable energy (ME) concentration or efficiency of utilization of ME (Wilkins, 1974). However, the reduction

Table 2
Intake and milk production from silage only diets

Source	Silage D-value (g/kg)	DMI (kg/day)	Milk yield (kg/day)
Autumn calvers			
Castle (1982)	702	13.2	14.4
Rae *et al* (1986)	650	11.4	15.8
Mayne (1989)	745	11.0	17.8
Tedstone (1990)	689	–	12.3
Spring-calvers			
Rae *et al* (1987)	700	12.4	21.1

in intake compared to the fresh crop results in depressed animal performance. The majority of studies on silage only diets carried out in the United Kingdom and Ireland have been undertaken with late winter or spring-calving cows and thus the winter feeding period has been of relatively short duration. Results of a number of recent studies are reviewed in Table 2. It is important to contrast these results with typical performance from grazed grass in early lactation, with herbage intakes of 15-17 kg DM/day and milk yields in excess of 25 kg/day.

The low silage intakes and poor animal performance obtained with silage only diets will generally preclude the adoption of silage as a sole feed with autumn-calving herds. However, results obtained at this Institute indicate that mean milk yields, adjusted for liveweight loss, of 21 kg/cow/day can be achieved over the first ten weeks of lactation with cows calving in late March and going to grass in mid April. Similar levels of animal performance have been recorded with spring-calving cows on silage only diets (Rae *et al*, 1987).

The results presented in Table 2 also indicate a wide range in silage intake and milk production which apparently bear little relation to silage digestibility (D-value). This effect may be attributable to the many interacting factors which appear to influence silage intake.

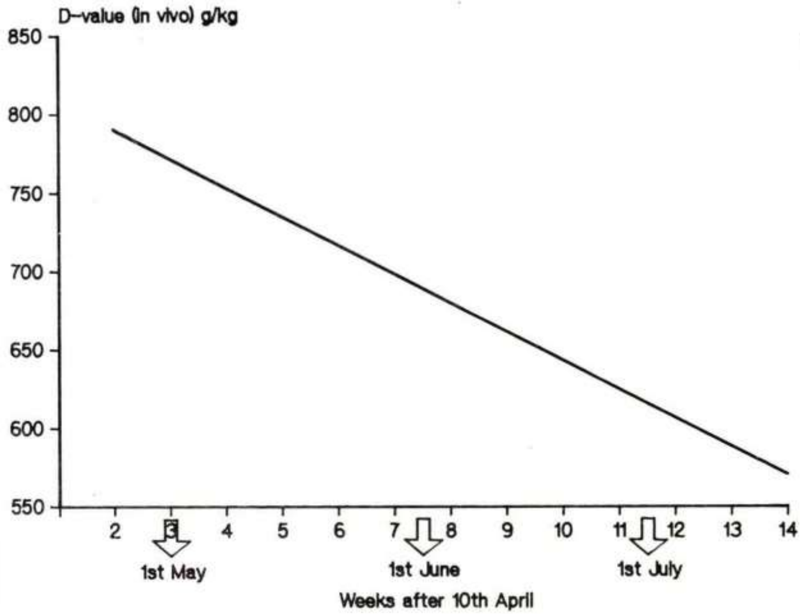
Factors influencing silage intake

Digestibility. One of the principal factors influencing silage intake and hence animal production from silage is digestibility. Recent studies carried out in England and Wales, based on herbage samples collected on farms over a number of years (Givens *et al*, 1989) indicate that herbage D-value (digestible organic matter in the dry matter) declines linearly from 1st May, with a mean decrease of 2.5 g/kg per day i.e. equivalent to a decrease in D-value of 18 g/kg per week (Figure 1). Gordon (1990) in a review of experiments carried out at Hillsborough noted that a 10 g/kg decrease in D-value on average depressed silage intake and milk yield by 0.16 and 0.37 kg/day respectively. Assuming the mean decline in D-value of 18 g/kg/week recorded by Givens *et al* (1989), this would indicate that each week delay in cutting of silage beyond 1 May will result in depressions in silage intake and milk yield of 0.29 and 0.67 kg/day respectively. In a milk quota context these results may be more meaningfully assessed in terms of the increased concentrate requirement associated with reduced silage digestibility. Gordon (1990) derived a value of 0.67 kg additional concentrate/day required to achieve a given milk output for each 10 g/kg decrease in silage D-value. Consequently for each week in cutting after 1 May on average an additional 1.2 kg concentrates/day will be required in order to maintain milk yield.

Season of harvest. A number of studies have shown reduced silage intake and animal performance with herbage harvested in the autumn compared to similar species of herbage harvested in spring. For example Castle and Watson (1970) observed silage intakes from autumn-harvested herbage were 9% lower than those produced from spring herbage of relatively similar digestibility. Similar studies reported by Peoples and Gordon (1989) have shown depressions in silage intake of 12% with autumn harvested material compared to those recorded with silage produced from the same sward, harvested in the spring, even though both silages had similar digestibilities and fermentation patterns. Similar depressions in intake have been recorded with autumn pasture in comparison to spring herbage (Marsh, 1975 and Reid, 1978). Peoples and Gordon (1989) noted lower crude protein and ash concentrations but higher fibre concentrations in spring-

Figure 1 Change in D-value with increasing maturity

(Givens et al, 1989)



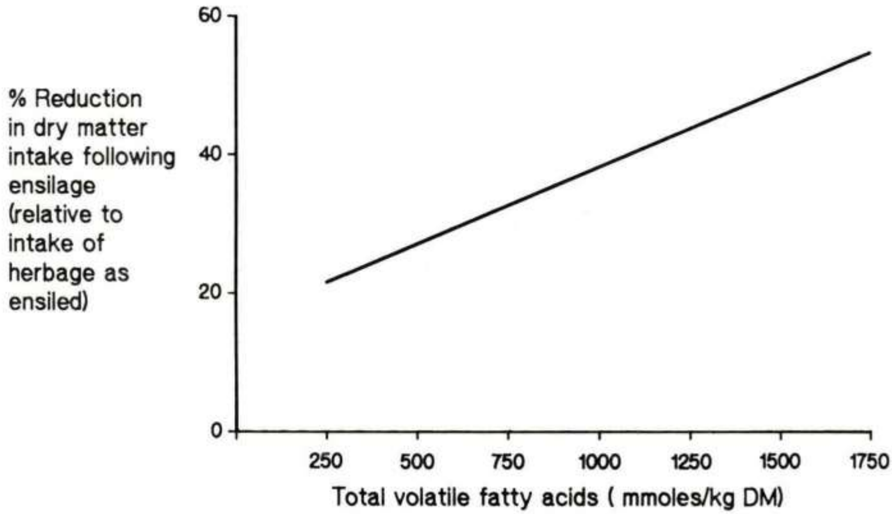
harvest material with improved animal performance with first harvest material being directly attributable to increased energy intake.

Dry matter concentration. Dry matter intake of silage is generally positively correlated with dry matter concentration. For example, Small (1986), in a comprehensive review of 38 dairy cow studies, noted a mean increase in intake following wilting of 13.7%, with greatest responses in intake occurring following wilting of low dry matter herbage. However, many of the unwilted silages examined in these comparisons were poorly preserved and consequently part of the increase in intake may be attributed to improvements in silage preservation. Rohr and Thomas (1984) and Gordon (1990) in their reviews of the effects of wilting on silage intake, when unwilted silages were generally well preserved, noted increases in silage intake of 4% and 6% respectively. However, increases in dry matter intake following wilting have not been reflected in improved animal performance, with Rohr and Thomas (1984) and Gordon (1990) observing reductions in milk yield of 2% and 3% respectively. Unsworth and Gordon (1985) have attributed the reduced animal performance with wilted silages to lower digestibility and reduced gross energy concentrations in comparison to unwilted silages made from the same herbage. These results clearly indicate the need to ensure that changes in ensiling technique, designed to improve silage intake, are reflected in commensurate improvements in animal performance as otherwise overall efficiency of silage utilisation will be decreased.

Fermentation pattern. The fermentation pattern of silage has a major effect on silage intake although the exact mechanisms for these effects are poorly

Figure 2 Effect of total volatile fatty acid content in silage on dry matter intake

(after Demarquilly, 1973)



understood as indicated earlier. Demarquilly (1973) concluded that the extent of the reduction in silage intake was closely correlated with the levels of lactic acid and volatile fatty acids present in silage (Figure 2). Further, it was noted that the effects of pH, ammonia nitrogen and butyric acid were much less significant. However, it is also important to note that the final characteristics of the silage as fed provides little indication of the time course of the fermentation process and clearly this may have important effects on residual water soluble carbohydrate levels (Mayne and Steen, 1990) and possibly intake.

There are a wide variety of silage additives available to modify the pattern of fermentation within the silo. Steen (1991) carried out an extensive review of this topic and results are summarised in Table 3. Treatment of grass with formic acid (2.8 litres/t) has generally improved silage fermentation with significant improvements in silage intake (mean response + 0.82 kg DM/day) and in the yield of milk fat and protein. However, it is important to note that Parker and Crawshaw (1982) and Mayne and Steen (1990) noted that formic acid treatment had much less effect on silage intake or animal performance when untreated silage was well preserved. Overall, treatment with sulphuric acid has produced much smaller increases in silage DM intake (mean response + 0.43 kg DM/day) and has tended to marginally depress animal performance relative to untreated material. In contrast, treatment of grass with bacterial inoculants based on *Lactobacillus planatarum* has produced relatively modest improvements in silage fermentation and silage intake (mean response + 0.46 kg/day) but has significantly enhanced animal performance.

More recently there has been renewed interest in the possibility of overcoming some of the factors contributing to reduced silage intake, through restricting the extent of fermentation in the silo by the application of high levels of organic acids. However, even when applied at levels in excess of 6 litres/t considerable

Table 3

Effect of silage additive treatment on silage fermentation, silage intake and animal performance (After Steen, 1991)

	Formic acid	Sulphuric acid	Inoculants	High levels organic acids
Change relative to untreated silage*				
pH	–0.4	0	–0.1	0
Ammonia N (g/kg total nitrogen)	–42	–14	–25	–53
Silage intake (kg DM/day)	+0.82	+0.43	+0.46	+1.1
Milk production (fat + protein yield, g/day)	+57	–43	+67	+110
Fat + protein Yield/kg additional DM intake (g/kg)	69	0	145	100

* Untreated silages differed with differing additive type

fermentation may still take place within the silo, although on average lactic acid levels have been reduced by approximately 50% in two recent studies (Jackson and Furniss, 1990 and Chamberlain *et al*, 1990). This approach has resulted in large increases in silage intake (+ 1.1kg/day) across five experiments with commensurate increases in animal performance. Furthermore, in a more recent study at this Institute (Mayne, 1991), application of high levels of organic acids has resulted in increases in silage DM intake and fat plus protein yield of 2.91 kg/day and 320 g/day respectively.

Other options for increasing DM intake with silage

Inclusions of legumes in silage

There has been renewed interest within the United Kingdom in recent years in the role of legumes in high forage production systems. A series of studies conducted by Castle, Reid and Watson (1983 and 1984) indicated that high levels of intake and animal performance could be obtained from white clover silage as a sole feed (Table 4) with milk yields up to 26.3 kg/day being obtained on silage only diets. However, more recent evidence (Wilman and Williams, 1991) indicates that silage produced from grass/white clover mixures may produce much more modest improvements in animal performance than would be predicted on the basis of silage produced from pure white clover swards (Table 5).

Mixed forage diets. An alternative approach to increase dry matter intake which has been examined recently (Phipps *et al*, 1988) involves mixing of two differing forages prior to feeding. For example, the data presented in Table 6 indicate that higher total DM intakes and improved animal performance were obtained by offering mixtures of grass and maize silages than by offering either silage separately. These results indicate the potential to increase total dry matter intake from forage by inclusion of complementary forage crops such as maize silage or fodder beet (Roberts, 1987).

Table 4

Intake and production from white clover silage (Castle *et al*, 1983 and 1984)

D-value (g/kg)	Silage DM intake (kg/day)	Milk yield (kg/day)
623	15.2	15.7
680	19.3	26.3

Table 5

Comparison of grass and grass/white clover silage for milk production (Wilman and Williams, 1991)

	Grass Silage	Grass /white clover silage
Dry matter intake (kg/d)	14.6	16.0
Milk yield (kg/d)	23.3	24.0
Butterfat (g/kg)	40.1	38.2
Protein (g/kg)	29.1	28.4

Table 6
Integration of grass and maize silage – effects on intake and animal performance (Phipps, 1988)

	Grass silage only	75% Grass silage + 25% maize silage	50% Grass silage + 50% maize silage	25% Grass silage + 75% maize silage
Grass silage (D-value 630 g/kg)				
Dry matter intake (kg/day)	7.8	8.2	8.5	9.6
Milk yield (kg/day)	23.8	24.7	24.9	26.4
Grass silage (D-value 680 g/kg)				
Dry matter intake (kg/day)	8.8	8.8	10.7	8.9
Milk yield (kg/day)	24.5	24.8	26.3	25.5

Effects of concentrate supplementation on silage intake

Provision of supplementary feed can also have a marked effect on silage intake with supplements tending to depress intake. The extent of this intake reduction, or substitution rate, is extremely variable although recent evidence (Thomas and Thomas, 1989) suggests a close correlation between substitution rate and the intake of silage as a sole feed. The higher the intake potential of the silage, the greater the depression in silage intake when the supplement is fed. Consequently, substitution rates will ultimately depend upon the many interacting factors which influence the intake potential of silage, as outlined earlier. However, the clear implication which can be drawn from the relationship between intake potential and substitution rate is that responses in both total dry matter intake and animal performance from supplementation of high potential silages will be much lower than those obtained with silages of low intake potential.

Supplement type. A wide variety of supplement types are used in practice ranging from high starch, cereal-based concentrates, through digestible fibre-based concentrates to high protein concentrates. At normal levels of supplementary feeding used in practice e.g. 4-10 kg/cow/day there is little evidence to indicate that concentrate energy source, i.e starch vs fibre has any effect on silage intake. Indeed, in some studies replacement of starch with digestible fibre as the principle energy source has resulted in a reduction in silage dry matter intake (Mayne and Gordon, 1984).

More recently, investigations at this Institute have examined the effect of protein content of the supplement on silage intake and animal performance.

Gordon, Unsworth and Peoples (1981) observed that increases in protein content increased overall ration digestibility and silage intake. Further studies have examined the effect of offering concentrates containing 100, 220, 340 and 460 g crude protein/kg on silage intake and animal performance (Mayne, 1990b). The results of these studies, presented in Figure 3 provide further evidence of positive effects of high protein supplements on silage intake. For example, offering supplements containing 100 and 220 g crude protein/kg resulted in substitution rates of 0.32 and 0.01, whereas with supplements containing 340 and 460 g crude protein/kg silage intakes were increased by 0.09 and 0.31 with each additional kg supplement. Consequently a fat plus protein yield of 1.50 kg/day could be produced by offering grass silage *ad libitum* with 8.3, 4.7, 3.3 or 3.3 kg/day of concentrates containing 100, 220, 340 and 460 g crude protein/kg respectively. It is clear from these studies that provision of specific nutrients as supplements to silage may facilitate the use of lower levels of supplements than used hitherto. However, the specific nutrients required to fully exploit the potential of a given silage may well depend upon the intake and degradability characteristics of the silage, which ultimately reflect the fermentation process occurring during ensilage.

Method of supplementary feeding

Method of feeding of supplementary feeds may also influence silage dry matter intake, particularly when high levels of supplements are offered. For example, the data summarised in Table 7 indicate that complete mixing of silage and concentrates prior to feeding has, on average, increased total dry matter intake by 7% relative to offering silage and concentrates separately. Gibson (1984) suggested that more frequent feeding of concentrates prevented marked

Figure 3 Effect of crude protein content of concentrate and feed level on silage intake

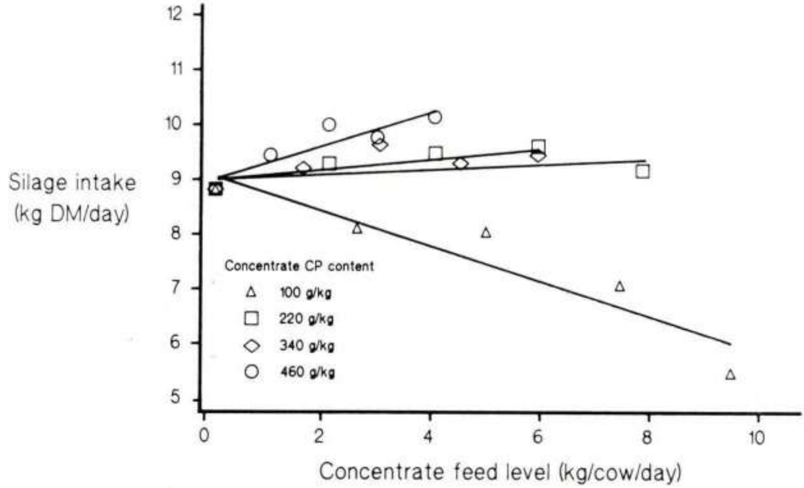


Table 7

Effect of method of concentrate feeding with grass silage based diets on silage intake and animal performance

Reference	Dry matter intake (kg/day)		Fat plus protein yield (kg/day)	
	Complete diet	Separate	Complete diet	Separate
Phipps *et al* (1984)	16.4	16.1	1.73	1.75
Agnew and Mayne (1990)	12.8	11.7	1.33	1.29
Murphy and Gleeson (1991)	16.4	14.8	1.69	1.85
Overall mean	15.2	14.2	1.58	1.63

declines in rumen fluid pH, thereby facilitating improved forage digestion and increased dry matter intake. However, from the data presented in Table 7 it is clear that improvements in total dry matter intake, as a result of complete diet feeding, are not necessarily always translated into improved animal performance. Further work is needed to examine the optimum combination of feed ingredients to accompany grass silage in complete diets for dairy cows.

Conclusions

With the prevailing climatic and soil conditions throughout much of the United Kingdom and Ireland, utilization of grass through grazing is only feasible for between 6-8 months/year. Consequently conserved forage, principally grass silage, forms a major component of the diet for the remaining period. However grass silage has a lower nutritive value and lower intake characteristics than grazed grass and this is a major limitation in developing low cost milk production systems. In part the lower intake of silage can be attrributed to fermentation end products, particularly acetic acid, although recent studies with inoculant additives suggest that the rate of fermentation following ensilage may also be an important factor. Silage digestibility also has a major effect on intake, with each week delay in harvesting after 1 May resulting in a depression in silage dry matter intake of 0.29 kg/day.

Provision of supplementary feeds tends to depress silage intake, with greater reductions being obtained with silages having a high intake potential when offered as a sole feed. However, recent evidence indicates that, with silages of high intake potential, provision of low levels of high protein concentrates can stimulate silage intake. Further work is required to identify the most appropriate type of supplements to use with silages of differing chemical composition and fermentation characteristics.

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Big Bale Silage

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Introduction

Of the approximately 20 million tonnes of silage produced in Ireland at present, less than 10% is conserved as big bale silage. However, national farm survey data assembled by Teagasc (Power, 1991 - unpublished) indicates that on farms of less than 10 ha area, 68% of those with silage make only baled silage. This percentage decreases to 40%, 24% and 16% for those in the 10 to 20 ha, 20 to 30 ha and 30 to 50 ha categories, respectively. These proportions are steadily increasing. The method of storing big bales under plastic has progressed from storage in clamps to individual bags in individually wrapped bales. The present system is a major technical advance on the baled silage system of the 1970's which were based on the available hay-making technology and involved small rectangular bales tightly packed in a polythene covered clamp. Manual handling of heavy bales and susceptibility to aerobic deterioration at feeding time made that system unpopular.

Large round-bale silage is relevant in two types of circumstances. Firstly, for farmers who normally make hay, it represents an opportunity to achieve some of the benefits of silage-making, without the ability to conserve their crops of grass when weather conditions for hay-making are unsatisfactory. Secondly, baled silage has a place on many farms making silage by conventional systems. It can be used to complement the existing silage-making systems where the quantity of grass to be ensiled is insufficient to justify opening the conventional silos, and risking excess wastage.

The baled silage can be used as a buffer feed for grazing cattle when grass growth is poor, or at the start of silage feeding in winter if stock numbers are low. In both cases it can help to reduce wastage due to aerobic deterioration at the silage face in conventional silos. Baled silage also has a role in allowing silage-making and feeding on an outfarm where conventional silos are not available.

Quality on farms

Based on over 6500 silage samples from Irish farms chemically analysed by Grange Laboratories each year, Tables 1 and 2 compare the composition of big

Table 1
Irish farm silages 1990

	Dry matter (g/kg)	pH	Crude protein (g/kg DM)	DMD (g/kg DM)
Big bale				
Average	342	5.1	148	623
Max	720	8.8	244	754
Min	134	3.7	86	222
Conventional				
Average	230	4.0	160	690

Table 2
Irish farm silages 1991 (incomplete data-base)

	Dry matter (g/kg)	pH	Crude protein (g/kg DM)	DMD (G/kg DM)
Big bale				
Average	327	4.9	175*	645
Max	602	6.4	212	728
Min	234	4.1	143	580
Conventional				
Average	220	4.0	155	690

* small sample size

bale silages with that of conventional (i.e. single, double and precision-chop) silages.

Wilting is clearly a more integral part of the baled silage system than of other silage making systems; however baled silages ranged from very wet (134 g DM/kg) to very dry (720 g DM/kg). Whereas higher pH values are associated with big bale compared to conventional silages, due both to the higher degree of wilting and slower release of cell contents associated with big bale silage, some values were so high as to indicate extensive aerobic deterioration. Both crude protein and *in vitro* DMD values tend to be lower for the big bale silage samples analysed than for samples from conventional silages. This is more a reflection of differences in the quality of the grasses ensiled in the different silage-making systems than any effects of the big bale silage system itself. The results clearly show that the quality of big bale silage ranges from very good to very poor in terms of preservation and feeding value.

Feeding value

The quality (feeding value) of baled silage is dependent firstly on its digestibility and then by how well preserved it is. Baled silage with a high digestibility (DMD over 700 g/kg DM) is made from leafy grass whereas stemmy grass will produce a low digestibility (DMD below 650 g/kg DM). Table 3 shows the type of performance expected from 450 kg steers offered well preserved baled silages of either high or low DMD. Clearly stemmy grass cannot make good baled silage.

Table 3
Expected performance from well preserved baled silage offered to steers

DMD (g/kg DM)	730	630
Silage DM intake (kg/day)	8.57	7.72
Liveweight gain (kg/day)	0.76	0.42
Carcass gain (gk/day)	0.46	0.22

Good preservation of baled silage depends on :

a) ensiling clean grass – no contamination by soil, animal manure, rotted grass etc.

b) wilting, if possible

c) getting the bales into the air-free environment quickly, and strictly maintaining these conditions until feeding time.

Although recent experiments at Grange have shown that excellently wrapped baled silage can be kept for a second year, it is advisable in most cases not to attempt to carry over bales from one year to the next.

Research at Grange has shown that good quality silage offered *ad libitum* to cattle is similar in feeding value to comparable silage made using more conventional machinery (Table 4).

Table 4

Comparison of baled silage with precision-chop silage (silage *ad libitum* + 1.6 kg concentrates daily)

	Unwilted		Wilted
	Precision-chop	Big bale	Big bale
DM (g/kg)	220	200	510
pH	3.8	4.2	5.9
DMD (g/kg)	710	730	690
Intake (DMI, % lwt)	1.5	1.7	1.7
Liveweight gain (kg/day)	1.1	1.1	1.0

Sheep are more sensitive to silage chop-length than cattle and intakes may not be as high with big bale silage as with finely-chopped silage (Table 5). This would not be the case with cattle (Table 4), where chop length has little effect on intake.

Table 5

The effects of cutting date, wilting and chop length of silage when offered to sheep

			Silage DM intake (Kg/day)	Ewe weight change (kg) (housing to lambing)
Cutting date	–	17 May	1.07	–1.5
		5 June	0.91	–6.5
Wilting	–	Unwilt	1.21	1.3
		Wilt	1.31	0.2
Harvester	–	Long chop	0.97	–5.0
		Fine chop	1.29	0.1

Source : Chestnutt, N.I.

Other factors

When drying conditions permit, grass for big baling should be wilted to about 30% dry matter. Achieving this target quickly will involve tedding/turning the crop. Even though wilting is very sensitive to weather conditions and will cause the loss of some nutritive value, it removes the requirement for preservation treatment, eliminates effluent, reduces the cost of baling and wrapping/bagging per hectare and makes bales lighter and therefore easier to handle.

If wilting is attempted during wet weather, the crop could remain on the ground indefinitely. Such grass would continuously lose nutritive value and become progressively more difficult to preserve. Under circumstances where clean fresh grass cannot be wilted and where it is harvested as big bale silage, it should be baled and wrapped as soon as possible after mowing. Wet, leafy crops of grass would usually need the addition of adequate effective preservatives to the grass ***before*** it is baled. It is pointless applying preservatives onto the bale ***after*** it is made.

It is fundamental to the success of baled silage that an air-free environment within the wrap is achieved quickly and maintained thus until feeding time. Failure to achieve air-free conditions quickly after baling or to strictly maintain them during storage is the major reason for disappointing results with baled silage on Irish farms. It is important to wrap/bag bales within 3 to 4 hours of baling. The air wrapped within the bale after wrapping/bagging has very little effect, since it will be used up within the first two hours. Good quality polythene, properly applied, must be used. Any handling of the wrapped/bagged bales should be very gentle and cause no damage to the plastic. Obviously the bales should be fenced off during storage and preventive methods taken to exclude vermin. Damage, from whatever source, must be repaired immediately.

If mould is found in baled silage at feeding time, it indicates that the silage had access to air for some time before the bale was opened. This silage will have lost some of its feeding value and may be unsuitable for certain classes of livestock (e.g. pregnant cows or ewes).

Nutrient Balances in Grassland

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The nutrient supply in grassland is continuously changing with changes in inputs, outputs and recycling of elements. A knowledge of the sources of new supplies of nutrients and the methods whereby nutrients are lost to the system is needed in order to manage the system so that the supply of feed to the animals is measured and the quality of the feed is adequate in terms of actual mineral contents and the balance between the nutrients.

The general scheme of sources and of losses of nutrients and also of internal cycling of nutrients is shown in Fig. 1.

New supplies of nutrients are brought into the grassland system from the soil minerals, the atmosphere, imported feeds, fodder crops and fertilisers.

Nutrients are lost to the system by leaching and runoff volatilization transfer to other crops and also in animal products.

Nutrients in the grassland ecosystem are in a constant state of flux. They move, or are cycled from different forms in the soil to the plants, to the animals and back again to the soil.

The nutrients essential for plant and animal production occur in varying amounts in the system. They interact with each other and with other soluble nutrients to produce herbage of different yields and mineral contents.

This mineral supply in the soil must be within certain limits relative to each other i.e. 'balanced' in order to produce high yields. Minerals in plants must also be balanced in order to be suitable for animal health and production.

Of most importance under Irish conditions are phosphorus, potassium, calcium, manganese, cobalt, nitrogen, sulphur, sodium, copper, molybdenum, selenium and iodine. Maps of areas of high and low availability of these elements have been produced by B. Coulter at Johnstown Castle and are now available.

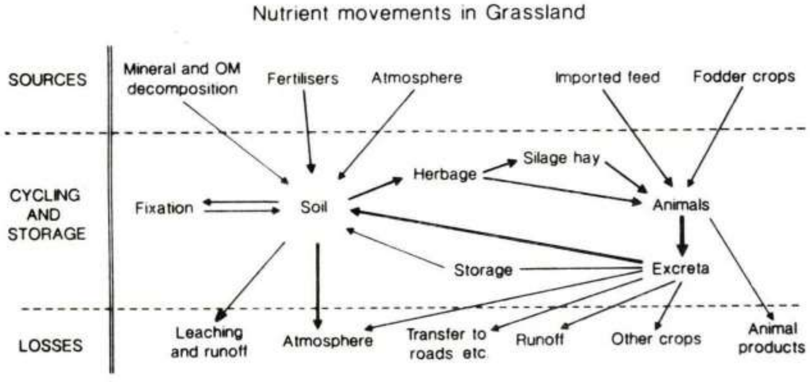

Fig. 1

Sources of nutrients

Nutrients coming into the grassland system are derived from a variety of sources. These include soil process resulting in the breakdown of minerals and organic matter in the soil. The natural weathering of soil constituents is a slow process but does result in a small steady supply of nutrients to the grassland system. The breakdown of soil organic matter especially fresh organic matter such as roots and leaves is quite rapid and makes available nutrients such as nitrogen on a seasonal basis.

Fixation of atmospheric nitrogen is an important source of fresh nitrogen supplies to grassland. This process has been the subject of extensive research and has been the subject of several reviews.

Nutrients are deposited from the atmosphere in small amounts. Apart from electrical storms which supply small amounts of nitrogen, the usual sources of these nutrients are industrial discharges which supply mostly sulphur but also other sometimes less desirable elements such as lead and cadmium. The atmosphere can also pick up some nutrients such as sodium and potassium from the sea surface and deposit this on land.

A major source of nutrients for grassland is imported feedstuffs. These supply nutrients such as nitrogen, phosphorus, calcium, sodium and magnesium by virtue of the natural content of the nutrients in the grain and also by virtue of minerals added by feed compounders. Often the supplementary minerals are equal to or in excess of the naturally occurring ingredients.

Fodder crops fed to ruminants and pigs use another important source of nutrients for grassland. These crops usually redistribute nutrients within the same farm or district whereas concentrated cereal feed can come from any part of the world. The root crops tend to be high in Ca and low in phosphorus and these balances have been discussed by Mengel and Kirby (1982).

Fertilisers are the main external source of nutrients for grassland. They supply mainly nitrogen, phosphorus, potassium and sulphur. Other elements such as sodium, calcium, magnesium and small amounts of trace elements are usually present as contaminants.

Losses of nutrients

Nutrients are removed from the grassland system by several mechanisms. these include leaching, runoff, erosion, volatilisation, animal manure disposal and constituents of animal products.

Leaching is the movement of nutrients down the profile in the drainage water. When the nutrients are moved permanently below the rocky zone they are lost to the grassland system. The amounts of nutrients that can be lost in this way vary greatly from virtually zero in the case of phosphorus to amounts of excess of 50 kg per hectare in the case of nitrogen.

Runoff of surface water occurs mostly in winter when soils are saturated with water and the next rain that falls has to run over the surface to the surrounding drains. Any material that is in solution such as fertiliser or material that can be suspended in the water such as slurry is in danger of being lost to the waterways. Erosion is not considered to be a serious problem in Irish grassland. Whenever it occurs nutrients that are already incorporated in the topsoil can be lost in this way. Some erosion occurs on over grazed hill peat soils. The problem is becoming more widespread as sheep grazing pressure increases.

The influence of leaching erosion and volatilisation on nitrogen is dealt with in more detail by Sherwood in another paper at this conference.

Volatilisation is a pathway for loss to the atmosphere, it affects mostly nitrogen and selenium.

Slurries and farmyard manure contain large quantities of nutrients. Normally they are recycled to the grassland. When they are used as sources of nutrients for tillage crops the grassland nutrients taken is affected.

Animal products, milk, meat, wool, all contain nutrients that are removed in the harvesting of such products from the system. The amounts removed vary with the stocking rate and with the product. The amounts of Ca, P, K and Mg removed by different animal categories are shown in Table 1.

Table 1

Nutrients removed (kg per L.U.)

Animal	Ca	P	K	Mg
Young Cattle	11.0	7.0	1.2	0.4
Mature Cattle	3.9	1.6	0.6	0.2
Cow 4,500 kg Milk	6.2	4.6	7.3	0.6
Sheep	8.9	5.0	1.6	0.4

These losses must be replaced from one of the input sources if livestock productivity is to be maintained.

Nutrient cycling and storage

Nutrients are stored in several areas in the grassland systems and cycled between these storage points.

The main storage points outside the soil are the sward (tops and roots), hay or silage and slurry pits or dungstead. In the soil the nutrients exist in several conditions from easily available to mineral and organic reserves. The easiest available nutrients are in the soil solution. These are removed by the plant roots and replaced from a labile pool of easily exchangeable or soluble nutrients. This pool is in turn kept in equilibrium by weathering of soil particles and breakdown of relatively stable organic matter. The system tends to remain in equilibrium influenced by the element involved, the climate, soil conditions and types of soil minerals. Thus when nutrients are added to the soil they may remain readily available for a long time or go into a longterm storage form i.e. become 'fixed'.

Soil conditions

The availability of nutrients to plants is influenced greatly by soil drainage and pH conditions. Low pH tends to reduce the availability of the essential nutrients and increase the solubility of manganese and aluminium. At the same time the rate of breakdown of organic matter is reduced. Where drainage is poor anaerobic conditions arise and nitrogen supply is reduced. However, other elements including toxic elements are more soluble.

Phosphorus

Phosphorus was almost universally deficient in the past. Farmers have been building up P levels in the soil by fertiliser application (Fig. 2) and in more recent times by extra concentrate feeding and better management of slurries and farm wastes. Fig. 2 shows that on a national scale soil P test results coincide with national P use figures with a lag phase of 2-3 years. Average P levels are now satisfactory. In some farms levels are high (>10 ppm) in 26% of the country (Tables 2 and 3).

Table 2

Phosphorus levels in Irish soils. Percentage of soil test results in different categories

	% of soils in each soil test category (ppm)				
	0-3	4-8	7-10	10+	Mean
1989-1990	25	28	21	26	8.3

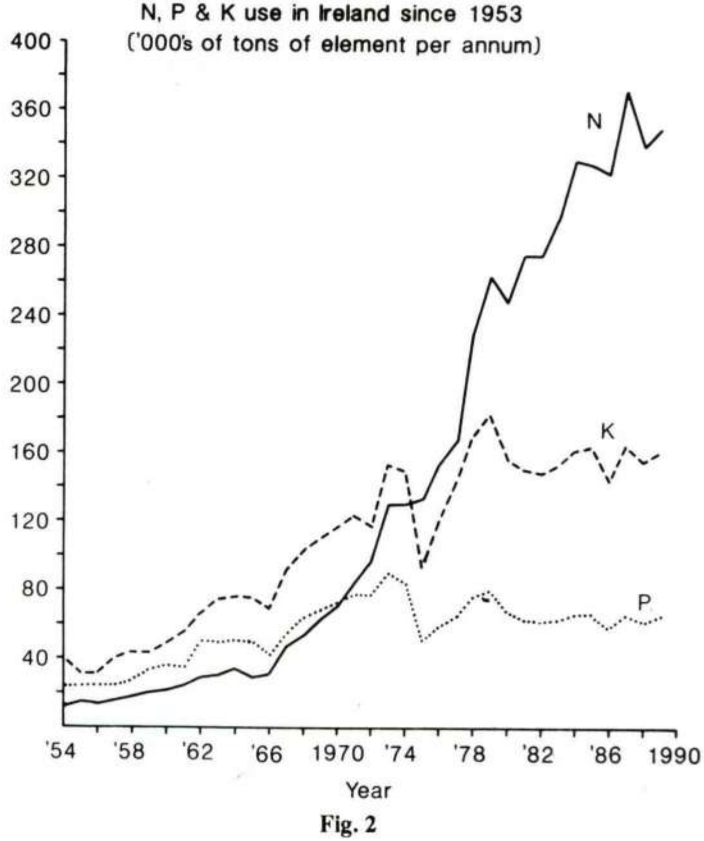

Fig. 2

Table 3
Phosphorus levels in Irish soils for grazing and silages

	% of soil in each soil test category				
	0-3	4-6	7-10	10+	Mean
Grazing	29	29	19	23	8.1
1st Cut Silage	20	30	23	27	8.7

When P levels are very high there is a danger of removal by some P to waterways, rivers and lakes with the consequent risk of eutrophication. Information on the actual level of P in various soils at which P is lost to the environment is not available. Table 3 shows that P levels can be high in the top few cm, and yet very low at 12 cm. This suggests that soil erosion could tend to lead to run-off of P. This is further illustrated by Table 4. In terms of balance of nutrients P supply to plants can be adversely affected at high pH by excess calcium in the soil at low pH by the presence of Fe and AI.

Table 4
Distribution of extractable P (using Morgan's extractant), with depth, in soils which received different fertiliser and slurry treatments

Depth (cm)	Soil extractable P (mg/PI) using Morgan's extractant		
Grazed grassland (W .E. Murphy, unpublished data)			
	P_0*	P_{15}*	P_{30}*
0-2	4.6	13.1	27.8
2-4	3.5	8.2	18.4
4-8	3.1	6.8	15.1
8-12	2.8	5.6	12.6
12-16	2.2	3.7	7.6
16-20	1.4	2.6	4.0
Cut grassland (M. Sherw: od, unpublished data)			
	P_0**	P_{300}**	P_{900}**
0-1.25	11	30	67
1.25-2.5	13	20	52
2.5-5.0	9	13	43
5-10	6	9	22
10-15	5	5	11

* P_0, P_{15}, P_{30} are treatments where grazed grassland received 0, 15 and 30 kg fertiliser P/ha/year for twenty years prior to sampling.

** P_0, P_{300} and P_{900} are treatments receiving a total of ca 0, 300 and 900 kg P/ha respectively in 7 split applications of pig slurry over a 30 month period prior to sampling.

Potassium

Potasssium (K) levels in grassland under grazing have tended to be satisfactory over large areas of the country. Table 5 shows that the 56% of country is

Table 5

Potassium levels (ppm) in grazing and 1st cut silage

	% of Soil in each Soil Test Category					
	0-50	51-75	76-100	101-150	150+	Mean
Grazing	7	12	15	30	36	124
1st Cut Silage	13	23	20	26	18	102

satisfactory. Under continuous cutting of hay or silage K levels have fluctuated considerably as fertiliser and organic manure application varied. This was due to the large removals of K in the crops especially silage where high yields and high levels of K in the dry matter were common. At present over 50% of soil samples show low K levels (Table 5).

Farmers have been applying K for many years and Fig. 2 shows that the soil fertility levels are still rising despite the fact that K consumption has levelled out since the mid 1970's. This reflects what has happened throughout Europe (Kochl, 1984). As in the case of P, this suggests that farmers are probably using the slurry on the farm more effectively than was the case in the past. In times when the price cost squeeze is very intense, the potential savings in both P and K can be significant if soil indices are high. Table 6 shows that at soil index 4 there is no need to apply P and K grazing situations.

High soil K levels and application of high rates of K and N have been shown to reduce the level of Mg uptake in the spring and thus increase the risk of grass tetany in cattle. The splitting of the linkage between P and K fertilisers by the introduction of the N-P and N-K of fertiliser go some way towards rectifying the dilemma of spring applications of P-K.

Magnesium and lime

Magnesium levels in herbage vary throughout the growing season. It is low in spring and increases in mid season (Fleming & Murphy, 1986). The removal of Mg by silage is of the order of 25 kg/ha ; this quantity is easily supplied by dolomitic limestone (10-12% Mg) on this basis. One tonne would supply total requirements for 4 years.

Calcium levels in Irish soils are usually high enough to support plant growth. Ground limestone is used as a soil conditioner to adjust the pH of the soil and thus to reduce the availability of iron and aluminium. In high pH soil there is free lime

Table 6

Soil index

Index	Response	P	K
1	Definite Response	0-3	0-50
2	Moderate Response	4-6	50-100
3	Maintenance Requirement	7-10	101-150
4	No P or K Requirement	10+	150+

Table 7

The national figures for the lime requirement status of the country

	% Soils in each soil test category				
XSL	0-4	5-10	11-15	15+	Mean (t/ha)
15	39	31	11	4	5.2

the excess calcium has the effect of reducing the availability of phosphorus. Water soluble phosphates are rapidly converted to insoluble calcium phosphates which are not available to plants.

The application of calcium carbonate increases the availability of molybdenum to plants, especially legumes. Where molybdenum is plentiful in the soil a balance must be struck between the beneficial effects of reduced soil acidity and the detrimental effect of increased Mo uptake by plants. At present the policy in such cases is to restrict the pH to a maximum of 6.3. The national usage of lime has declined significantly in recent years and it is quite clear that it is false economics in that the lack of lime can lead to the inefficient use of other fertilisers, especially P.

Nitrogen

The sources of nitrogen for intensive grassland are fertiliser, nitrogen fixation of atmospheric nitrogen and supplementary feeds. The losses from the system are leaching, slurry application to other crops, volatization, dentrification and animal products (Sherwood, 1991).

The amount of nitrogen removed in animal products is about 70 kg per ha under high stocking rate milk production and 70 kg per ha under beef production. The inputs of nitrogen of highly stocked dairy farms are frequently 400 kg N per ha from fertiliser plus 60 kg per ha from meal feeding and imported fodder crops. The amount supplied by clover is virtually nil when high rates of N are used on the swards but can be over 150 kg N per ha in the absence of applied N. Some small amounts are obtained from the atmospheric precipitation leaving almost 400 kg N per ha to be accounted for in accumulation in soil organic matter, leaching losses, dentrification and volatilisation losses and transfer to other crop systems as slurry. There is only a limited possibility of maintaining a balance of nitrogen from year to year to meet the requirement for intensive production in the system as transformations of N in the soil tend to produce nitrate, which is leached below the rooting zone in the winter. However, there is some build-up of available nitrogen over the first 4 years of high nitrogen treatment. In a study of response to N in a number of grazing trials in Ireland, Ryan *et al*, 1984 showed that the response to 200 kg N ha^{-1} at low clover contents decreased from a range of 30 to 45% in the first year to 23 to 33% in the second year. Volatilisation of ammonia can be very high when N is applied as slurry or urea and runoff from the surface after spreading can also account for a large proportion of slurries and mineral fertilisers. The environmental implications of the loss of N from the system is a major cause of concern in all countries where intensive agriculture

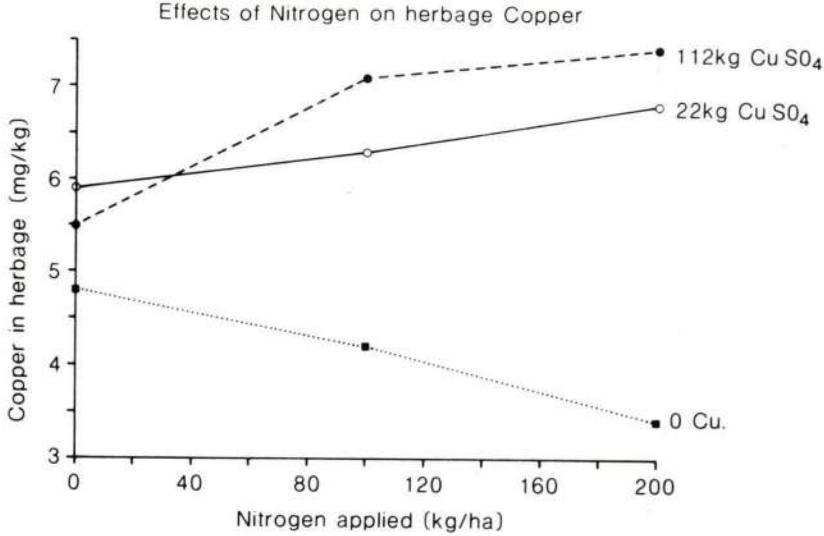

Fig. 3

is practised. Sherwood and Fanning (1981) showed that rate of runoff depends, on rainfall immediately after application, the moisture content of the soil, the permeability of the soil and weather conditions at the time of spreading. The losses can be over 30% of the nutrients applied. When nitrogen is applied to herbage on copper deficient soils the increased growth has the effect of diluting the copper in the herbage. However, when nitrogen is applied to soil with a plentiful supply of Cu, the Cu concentration in the herbage is increased over the Cu concentration in the herbage not receiving nitrogen (Fleming, 1977) (Fig. 3). This effect of nitrogen can also be observed for other elements e.g. Mg, Se and S.

Sulphur

Sulphur is an important element in grassland systems. The sources of sulphur are atmospheric deposition and fertilisers plus small quantities in imported feeds. Losses of sulphur from the system are caused mainly by leaching and transfer to other crops via slurry. The quantities in animal products are very small. In recent years there has been a tendency to change the systems of manufacturing fertiliser so as to exclude sulphur from compounds and also to permit blending rather than compounding of fertilisers. This reduces the amounts of S available to crops and grassland. This tendency has advanced further in Ireland than in any other European countries.

As the level of emission of sulphur dioxide from fuel combustion is low in Ireland responses to sulphur have been found over wide areas (Murphy (1963). The responses were found on light textured soils where the possibility of leaching was greatest. The results of one experiment in Co. Kilkenny is shown in Table 9.

Table 8
(N+P+K)/S ratio of fertiliser in some European countries 1990

Country	N/S ratio
Ireland	30
France	12
U.K.	8
Italy	3
Spain	2

Table 9
Effect of sulphur application (50 kg/ha) on DM yield (kg/ha)

Date of harvest response	0	50	Per cent
April	3640	3917	8
June	2296	2546	11
August	1589	2735	72
October	2050	4370	113
Total	9575	13568	42

It may be expected that the requirement for added S will increase as fertiliser technology changes and sulphur dioxide emissions are controlled.

Copper problems

Simple copper deficiency only account for a small proportion of copper problems in grassland. The vast majority of problems are concerned with nutrient balances.

The presence of levels of molybdenum in grazed plants higher than 3 ppm may cause an interference in the ability of animals to utilize copper even when it is present in the plant at maximum uptake levels. It has been found, Walsh *et al* (1951) that the application of sulphur reduces the uptake of Mo by the plant. However, it has also been found (Suttle, 1978) that the presence of high levels of dietary sulphur enhances the ability of the molybdenum to interfere with the utilization of Cu by the animal. It is also well known that high soil pH increases the availability of soil molybdenum. All these circumstances are present in several intensive grassland areas in northwestern Europe. They are a cause for concern and indicate a need for extreme care and vigilance in farm and advisory practice in problem areas. Where molybdenum is high and pH low, a compromise must be reached between the best practice for herbage yield and the best practice for maintaining a satisfactory trace element balance.

Cobalt and manganese

Cobalt deficiency in sheep is well known and has traditionally been associated with granitic hill soils. More recently the importance of high soil manganese in interfering with the uptake of cobalt has been established (Adams *et al*, 1969;

Fleming, 1977). The situation occurs in many intensive grassland areas and may well affect bovine as well as ovine animals. In these situations application of cobalt to the soil is of little value and cobalt supply must be maintained by treating the animals.

Conclusions

It is essential for intensive production to maintain a balance of nutrients in the grassland swards that not only allows maximum growth of herbage but also provides correct levels of optimum animal health and production. In intensive grassland there are problems of deficiency and excesses of nutrients. The deficiencies can usually be corrected by using fertiliser and by improved management of the nutrient cycles. Some of the problems of excess such as excess molybdenum are associated with particular soil types and may require particular skill in managing the situation to even achieve suboptimal levels of productivity. In other cases a long term build up of major nutrients such as phosphorus and potassium may be due to feeding large amounts of imported feeds and the spreading of pig slurry on land that is either in grassland or part of a grassland/tillage rotation. In the long term, soil fertility conservation and protection of the environment considerations may force farmers to rely more completely on grassland for animal production. The apparent productivity of intensive grassland is frequently due to large quantities of imported feedstuffs which lead to excessive build up of nutrients causing imbalances and danger to the environment.

On the other hand intensive production from grassland and proper nutrient balance can be maintained by the rational use of fertilisers and limited imported feed inputs.

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Scope for Reducing the Costs of Milk Production

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Irish Farmers' Journal

Dairy farmers' incomes are likely to be reduced in coming years due to falling milk and calf prices, and possible further quota reductions. Also, incomes from alternative enterprises relative to dairying are poor. The outcome of the GATT negotiations may cause further erosion in the coming years and in this situation dairy farmers must consider all aspects of technical efficiency and cut costs of production.

In pre-quota days it almost always made good financial sense to lift milk production by increasing stocking rate (i.e. carry more cows) and lifting milk yield per cow. The emphasis was on expanding production at a given level of efficiency, rather than improving efficiency at a given level of production. The objective now on dairy farms is to maximise the profit margin per litre of quota. If the quota could be produced on an all grass silage based system it would significantly reduce the costs of milk production (Table 1).

The results of a survey (Dairymis II) on the cost of producing a litre of milk are shown in Table 2. The average cost of producing a litre of milk was 11.4p/litre. The average cost of the top 25% was 8.8p/litre, and the lower 25% was 14.7p/litre. It is obvious that there is a large variation between the farms surveyed. The large costs (concentrates, fertilisers, hired labour, machinery and contractor charges) were 4.4p/litre on the least efficient farms compared to the most efficient ones. Table 3 shows the costs of producing a litre of milk for different quota sizes (Dairymis II and Irish Farmers' Journal Survey). This indicates that there is very little difference in the efficiency of milk production with different quota sizes. In this article, a number of options are outlined for reducing costs of milk production where milk price is falling and quota dininishing.

1. Fertiliser and grassland management

The Dairymis II Survey showed that the average cost of fertiliser was 1.5p/

Table 1
The relative costs of grass and concentrate

	£/tonne DM	£/tonne DDM	Relative
Grass	30	40	100
Silage	86	122	305
Concentrate	150	202	505

Table 2
Costs per litre of quota (p/litre)

	Average	Low Cost Producer	High Cost Producer
Concentrates	2.8	2.2	3.2
Fertiliser	1.5	1.6	1.8
Hired labour	1.1	0.2	1.9
Machinery hire and silage	0.9	0.8	1.1
Med. & Vet.	0.5	0.4	0.7
A.I. & Bulls	0.3	0.3	0.4
Machinery costs	1.8	1.3	2.5
Milk replacer	0.2	0.2	0.3
A/C's & Lease	1.0	0.9	1.1
Farm maintenance	0.4	0.3	0.6
Parlour sundries	0.2	0.1	0.2
E.S.B.	0.3	0.3	0.4
Miscellaneous	0.3	0.2	0.6
Total	11.4	8.8	14.8

Table 3
Costs per litre for different quota sizes

	Average	Low Costs	High Costs
<136,000	13.6	10.5	17.5
136 - 273,000	12.7	10.9	14.8
>455,000	13.5	10.1	17.7

litre where stocking rates of 3.1-2.8 cows/ha were recorded. Given that 0.5-0.7 of this is associated with P, K and lime, around 0.9 would be accounted for by nitrogen. Moorepark experiments have shown that a depression of less than 182 litres/cow results from reducing total nitrogen from 390 to 270 kg/ha at high stocking rate (3.1 cows/ha) (MacCarthy, 1984). The potential saving is therefore around 0.2p/litre. Savings of up to 0.2p/litre can be made where urea is used instead of CAN for first cut silage and on grazing ground up to late May. However, where stocking rates are lower (2.1-1.7 cows/ha) much lower levels of nitrogen or systems based white clover could be used.

These savings are small when compared to the saving that can be achieved by reducing the input of concentrate and correctly managing pastures. Correct grazing management is probably the most undervalued operation on dairy farms where cost reduction is concerned. Management procedures which will increase the potential production at pasture will by default reduce the feed cost. Recent research at Moorepark has highlighted the potential of high quality pasture to sustain high levels of milk production (Stakelum and Dillon 1988).

This series of experiments have shown that the quality of grass is just as important as the quantity. Tight grazing in spring (April-June) to a surface height

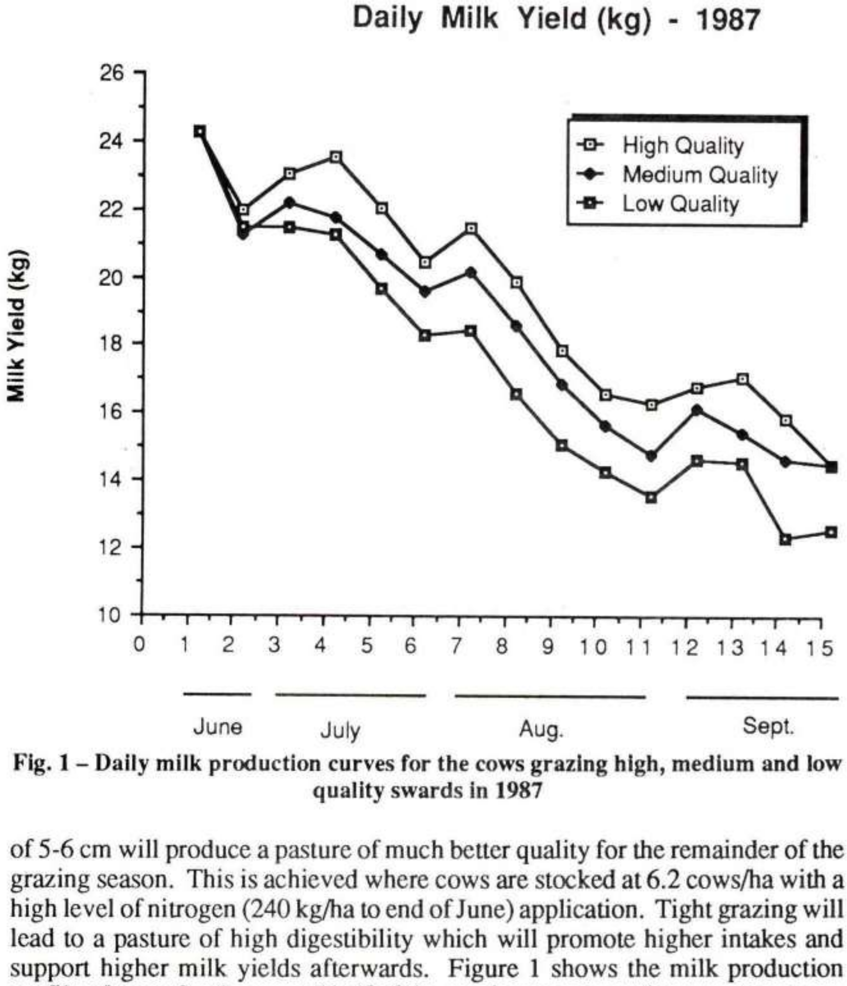

Fig. 1 – Daily milk production curves for the cows grazing high, medium and low quality swards in 1987

of 5-6 cm will produce a pasture of much better quality for the remainder of the grazing season. This is achieved where cows are stocked at 6.2 cows/ha with a high level of nitrogen (240 kg/ha to end of June) application. Tight grazing will lead to a pasture of high digestibility which will promote higher intakes and support higher milk yields afterwards. Figure 1 shows the milk production profile of cows for the second half of the grazing season on three pasture types. The high quality pasture supported average daily yields of 19.1 litre/cow compared to 17.7 and 16.8 for the medium and low quality swards respectively. The high quality pastures were the result of grazing to 6 cm while the low quality pastures were the result of grazing to 10 cm in the April-June period.

The other important benefit to dairying from using correct grazing strategies at that time is the effect on the amount of silage conserved on the farm. Increasing the early season stocking rate from 4.9 to 6.2 cows/ha will result in approximately 1 tonne extra of silage conserved/cow. The significance of this should not be underestimated as it highlights a relatively low-cost method of increasing the quantity of silage conserved on the farm without resorting to high cost methods of reseeding or increased inputs of fertilizer. Additionally, first cut silage is far cheaper than later cuts (see later section).

The loss in milk production by using high stocking rates (6.2 cows/ha) in the April-June period is likely to be small. The difference in milk production between 6.2 and 4.9 cows/ha in the April-June period was 4-5% in 1989 and 1990.

2. Silage costs

Table 4 shows the cost of producing first, second and third cut silage. The source of nitrogen for first and third cut silage is urea and for second cut is CAN. Contractor charges for first, second and third cuts were £124, £99 and £74/ha, respectively. A fixed charge for land of £124, £99 and £74/ha was associated with first to third cut silage, respectively. The silage additive used was sulphuric acid. First cut silage costs/hectare are 20% and 48% higher than the second and third cuts, respectively. Table 5 shows the effect of cut and yield on the cost per tonne of silage: (a) including cost of land, and (b) excluding cost for land. The much higher yields of first cut silage gives a major advantage in costs/tonne of DM.

The first point to be made is that first cut silage at high yields (27 tonnes of settled silage/ha) is by far the cheapest silage. There is a progressive increase in silage costs as you go to second and third cuts. Increasing yields of silage for each cut has a dramatic effect on costs/tonne. Third cut silage at low yields is extremely expensive and is almost equivalent to purchased concentrate feed. Where medium yields are got with third cuts, the silage is comparable in costs to the lower cost byproduct feeds. Where the opportunity cost of land is not

Table 4
Silage Conservation costs per hectare

	First Cut	Second Cut	Third Cut
Fertiliser – Nitrogen	44	47	42
– P & K	54	27	17
– Lime	5	5	2
Total Fertiliser Costs	104	79	62
Machinery Hire	124	111	99
Reseeding	17	17	17
Acid	17	15	10
Covering	17	10	10
Mach, Dep. & Rep.	15	12	10
Misc.	2	2	2
Working Capital	15	12	10
Sub Total	207	180	158
Fixed Charge for Land	124	99	74
Total costs	435	358	294

Table 5

Effect of cut and yield (tonnes/hectare) of settled silage on costs per tonne silage DM

(a) (including costs for land)

First Cut		Second Cut		Third Cut	
Yield	£/tonne	Yield	£/tonne	Yield	£/tonne
22	98	15	121	10	149
25	88	17	104	12	119
27	80	20	91	15	99

(a) (including costs for land)

First Cut		Second Cut		Third Cut	
Yield	£/tonne	Yield	£/tonne	Yield	£/tonne
22	70	15	88	10	112
25	63	17	76	12	89
27	57	20	66	15	74

included the costs/tonne of DM is in the range of £140-£173/ha for first silage over the range of silage yields listed. This fixed charge for land may not be as important in the future if the returns from alternative enterprises to dairying disimprove.

3. Machinery costs

The survey on cost per gallon showed that machinery and contractor charges were 2.7p/litre. Table 6 shows that these potential costs on a dairy farm where silage and slurry spreading is contracted out, could be reduced to 1.5p/litre. On most dairy farms the only other equipment needed is a fertiliser spreader, roller and maybe a topper.

Where a good contractor service is available, machinery ownership for silage harvesting is only viable where more than 40 ha are cut on an annual basis (Forristal, 1988). This is based on a double-chop harvesting system and where tractors are available on the farm. Where only one tractor is available and others have to be purchased then the minimum requirement goes up to more than 65 ha annually. For most dairy farmers, the best advice is to rely on a good contracting

Table 6

Machinery cost

Survey :	Machinery + Contractors Charges	2.7p/litre
Silage costs	— 0.8p/litre	
Slurry	— 0.1p/litre	
Tractor (70 HP)	— 0.6p/litre	
Total Cost	— 1.5p/litre	

service. With the advent of easy-feed silage and the feeding of concentrates as straights there is a proliferation and elaboration of expensive apparatus and machinery on dairy farms. This may have some role to play in offsetting tax liability but in an era of falling prices the tax bill will also fall but the machinery costs will be still there. The best advice is to have as little machinery on the farm as possible.

4. Concentrate feeding

There are a number of options available to dairy farmers whereby the cost and quantity of concentrates could be reduced. These will be considered under three main headings

A. *Reduce the level of feeding indoors*

The optimum level of concentrates to feed this winter was 7 kg/cow/day (Murphy and Fitzgerald, 1990). This is based on concentrates costing £140-160/tonne, at a milk price of 18p/litre where good quality silage is available. Reduced concentrate feeding from 7 to 5 kg will both reduce milk yield in the indoor period (77 litres) and subsequently during total lactation (164 litres) with a spring calving dairy cow. Where a farmer is in excess of quota reduced feeding levels are only possible where silage quality is excellent and a generous supply is available.

The results from our Moorepark experiments suggest caution is required in regard to the feeding of low levels of high protein concentrates. Further experiments are continuing on this subject.

B. *Feeding straights*

There is a possible saving of £20-£30/tonne with feeding straights rather than a pelleted compound ration. While undoubtedly savings can be made using straights, a number of problems arise at farm level. Firstly, there is the problem of achieving the correct balance of minerals and vitamins in the ration. Secondly, the costs involved, including machinery and storage facilities can be high on certain farms. For dairy farmers with simple feeding systems there would be a high cost involved in feeding straights as well as a high labour requirement at a busy time of the year.

C. *Eliminate concentrate feeding at pasture*

The average input of concentrate to an early calving herd is 750-800 kg/cow. This suggests that around 150-200 kg of concentrate is fed during the grazing season. The average milk production response from a large number of experiments at Moorepark where concentrates fed at pasture was 0.5 litres of milk/kg of concentrate fed (Stakelum and Dillon, 1988). If milk prices are 19p/litre in 1991, then concentrate would have to cost less than £92/tonne in order to get an economic response. Thus a response of 0.8 litres of milk/litre of concentrates fed would be required to achieve a breakeven situation. A response of that magnitude is extremely unlikely under the conditions at which most dairy farmers would consider supplementation with concentrates necessary. Molassed beet pulp nuts and wet brewers grains gave this response at Moorepark during the difficult grass growing period of 1989 when compared to a cereal based ration (Dillon and Stakelum, 1989).

5. Systems of milk production

At Moorepark in 1989 a three year project was set up in Curtins farm to compare the economic efficiency of different systems of milk production. The standard Moorepark system of high stocking rate and early compact calving (M.C.D. 23rd Jan.) was compared to two late calving herds (M.C.D. 15th March) based on silage and grass only. Extending the lactation of the late calving herd by supplementation with extra silage was also examined. The first year's results are now completed, but a further two years have yet to be completed before definite results can be given.

The Herds

Three herds were established as outlined in Table 7. The standard Moorepark system (A) of high stocking rate and early compact calving was compared to two late calving herds (B and C). In the first late calving herd, the overall stocking rate was the same as for herd (A) but with much reduced concentrate input (125 kg per cow). In the second late calving herd (C) the stocking rate was reduced resulting in 8.75 tonnes of silage/cow being conserved compared to 6.75 tonnes. The stocking rate in the grazing area was the same for the three herds in the April-June period.

Table 7
Experimental herds

Herd A		
	Mean calving date	23rd January
	Stocking rate (ha/cow)	0.34
	Silage conserved (tonne/cow)	6.75
Herd B		
	Mean calving date	15th March
	Stocking rate (ha/cow)	0.34
	Silage conserved (tonne/cow)	6.75
Herd C		
	Mean calving date	15th March
	Stocking rate (ha/cow)	0.38
	Silage conserved (tonne/cow)	8.75

Grazing Management

Calved cows were moved to grass by day on the 12th March and were out day and night on the 23rd March. Herd C were supplemented with silage for 2-3 hours per day from the 25th September to 16th October. From 16th October to 1st December they were supplemented with silage by night. Herds A and B were supplemented with silage by night from 10th November to 1st December. All cows were housed both night and day from the 1st December. The silage cutting dates, yields and analyses are outlined in Table 8. Total nitrogen input was 390 kg/ha.

Performance

The milk yield, composition, lactation length and concentrate inputs for the three

Table 8
Silage yields, culling dates and analysis

	DM	pH	DMD	Yield Silage/ Hectare	Cutting Date
1st Cut	25	4	74	27	23rd May
2nd Cut	24	4	71	20	18th July

Table 9
Production data for the herd

	A	B	C
Litres/cow	5614	5114	5546
% Fat	3.52	3.69	3.83
% Protein	3.20	3.33	3.37
Lactation length (days)	313	300	313
Concentrate (kg/cow)	625	125	85

herds are outlined in Table 9. The milk yields for Herds A and C were significantly higher than that for herd B. Milk protein and fat contents were significantly higher for the two late (B and C) calving herds. Concentrate inputs differed significantly between the herds due to calving date. Lactation length for herd B was 10 days shorter than for Groups A and C. The proportion of milk produced at periods during the year are presented in Table 10. Supplementing Herd C in the autumn resulted in prolonging their lactation and contributed substantially to milk putput in the October-December period (20%). In an associated study by B. O'Brien (Moorepark) the F.F.A. levels (free fatty acid) in the milk for the three herds in the October to December period were measured (Fig. 2). Bulk milk with F.F.A. levels greater than 1.3 (m.moles per 100 g of fat) are deemed usuitable for the manufacture of our range of short-life products and cheeses. The F.F.A. analysis of the milk shows that the milk from the C herd is of good quality in the October-December period. The milk of the other two herds was of lower quality.

Financial Implications

Detailed costings of the three herds for 1990 were prepared based on the coefficients as outlined in Table 11. The milk production and composition

Table 10
Milk profiles (%) for the three herds

	A	B	C
January - March	29	8	10
April - September	62	76	70
October - December	9	16	20

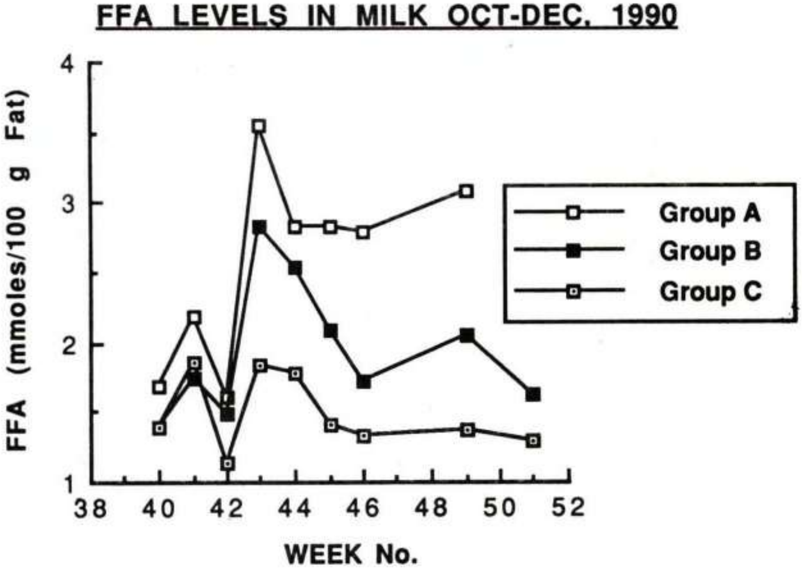

Fig. 2 – Free fatty acids (FFA) levels in the milk (Oct.-Dec.) of the cows in the three herds.

Table 11
Coefficients used for 1990 costings

Calf price – Male (£)	150
– Female (£)	250
Cull cow (£)	350
Replacement heifer (£)	900
Milk price (p/litre)	20
Beef at years (£)	650
Beef stocking rate (LU/hectare)*	2.47
Concentrate to beef (kg/LU)	670
Whole milk fed to calves (litres)	227
Concentrate cost to cows (£/tonne)	150

*Stocking rate on surplus acres

patterns achieved in the different herds influenced the costings. The costings were done with a quota restriction of 360,000 litres (Curtins Farm Quota) with 2 year old beef being used as the alternative enterprise. For Herd A to fill Quota, 67 cows would be required. The extra land would support 6.5 units of beef. Herd B would require 73 cows and the extra land would support 1.6 units of beef. Herd C would fill the Quota (Table 12). Each of the herds were costed on a total farm operation. The variable, fixed, depreciation and total costs per litre of quota are presented in Table 13. The fixed costs include a modernisation and pollution

Table 12
Outline of option within quota situation

	A	B	C
Acres	25.9	25.9	25.9
Cows	67	73	67
Beef	6.5	1.6	-
Stocking rate (cows/ha)	2.94	2.94	2.63
Quota (litres)	360,000	360,000	360,000

Table 13
Variable, fixed and depreciation costs (p/litre of quota) for the three herds

	A	B	C
Variable costs			
Concentrates	2.0	0.5	0.3
Fertiliser and lime	1.6	1.6	1.6
Replacement	3.3	3.7	3.3
Machinery and silage	1.0	1.0	1.1
Vet., Med. and A.I.	0.7	0.8	0.7
Total variable costs	8.7	7.6	7.1
Fixed costs	3.9	3.9	3.9
Depreciation	1.1	1.1	1.1
Total costs	13.7	12.6	12.1

control investment which amounted to a yearly repayment of 2.2p/litre. The costs exclude labour and income tax liabilities. Concentrate costs were much lower for the two late calving herds. Replacement costs were higher for herd C due to the higher cow numbers. Machinery hire and silage costs were higher for Herd C due to the larger quantity of silage harvested. Total costs were highest for Herd A and lowest for Herd C.

Receipts and Profit

The receipts minus variable, fixed and depreciation costs are shown in Table 14. Interest earned on cash flow was also included to calculate the net profit per

Table 14
Financial costs and returns (p/litre) for the three herds 1990

	A	B	C
Milk sales	19.7	20.6	21.3
Livestock sales	5.5	5.3	4.7
Interest earned	0.8	0.5	0.6
Total receipts	26.1	26.5	26.6
Net profit	12.3	13.9	14.5
Net profit (similar milk comp.)	12.3	13.0	12.9

litre. The new profit per litre is also shown if there was no composition difference between the herds. The price per litre was much higher for the two late calving herds, reflecting their higher composition. The livestock sales were highest for Herd A and lowest for Herd C. Interest earned was higher for Herd A reflecting the better cash flow. The net profit per litre of quota was much higher for the two late calving herds compared to Herd A. There was 1.5p/litre advantage to Herd B and almost 2.2p/litre to Herd C. If the milk composition difference was removed, there was still an advantage of 0.7p/litre to each of the two late calving herds. The new profit per litre was also calculated for 1991 where calves, milk and concentrate prices were reduced. However, relative profit difference per litre of quota remains the same as for 1990.

The results from the first year of this experiment would indicate the following:-

1. The first priority of a dairy farmer is to maximise his profit with the dairy enterprise (i.e. milk, calves and cull cows) rather than considering on an alternative enterprise.
2. In this experiment (year one) later calving increased the net profit per litre of quota by at least 0.7p and if the composition differences were taken into account there was a difference of 1.5-2.2p/litre.
3. A large proportion of the advantage to later calving was associated with better milk composition. This has not been shown previously. More information is required to draw definite conclusions.
4. The two essential management factors for later calving is a compact calving pattern and good grassland management.
5. The high level of milk production achieved from grass and silage (5546 litres/cow) indicates the potential for cost saving. The importance of research to explore further methods of optimizing production and utilization of grass is vital to maintaining our competitive edge.

Summary

For dairy farmers to maintain incomes in the future they should have a serious look at cutting cost and eliminating any waste which is under their control. Every 0.2p/litre saved will result in £500 increase in income for a 227,305 litre quota. In this article we have looked only at where savings can be made in the big cost items. There is scope for reducing cost in many of the smaller items, e.g. concentrates for replacement heifers, acid, medicines, veterinary costs, lease and insurance charges.

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An Optimistic Look at Sheep Production in the 90's

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Whilst I firmly believe the prospects for sheep production look promising for the mid-1990's it would not be fair to ignore the fact that the sheep industry is in the middle of a difficult period. A number of factors have contributed to poor lamb prices. There are a lot of political uncertainties that seem likely to continue for another 18 months or so before a more settled situation evolves.

Firstly let us examine the current position. The hill breeds are still the most numerus individual breeds and from them come the halfbred females that make up over 40% of the national sheep flock. This is typified by the North Country Mule which forms about 23% of the U.K. flock.

Table 1
Ewe numbers in the U.K.

1980	1990	1991
14.9m	20.5m	20.4m
Av. flock size		231 ewes
% in LFA		61.5%

Table 1 indicates just how much the U.K. flock has increased during the 1980's. The U.K. flock reached its peak in 1990 and has started to decline a little. Certainly a lot of ewe lambs were slaughtered in the 1990/91 winter. During this period the extra production in the U.K. has been absorbed by reduced New Zealand supplies and by increased exports especially to France.

Table 2
U.K. exports of sheep carcases ('000 tonnes)

1975	1980	1985	1989	1990
36.9	36.9	48.7	89.2	79.7

Table 3
U.K. exports of live lambs ('000)

1985	1987	1989	1990
81.4	370.3	589.5	584.3

Tables 2 and 3 show just how important the export trade has become to the industry.

Table 4

Seasonal lamb slaughteriing in the UK.

	1980s	1990	1991 estimated
Jan.-Mar	21%	22.2%	23.8%
Apr.-June	16%	20.6%	18.1%
Jul.-Sep.	31%	29.2%	28.7%
Oct.-Dec.	32%	27.9%	29.4%

Table 4 shows the pattern of lamb sales has changed a bit over the last 10 years. One of the aims of the Variable Premium system was to encourage more lamb sales in the first half of the year and it was partially successful in this. The market itself has also changed as shown in Table 5.

Table 5

Lamb outlets in the U.K.

Butchers	33%
Supermarkets	26.8%
Export	23%
Catering	9%
Co-ops/Grocers	6.1%
Freezer Centres	2.1%

There has been a marked growth in the sales of lamb through the supermarket and a decline in sales through private butchers. This has concentrated purchasing power in the hands of very few buyers and is a factor that no-one can ignore.

After a profitable and expanding period through the 80s, the last two seasons have proved particularly difficult. The main problems are:-

1. Irish competition – strength of £
2. Recession
3. Eastern Europe
4. Depressed value of wool, hides and offal
5. MacSharry and GATT proposals

Some of the problems are very complex and affect all exporting industries and not just sheep. One of the main talking points is to try and assess just what impact the various proposals put forward by MacSharry or the GATT negotiators will have.

Table 6

Possible effects on ewe margins – 1992 lowland

	V. Early	Feb. born	March born
V. Premium	–£12.6	–21.12	–£20.7
Ann. Ewe Premium	+ £1.3	+ £1.3	+ £1.3
Market prices	+ £2.36	+£15.76	+ £7.11
GATT effects	0	0	0
	–£8.94/ewe	–£4.06/ewe	–£12.29/ewe

900 ewe flock. Worst scenario MacSharry and GATT

Table 7
Possible effects on ewe margins – mid-90s lowland

	V. Early	Feb. born	March born
V. Premium	–£12.6	–21.12	–£20.7
Ann. Ewe Premium	+ £2.3	+ £2.3	+ £2.3
Market prices	+ £11.0	+£24.09	+ £20.05
GATT	–£2.3	–£2.3	–£2.3
	–£6.2	–£1.63	–£5.25

900 ewe flock. Worst scenario MacSharry and GATT

I have tried to take into account all the factors in arriving at the estimates in Tables 6 and 7. In the first place none of the proposals have been agreed. The final European scene may well be very different after all the negotiations have taken place. Secondly, I have only allowed a fairly modest price rise to take place after the removal of the Variable Premium. It is on this point that I feel that there is room for optimism. There are a number of factors that are very much in favour of the U.K. and I feel that eventually the price rises will be greater than those I have used in the calculations for Tables 6 and 7.

Table 8
U.K. lamb – the image

Most systems	
	97 to 75% of diet is GRASS fresh or conserved
	3 to 5% of diet is concentrates

Firstly, the fact that our sheep systems are firmly based on grassland gives us two positive points. Firstly, it is a valuable marketing point. Secondly, it means we can produce meat much more cheaply (apart from the Irish) than all of our European neighbours who rely much more heavily on compounds. The U.K. scene with its reliance on halfbred ewes and terminal sires can produce a rather better quality product. It is not a factor we can be complacent about. There is still much scope for further improvement in carcase quality. However, once the Variable Premium disappears I feel that our exports will become much more attractive. Once all of Europe has its calculation for the Annual Ewe Premium undertaken on the same basis, the competitive advantage by the Irish may disappear. There are clear signs already that the expansion of the Irish flock is slowing and in a year or so may well have stopped altogether.

Another factor to be considered is the fact that after a long period of decline, consumption of lamb has increased a lot over the last 5 years as shown in Tables 9 and 10. Not only in the U.K. has this happened. The figures from France and the rest of Europe are just as encouraging.

Table 9
Lamb consumption in U.K.

1985		1990
6.3 kg/head		7.3 kg/head
	up to 15.9%	

Table 10
French sheep situation

Production falling 2%/year
Consumption increased 44% 1980-1990
Average flock size 60
In Europe overall lamb consumption up 13% in 5 years

Technical developments are likely to play a role. The use of straw feeding has been developed by ADAS as a result of much experimental work. In situations where a lot of money has to be spent on silage making this may offer a way forward. The use of forage roots or fodder beet in the right situation offers the potential for a very cheap but high quality material. The open topped shed at Rosemaund EHF has proved a very effective and cheap form of housing for finishing lambs. More effective and reliable feeding systems and better utilisation of grassland are two key areas that can save money.

I return then to my original strongly held feeling. There are difficulties at present but the medium and long term indications are all very positive for sheep. There are technical developments already in place and others just around the corner that offer scope for those concerned with good husbandry, to get the very best out of their flocks in both quality and level of production.

Cutting Costs in Spring Lambing Flocks

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The general thrust of the CAP reform proposals points to lower incomes through a combination of lower lamb prices and restrictions on ewe premium payments. A critical appraisal of current output and input levels on farms indicates that the most realistic response by sheep producers is to seek improvements in flock productivity and to pursue ways of reducing costs, particularly through better grass utilisation. As one of the three main producers of quality lamb in Europe, Ireland must develop further its main competitive advantages, i.e. lower costs and the ability to convert grass into lamb at the expense of the higher cost areas in the EC. This article summarises how incomes can be improved and how current costs in lamb production and the components of those costs can be reduced.

Output and input costs

Table 1 shows the gross income, variable costs and gross margin per ewe with 1.5 lambs sold at 1991 prices. The lamb price refers to a 18 kg carcass of export quality, while the ewe premium is estimated at £23, supplemented in Disadvantaged Areas by £3.50 plus headage. At a ewe replacement rate of 20%, culls sold at £8 and replacements purchased at £55, the average cost of replacement is £9 per ewe. Fertiliser inputs refer to dry land that is grazed at the rate of 12.5 ewes per ha. Silage production costs about £13 per tonne and is budgeted at the

Table 1
Gross margin per ewe (£)

1.5 lambs @ £34	51	
Wool	1	
Premium	23	
	——	75
Less replacement		9
		——
		66
Direct costs per ewe £		
1. Fertilisers for grazing 12.5 ewes/ha		
250 kg 0.10.20 @ £127/tonne	2.54	
90 kg N	3.14	
2. Silage 0.5 tonne @ £13/tonne	6.50	
3. Concentrates 25 kg	4.12	
4. Vet/medicine	3.60	
5. Other	5.00	
	——	25
GROSS MARGIN PER EWE = £41		

rate of 1/2 tonne per ewe for 3 months, early December to early March, supplemented with 25 kg meals per ewe in the final 6 weeks pre-lambing. Other costs include straw bedding, 5 bales per ewe @ 70p each, and shearing at £1.

The direct costs amount to £25 per ewe or nearly £17 per lamb and the gross margin per ewe is estimated at £41. It is seen that about half of the income from lamb sales at £34 per head is accounted for by direct costs, before fixed charges are taken into account.

Let us now examine the output and input levels and the components of the various costs, to see how income can be improved.

Extra lambs

By using ewes derived from the Belclare or Cambridge breeds lamb output per ewe can be raised from 1.5 to 1.7 lambs sold per ewe joined, thus increasing lamb sales to almost £58 per ewe at 1991 prices. Results by Dr. J. P. Hanrahan at Belclare show that there is about £3 gain in income per ewe in response to each 0.1 lamb extra that is reared.

Many sheep producers are reluctant to change their breed of ewe and the incentive to do so has been masked by EC financial supports. But when ewe premia are restricted, the objective of producing as many lambs as possible from the existing flock becomes ever more important. In a flock of 200 ewes, raising productivity from 1.3 to 1.5 lambs per ewe joined or from 1.5 to 1.7, increases income by £1,360, i.e. 40 extra lambs @ £34. No additional capital for extra land or extra ewes is required and the fertiliser, forage and feed inputs remain about the same.

Grass budgeting saves housing costs

Current research results indicate that savings in costs can be made under all headings in Table 1. Since fertilisers, feed and forage comprise 65% of direct costs, these will be discussed first. Possible savings are listed in Table 2.

If ewes can be winter grazed on pasture without affecting spring grass and if housing can be delayed until the last 5-6 weeks, in-lamb ewes would cost less to keep. These objectives can be achieved on all-grass farms that are stocked at 5 ewes per acre or less by grass feed budgeting.

A bank of grass is allowed to accumulate on the farm in autumn and is carried

Table 2
Cutting costs

		Savings
Winter grazing:	Less silage	£3.25/ewe
	Less straw	£1.75/ewe
	Less work: Indoor feeding period reduced to 5-6 weeks	
No concentrates post-lambing		£1.50-£2.50/ewe
Clover N		£3/ewe
P and K: Skip a year		£2.50/ewe
Strategic dosing		£40/100 lambs

forward, for winter grazing. Two years results at Blindwell have shown that when pasture that is mob stocked in August by weaned ewes is rested from mid-September without fertiliser N, grass supply in early December was 2150 kg DM per ha. For ewes of 62-68 kg liveweight and in good condition (body score 3), this grass supply provided enough feed for 37 ewes per ha for 6 weeks when strip grazed on a daily basis at the rate of 5.7 sq. metres per ewe per day from early December to late January. The flock was then housed. Grass budgeting can reduce silage and straw requirements for housed flocks by 50%, i.e. by £5 per ewe, and the amount of work is halved.

Use of back fence

By using a back fence in the process of strip grazing, to prevent access to the ground already grazed, poaching is prevented and the grazed grass is allowed to recover immediately in contrast to continuous grazing. Hence, grass supplies in spring are not reduced significantly.

No meals post-lambing

For spring lambing ewes housed on silage, the use of concentrates is restricted to 25 kg per ewe fed at an ascending rate over the last 6 weeks pre-lambing. In practice, however, concentrates are often fed on spring grass post-lambing costing £1.50 to £2.50 per ewe. There are no biological or economic responses to these supplements unless grass is very scarce, i.e. less than 4 cm sward height. Research in Scotland has shown that where sward height is 4 cm or over, the feeding of concentrates results in ewes substituting the concentrates for grass so that total feed consumption is unchanged and lamb growth rate is not increased.

For farms that are stocked at 12-15 ewes per ha the choice of lambing date to coincide with grass growth in spring is critical. Mid-March is the recommended date and at Teagasc sheep farms in Blindwell and Knockbeg sward height post-lambing is normally 4-5 cm so that no meals are required. February lambing is problematic in terms of grass supplies except on farms with low stocking rates, less than 9 ewes per ha.

Clover N

The use of white clover in sheep pastures as a substitute for fertiliser N is another way to cut costs, by exploiting the ability of clover to fix its own N. On all-grass swards it is necessary to apply 125 kg N or 185 kg N per ha to maintain 12 ewes or 15 ewes per ha costing £40 to £64 per ha respectively.

Perennial ryegrass/white clover pastures with a high content of clover were established at Knockbeg in 1985/86 and have been stocked at 15 ewes per ha annually for the past 5 years in a low fertiliser N input system. Botanical separations in July 1991 showed that clover contributed 40% of total pasture DM and lamb performance has been excellent with 11 lambs sold per acre. For grazing 15 ewes to the ha in this system the annual fertiliser N input is 79 kg per ha, a saving of 43 kg or £19 per acre compared with all-grass swards.

Where cereals are being undersown or where pastures are being renewed for sheep, a seeds mixture which favours clover development should be sown. Once established, clover can be manipulated by management for high output at low cost.

Soil analyses

Results at Johnstown Castle show that some farms have high soil readings for P and K. Depending on soil analyses, it may be possible to skip a year's application of P and K fertilisers for grazing sheep.

Cost of dosing

In the control of worm parasites, dosing must be combined with a grazing plan. The standard recommendations for March lambing flocks are to dose lambs at 5 weeks and at weaning. But the dose at weaning must be combined with a change to high quality pasture, e.g. silage or hay aftermaths, for satisfactory lamb growth rates. A third dose is given to lambs remaining unsold in late July.

Three doses cost about 60p per lamb or £60 per 100 lambs. Reports indicate that lambs on some farms are being dosed routinely at 3-weekly intervals, costing £1 or more per lamb. Research at Belclare has shown no response to routine dosing compared with strategic dosing and £40 per 100 lambs can be saved by linking grazing management principles with strategic dosing.

Fixed costs

To determine the farm income, fixed costs must be deducted from the gross margin per ewe shown in Table 1. Fixed costs vary widely between farms. Contrasting examples are provided by long established sheep farms on which fixed assets have been almost written off and those sheep farms developed by new entrants in the late 1980's on which depreciation charges on facilities and equipment remain relatively high. Fixed costs vary from £10 per ewe to £25 per ewe on these two farm categories respectively.

On some farms labour and repayments on borrowings are important costs which are not included here.

With the fall in sheep incomes, high fixed costs may present a difficulty for some sheep producers who developed intensively in recent years. Having established their sheep systems, farm structure and facilities, it is diffcult to cut back and maintain profit.

Conclusion

Looking ahead to post-CAP reform, ewes that are not eligible for premia are best retained in the case of farms that are highly stocked. Overhead costs can then be spread over as many ewes as possible.

Reform changes will not be fully applied until 1996, hence there is time to adjust. Improving productivity and cutting costs are the priorities.

Lamb consumption continues to increase, by 13% in the EC and by 16% in the U.K. since 1986. There is a chance for sheep numbers to expand further if market prices and profits are high enough; ewe numbers would increase to keep pace with this. There are no proposals to restrict the number of lambs that can be produced or on how heavily land can be stocked with sheep. EC sheep producers would be unable to respond to such possibilities if they were trapped in the same situation as dairy farmers.

Scope for Decreasing Feed Costs in Winter Beef Production

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In a time of decreasing profit from agriculture in general, attention must be directed to all factors influencing the profitability of any particular enterprise. In the case of winter beef production, animal feed represents a major cost and therefore a major determinant of profitability. For example, a 625 kg steer fed silage with dry matter digestibility (DMD) of 680 g/kg dry matter (DM) (12 £/tonne) and 4 kg barley (130 £/tonne) would grow at approximately 0.95 kg/day and cost approximately £146 in feed (of a total variable cost of £170) over a 140 day period (Anon, 1991). If this figure could be decreased without impairment of animal performance overall profitability would be increased. The objective of this paper is to demonstrate that there is scope for decreasing feed costs by paying closer attention to the formulation of rations for cattle to be slaughtered during/after the winter period.

The most logical approach to formulating cost-effective rations is to define the requirements of the animal for a particular level of performance and to match them with the cheapest available feedstuffs.

Nutrient requirements of finishing cattle

The major requirements of all living animals are a source of energy, protein (nitrogen), water, minerals and vitamins. Only energy and protein will be considered in this paper.

(a) *Energy*

Since energy yielding nutrients normally form the major portion of a diet and since animals tend to show a continuous response to changes in the quantities supplied, those nutrients supplying energy are usually given first consideration in designing rations. Energy systems have been developed which attempt to relate the energy value of feeds to the energy requirements of animals, using common units of expression. The energy term used in ruminant nutrition is metabolisable energy (ME) measured in megajoules and is the portion of the total energy of the feed that can be utilised by the animal. It is the total energy less the energy contained in the faeces, urine and gas produced in the rumen. Measurement of the absolute ME value of a feed therefore requires an analysis of the energy content of the urine, faeces and gases produced by an animal when fed this feedstuff. *In vivo* measurement of ME requires the use of large respiration chambers or calorimeters and is therefore costly and time consuming. This approach has however, been used in several locations in the UK and *in vivo* ME values for a range of feeds have been published (e.g., MAFF, 1986). ME can also be predicted from various laboratory analyses. However, it should be noted that as with all predictive equations, their use outside the limits of the data from which

Table 1
Daily ME allowance for growing and fattening cattle (MJ/day)

Liveweight (kg)	Ration M/D (MJ/kg DM)	Rate of gain (kg/day) 0	0.25	0.50	0.75	1.00	1.25	1.50
450	8	49	61	75				
	10	49	59	70	83			
	12	49	57	67	78	91	108	
	14	49	56	64	74	85	100	118
500	8	54	67	82				
	10	54	64	76	91			
	12	54	63	73	85	99	117	
	14	54	61	70	80	93	108	128
550	8	59	73	89				
	10	59	70	83	98			
	12	59	68	79	91	107	126	
	14	59	67	76	87	100	116	137
600	8	63	77	94				
	10	63	75	88	104			
	12	63	73	84	97	114	134	
	14	63	71	81	92	106	124	146

(From MAFF, 1984)

they were derived is likely to result in erroneous values. The energy requirements of an animal are the sum of the energy lost during fasting, the energy expended in muscular work, i.e., standing, lying, walking, etc., and the energy retained by the body as a result of growth and fattening. Based on a wide range of experimental findings, equations have been developed which describe the dietary ME needed to meet these different aspects of energy metabolism in the animal. Using these equations, tables have been published outlining the ME required by different classes of ruminants for different levels of performance (MAFF, 1984). The energy requirements for finishing cattle are shown in Table 1. It should be noted in Table 1 that the ME allowance for beef cattle for a partricular rate of gain varies according to the ME concentration of the ration. Thus, the ME of a poorer feed such as hay (MJ ME/kg DM=8) is used less efficiently for gain than barley (MJ ME/kg DM=13).

(b) *Protein*

Protein as a major nutrient for ruminants has traditionally been evaluated in terms of crude protein (CP) (nitrogen x 6.25) or digestible CP (DCP). However, the concept of DCP fails to cope adequately with the complexities of nitrogen metabolism in the ruminant. The protein system presently in use (ARC, 1989), 1984) recognises two types of protein, one which is degradable in the rumen and subsequently incorporated into microbial protein (rumen degradable protein - RDP) and a second termed by-pass protein which passes undegraded to the small intestine (undegraded dietary protein - UDP). The requirements for amino acids at tissue level which are not met from microbial protein must be supplied by

Table 2
Daily protein requirements (g/day) for growing and fattening (steers of breeds of medium mature size and heifers of breeds of large mature size)

Liveweight (kg)	Ration M/D (MJ/kg DM)	Form of Protein[1]	Rate of gain (kg/day) 0	0.25	0.50	0.75	1.00	1.25	1.50
400	7	RDP	360	440	540	675			
	9	RDP	340	405	485	590	720		
	11	RDP	325	380	450	530	630	750	910
	13	RDP	310	360	420	485	565	660	775
500	7	RDP	420	510	625	785			
	9	RDP	395	475	565	685	835		
	11	RDP	380	445	525	615	730	870	1005
	13	RDP	360	420	490	565	660	765	900
600	7	RDP	475	575	710	885			
	9	RDP	450	535	640	770	940		
	11	RDP	430	505	590	695	825	980	1190
	13	RDP	410	475	555	640	745	865	1015

(Adapted from ARC, 1989).

[1] RDP = Rumen degradable protein.

UDP. As for energy requirements, a series of equations have been developed and from these tables of the RDP and UDP requirements of different classes of ruminant have been published, an example of which is given in Table 2. A knowledge of the degradability of dietary proteins is essential to the system since this affects the value of the protein as a source of nitrogen for the rumen micro-organisms. This is usually done by measuring the rate of disappearance of proteins sealed in porous nylon bags and suspended in the rumen of a fistulated animal.

In general, the protein requirements of finishing cattle are low and can be provided by good quality silage (DMD 700 g/kg DM; 120-140 g protein/kg) supplemented with barley or its equivalent in protein. From Table 2 it can be seen that above 400 kg liveweight the protein requirements of a growing heifer or steer can be provided by RDP alone and that it has no requirement for UDP. The protein system (ARC 1980; 1984) recognises different types of animal (bulls, steers and heifers) and breeds (large, medium and small mature sizes) and there are small differences in protein requirements at the later stage of growth among the different classes of animal considered. In this context, Steen (1989) recently concluded that "for non-implanted steers and heifers offered well preserved silage of medium to high digestibility, increasing the protein content of supplementary concentrates above 110 g (kg DM)$^{-1}$ is likely to produce no response in performance and may increase carcass fatness. However, when young bulls are given similar diets during the finishing period increasing the protein content of supplementary concentrates from 110 to 190 g (kg DM)$^{-1}$ is likely to produce a worthwhile response in the performance of animals of high growth potential without affecting carcass fatness".

Ration formulation

The classification of raw materials according to their ME and protein contents is therefore a first step when formulating a ration to contain a given level of energy and protein. The combination of energy and protein is that which is necessary for the animal to achieve a desired level of performance. The chemical composition of concentrate feedstuffs is readily obtained and from this an estimate of its ME content. However, since the efficiency with which ME is used is determined by the ME content of the diet, supplements can only be accurately compared at a particular level of performance. Examples are given in Table 3 of the chemical composition and relative economic values of a number of alternative feedstuffs compared to barley and soyabean meal for a 500 kg steer growing at 1.0 kg/day. While this approach assumes that all nitrogenous components are digested equally well (which is frequently not the case) it does provide guidance to the potential purchaser of the relative monetary value of the available feedstuffs. It must be also remembered that considerable variation can occur in the composition of any feedstuff. This is particularly true of by-product feeds and reflects variations in the treatment processes from which these materials are produced. Examples of this are given in Table 4 for corn gluten and brewers grains. Ideally therefore, samples of these materials should be chemically analysed before purchase and before formulating a ration. The costs of feeding cattle in two situations, i.e. when fed grass silage supplemented with concentrates or when fed diets based on "fodder concentrates" will be examined.

Table 3

Values of feedstuffs relative to the value of barley and soyabean for a 500 kg bullock gaining 1 kg/day

Feed Ingredient[1]	Dry matter g/kg	ME content (MJ/kgDM)	Crude Protein (g/kgDM)	Relative Monetary Value (£/tonne fresh): Energy[2]	Relative Monetary Value (£/tonne fresh): Energy+ protein	Current[3] price (£/tonne fresh)
Barley	860	12.9	120	130	130	130
Soyabean	880	13.2	500	137	164	164
Wheat	860	13.3	120	137	137	140-143
Molassed Beet-Pulp	880	12.0	100	120	119	120
Cane Molasses	740	10.9	45	87	84	82*
Corn Gluten Meal	880	12.4	200	127	132	117*
Brewers Grains	250	10.0	250	26	30	28*
Distillers Grains	880	13.0	250	135	143	122*
Citrus Pulp	880	12.4	66	127	122	118*
Rapeseed Meal	880	10.5	400	99	121	104*
Pressed Beet Pulp	200	12.3	120	28	28	20*
Fodder Beet Roots	180	12.1	80	25	24	18*

[1]Composition data from Drennan and Keane, 1990

[2]Using the variable Net Energy System (MAFF, 1984)

[3]Irish Farmers' Journal (16/11/91)

*=current price less than monetary value relative to barley

Table 4
Variation in chemical composition of 2 by-product feedstuffs

Feed Ingredient	Number of Samples	Measurements Minimum	Maximum	Average
(1) Corn Gluten				
Dry Matter (g/kg)	11	871	901	887
ME (MJ/kgDM)	11	11.4	13.9	12.7
Crude Protein (g/kg DM)	11	213	275	232
Crude Fibre (g/kgDM)	11	67	96	84
(ii) Brewers Grains				
Dry Matter (g/kg)	6	260	304	277
ME (MJ/kgDM)	6	10.9	12.5	11.7
Crude Protein (g/kg DM)	6	196	276	245
Crude Fibre (g/kgDM)	6	143	193	170

(From: MAFF, 1986)

(1) *Grass silage-based diets*

In Ireland most cattle fed indoors are fed a diet of silage supplemented with concentrates. Supplementation is necessary since even with optimum management, cattle are unable to consume sufficient amounts of a good quality silage (e.g., DMD = 750 g/kg DM) to support an adequate gain in liveweight (minimum 1 kg/day). As the quality (and energy content) of the silage increases however, there will be a corresponding reduction in the proportion of the total energy required that must be supplied in the form of a concentrate supplement. The studies of Drennan and Keane (1990) demonstrated that the same performance of steers (400 kg initial liveweight) given silage with a DMD of 600 g/kg DM and 6 kg concentrates could be obtained from silage with a DMD of 720 g/kg DM and only 3 kg of concentrates. In addition to digestibility, the quality of preservation of the grass ensiled is important in determining the value of the silage. Clearly, if preservation is sub-optimal the silage intake will be low and the level of supplementary concentrates required will increase. Bad preservation can be prevented by application of preservatives at adequate rates, by wilting prior to ensiling and by rapid filling and sealing of the silo (O'Kiely, 1989). In addition, management of silage at feeding time must be such as to minimize losses and to ensure no deterioration in the quality of the silage consumed. The question therefore is, "what is the most cost-effective composition and quantity of concentrates required to correct an energy deficit in the silage-fed animal?"

In some cases, substitution of one concentrate with a cheaper alternative (e.g. substituting barley with corn gluten at current prices) might be adequate. However, more cost-effective rations are frequently best formulated by considering a blend of concentrates. Also, there are theoretical advantages with respect to cellulose digestion to formulating on a rumen degradability basis and theoretical benefits with respect to nitrogen metabolism from the inclusion of sugar in the ration. A variety of computer programmes are available which will formulate

Table 5

Performance of steers offered 3.5 kg of isoenergetic (11 MJ ME/kg) and isonitrogenous (126 g protein/kg) supplements to grass silage

	Supplement			
	Barley/Soya	Citrus Pulp/ Rapeseed	Molasses Rapeseed	Significance
Ingredient				
Composition (g/kg)				
Barley	915	–	–	
Soyabean	70	–	–	
Cirtus pulp	–	768	–	
Rapeseed	–	199	293	
Molasses	–	–	626	
Tallow	–	18	66	
Minerals/Vitamins	15	15	15	
Animal performance				
Initial weight (kg)	504	500	510	NS
Liveweight gain (g/day)	952	1083	1025	NS
Cold carcass weight (kg)	302	311	308	NS
Kill-out (%)	51.2	52.1	51.1	0.08
Supplement Cost £/tonne				
August 1990	130	101	92	
November 1991	136	120	102	

NOTE: Silage DMD = 700 g/kg DM)
Source: Moloney (1990)

the cheapest ration of specific ME and protein content by selecting from a database which contains various feed ingredients, their chemical composition and their price. An example of this approach is given in Table 5 which summarises data from a study carried out in Grange in which the liveweight gain of finishing Friesian steers offered three supplements at 3.5 kg daily was compared. The supplements were formulated to provide equal quantities of ME and protein but to differ in composition, i.e., to be based mainly on starch, digestible fibre and sugar, and cost. It can be seen from this study that similar performance was obtained from both the least and most expensive supplements and from supplements that differed markedly in both rate and end-products of fermentation in the rumen. This is the first of a series of experiments which will examine this concept, but illustrates clearly the savings that can be made by judicious supplement formulation. Moreover, Table 5 illustrates the fluctuations in cost of ingredients over time, indicating that the most cost effective ration formulated from a fixed spectrum of raw materials will not always have the same ingredient composition.

It should be noted however, that supplements formulated to provide the same ME and protein do not always result in the same performance. Table 6 shows recent data from a study designed to address this point. It can be seen that while

Table 6

Performance of steers offered 5.8 kg of isoenergetic (11.2 MJ ME/kg) and isonitrogenous (129 g protein/kg) supplements to grass silage

	Supplement			
	Barley/Soya	Distillers Grains/ Beet Pulp	Fat/Rice Bran	Significance
Ingredient				
Composition (%)				
Barley	803	–	02	
Soyabean	99	–	30	
Molasses	52	52	50	
Fat Prills	21	31	83	
Distillers Grains	–	250	–	
Beet Pulp	–	642	–	
Rice Bean	–	–	721	
Megalac	–	–	83	
Urea	–		06	
Minerals/vitamins	25	25	25	
Animal performance				
Initial weight (kg)	587	587	587	NS
Liveweight gain (g/day)	771	892	513	*
Carcass weight (kg)	356	365	346	*
Kill-out (%)	54.0	54.0	53.2	0.07
Supplement Cost £/tonne				
November 1991	138	125	161	

NOTE: Silage DMD = 630 g/kg DM)
Source: Moloney (1991)

similar performance was obtained from the starch (barley) and by product based supplements, these were greater than the fat-based supplement. Because of its detrimental effect on fibre digestion in the rumen, it is generally recommended that rumen unprotected fat should not exceed 50 g/kg of the total DM consumed. Fat, protected from rumen digestion (i.e. Megalac) was therefore also used in this study. The poorer performance of the cattle fed the fat-containing supplement reflects a decrease in silage consumption. This must have been caused by feed-back inhibition of intake by fat absorbed from the small intestine rather than an impairment of rumen digestion *per se*. This study further illustrated that supplements differing in cost can result in similar animal performance.

Ration formulations using current prices and available ingredients are given in Table 7. When no restrictions were placed on inclusion of ingredients the cheapest supplement (£101/tonne) consisted of barley, molasses and rapeseed. Since the level of molasses in this combination might be unattractive from a management perspective or indeed might be higher on a total diet basis than desirable (see below), the supplement was reformulated with molasses restricted to 50 g/kg inclusion (on a fresh weight basis). This increased the price of the supplement by £19/tonne and it now consisted mainly of beet pulp, with small amounts of barley and rapeseed. Restricting molasses and excluding barley, increased the cost of the ration by a further 65 p/tonne.

When formulating rations on a least cost basis it should be noted that wheat is more likely to cause digestive upsets (i.e., rapid decrease in rumen pH) than barley and that the efficiency of utilisation of molasses appears to decline more rapidly than for other ingredients as the level of supplementation increases with a maximum inclusion level of approximately 200 g/kg consumed.

As outlined earlier, the quantity of concentrate required will be determined by its ME content and the intake characteristics and quality of the silage on offer. The shortfall in ME and protein that needs to be supplied by concentrates to

Table 7
Least cost formulations

Ingredients used in programme	Cost (£/tonne)
Cottonseed (expeller) (50%)	120
Corn gluten	117
Sunflower	108
Distillers grains	122
Citrus pulp	118
Imported beet pulp	118
Pollard	122
US Soya 50%	164
EC rapeseed	104
Tapioca	136
Barley	129-133
Wheat	140-143
Oats	132
Fishmeal	450

(Source: Irish Farmers' Journal, 16/11/91)

	Rations		
	1 (no restrictions)	2 (molasses restricted to 50 g/kg)	3 (molasses restricted to 50 g/kg,.no barley
Ingredient Composition (g/kg)			
Barley	197	159	–
Molasses	567	50	50
Rapeseed	211	116	27
Minerals/vitamins	25	25	25
Beet pulp	–	650	528
Pollard	–	–	370
ME (MJ/kg)	11.0	11.0	11.0
CP (g/kg)	120	120	120
Cost £/tonne	101.24	120.70	121.35

achieve a particular level of animal performance can be calculated using (i) the ME and protein of the available silage (provided with the results of chemical analysis), (ii) the requirements presented in Table 1 and Table 2, and (iii) an estimate of the likely intake of the silage. If a choice of silages is available they can be examined in the same least cost formulation procedure using individual costings, composition, etc., as described above for concentrate ingredients. Negative interactions between silage and concentrate supplements have been indicated above. Theoretically, to maximise silage digestion and intake, more attention should be paid to the composition of the supplement than has been the case heretofore. While there are some suggestions that silage consumption can be increased by inclusion of fodder beet or pulp-type ingredients in the ration, sufficient data are not available at present to allow accurate definition of the most appropriate mix of concentrates and silage but work is progressing with that goal. Studies in progress in Grange are examining the interaction of silages that underwent different patterns of fermentation in the silo, with concentrates based on starch, sugar or digestible fibre. While there has been a progressive recognition over time that the amount and composition of the supplementary feeds given to cattle influences silage intake and the milk yield of milk fat and milk protein, it is only comparatively recently that this has begun to have a major impact on ration design. This will lead to a more creative approach to ration formulation which rejects the classical principle that supplementary feeds can be equated simply on the basis of their ME and (digestible) protein contents and emphasise the importance of complementary feeds.

(2) ***"Fodder concentrate"-based diets***

The term "fodder concentrate" is used in this paper to describe whole crop cereals, whole crop fodder beet silage and materials such as ensiled pressed pulp or ensiled brewers grains. Three potential problems arise when deciding if these materials should be included in a least-cost formulation procedure. Firstly, the cost of the material needs to be defined. This will be determined by individual operational costs and for home-grown crops will vary from farm to farm. Secondly, an estimate of the ME and protein must be obtained, by chemical analysis. Thirdly, any unusual features of these materials which require specific considerations to ensure a balanced ration need to be considered. This is an area of active research activity, but Grange studies indicate that balancing for ME, protein and minerals/vitamin in the conventional way is adequate. An example of the cost of producing 1 kg carcass from ensiled beet pulp, whole-crop fodder beet silage and whole-crop barley silage in experiments carried out in Grange is given in Table 8. The "fodder-concentrate" costs were estimated costs of production and were (p/kg dry matter) 7,13.5, 6 and 9 for grass silage, ensiled pressed pulp, whole crop fodder beet silage and whole crop barley silage, respectively. The effects of ration composition on profitability can be clearly seen in this table. While comparing rations on a feed cost/kg carcass gain basis takes into account the efficiency of utilisation of dietary DM, the costs assigned to the "fodder-concentrates" do not fully take into account the yield of the different crops under optimum growing conditions. Thus, on a DM basis, 1 kg of a low yield, low cost material could be costed the same as 1 kg of high yield,

Table 8

Cost of producing 1 kg of carcass from a variety of "fodder concentrate"-based rations

Experiment 1 (Drennan and Keane, 1990)

Feed	Silage + 4 kg barley	Ensiled pressed pulp + 0.6 kg soyabean*
Initial liveweight (kg)	491	491
Liveweight gain (kg/day)	1.04	1.18
Carcass gain (kg/day)	0.65	0.69
Feed cost of carcass gain (£/kg)	1.51	1.80

*+ 2.5 kg grass silage

Experiment 2 (O'Kiely and Moloney, 1990)

Feed	Silage + 4 kg barley	Whole-crop fodder beet silage* + 1 kg Barley	Whole-crop fodder beet silage* + 1 kg Soyabean
Initial liveweight (kg)	468	470	470
Liveweight gain (kg/day)	0.91	1.12	1.10
Carcass gain (kg/day)	0.69	0.79	0.76
Feed cost of carcass gain (£/kg)	1.33	0.93	0.98

*+ 6 kg grass silage

Experiment 3 (O'Kiely and Moloney, 1991)

Feed	Ensiled spring barley without concentrate	Ensiled spring barley + 2 kg barley
Initial liveweight (kg)	347	347
Liveweight gain (kg/day)	0.69	0.94
Carcass gain (kg/day)	0.36	0.57
Feed cost of carcass gain (£/kg)	1.96	1.64

high cost material. Since more of the latter would be available for feeding, comparisons made on a carcass yield/unit area basis are probably more relevant. If various "fodder concentrates" are available they can be used in a least cost programme to define the most cost effective combination. Similarly, the least cost approach can be used to design appropriate "balancers" for "fodder concentrates" that are fed *ad libitum* or form a large proportion of the diet.

Conclusions

In conclusion, considerable scope exists for decreasing feed costs in winter beef production. However, particular attention must be paid to the quality of the feed ingredients purchased particularly if they are by-products and if it is intended that they should form a large proportion of the ration. Ideally, all ingredients should be chemically analysed before use. Similarly, accurate costing of home produced feeds whether grass silage, concentrate or "fodder-concentrate" is important if they are to be sensibly included in least cost formulation. Finally, it should be remembered that there are limitations to the level of inclusion of some ingredients (despite what the computer might recommend) and that not all ingredients are compatible in the rumen.

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Economic Returns from Beef Production and Future Prospects

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The Commission of the European Communities recently (Brussels July 7, 1991) published reform proposals for the Common Agricultural Policy.

The main effects of these proposals on cattle producers are:

* *Intervention price reduction 15%*
* *Sheep quotas*
* *Continued milk quotas*
* *Suckler cow premium increased*
* *Special beef premium increased*
* *Extensification requirements to qualify for premia*
* *Cheaper cereals*
* *Less dairy cows and greater retention of calves on dairy farms*

While the proposed premia may have limitations, beef producers will find it necessary to adjust as their economic viability will depend on receiving these premia. While it is not proposed to examine the effects of these proposals nationally, recent calculations by Teagasc and other organisations have shown that incomes from beef production will be most adversely affected when compared to the other farm enterprises. Examination of present Family Farm Incomes show that beef producers cannot withstand a further reduction in income if they are to remain economically viable (Table 1). While many beef producers are also involved in dairying or sheep production which will obtain greater benefit from the proposals, at least 35 percent of total cattle producers are involved only in beef production. It is this latter group that will have greatest difficulty remaining economically viable in the long term and this paper is primarily concerned with these.

Table 1
Family farm incomes on full-time farms

	Dairying	Beef	Sheep
Family Farm Income per farm (£)	18,030	7,809	9,294
Contributions from subsidies (£)	475	2,396	5,653
Acreage (hectares)	29.5	45.9	60.7
Family Farm Income (£) per acre (hectare)	247 (611)	69 (170)	62 (153)

Source: National Farm Survey 1989

Premia

The existing and proposed premia per animal (£) are as follows:

Premium	Present	Proposed	Proposed Maximum/farm
Suckler cow	52	83[1]	£7,471
Special beef	35	52	£4,719

[1]Proposed £87.38 (100 ECU) Ireland £83,01 (95 ECU)

The number of eligible animals for both the suckler cow and special beef premia is 90. Both premia will be increased gradually over three years and the figures presented are for year 3. Payments under the special beef premium applies only to males (heifer excluded) and are on the following three occasions during the animals life, 6 to 9 months, 14 to 22 months and 28 to 34 months. As both premia can make substantial contributions to overall beef incomes it is important to consider the extensification requirements needed to avail of the premia.

Extensification criteria

The extensification criteria which must be met in order to avail of the premia are as follows:

Disadvantaged areas (DA) *0.57 livestock units per acre (1.4 per hectare)*
Non-Disadvantaged areas (NDA) 0.81 livestock units per acre (2.0 per hectare)

Dairy cows, suckler cows, male bovines and ewes will be included in the calculation of stocking rates. Heifers are excluded from the calculations. Further clarification on livestock equivalents is necessary in order to calculate stocking rate requirements. The proposed livestock unit equivalents are as follows:

Cows (and steers over 2 years) *1.0*
Steers - 6 months to 2 years *0.6*

If livestock units are applied on each occasion the special beef premium is collected, then in a calf to two-year-old beef system the number of livestock units would be 1.2 (severe interpretation). However, as calves from 0-6 months are excluded when calculating LU then the animal is only considered over 18 months and should thus have a livestock unit equivalent of 0.9. Estimation of livestock unit equivalents per acre for some moderately intensive beef systems (Grange) are shown in table 2.

Table 2
Livestock unit equivalents (LUE) per acre

	System					
	Suckling		Calf to 2 year beef[2]		Winter finishing[2]	
Interpretation of L.U.E.	Severe	Less severe	Severe	Less severe	Severe	Less severe
Acres/animal sold	1.9[1]	1.9[1]	1.2	1.2	0.32	0.32
Livestock units	1.6	1.45	1.2	0.9	0.6	0.3
Livestock units/acre	0.84	0.76	1.0	0.75	1.9	0.94

[1]Cow and progeny (50 per cent heifers) [2]Continental breeds

Assuming the severe interpretation of livestock unit equivalent none of the systems would be eligible even in the non-disadvantaged areas. With the less severe interpretation both the suckling and calf to beef systems would be eligible in these areas. However, substantial reductions in stocking rate would be necessary to ensure eligibility in the disadvantaged areas. Winter finishing would not meet extensification requirements in any area. Further clarification of the proposals is necessary to allow proper evaluation of the implications of extensification. However, the above data would indicate that adjustments to the extensification requirements are necessary in order that those in disadvantaged areas and those specialising in winter finishing can avail of the premia.

Economic returns

Economic returns were calculated for a number of beef systems in non-disadvantaged areas, using Grange standards. High animal performance was assumed and continental crosses were used in all systems. Incomes were estimated using present prices and following full application of the proposals. The following conditions were applied:

		Present	*Following proposals*
Steer purchase prices (£/100 kg)		118	100
Calf price (£)		250	213
Sale prices (p/kg carcass)	Steers	227.1	193.0
	Heifers	198.4	168.6
Concentrates (£/tonne)		130	100
Overhead costs (£/acre)		70	70

Interest was charged on all working capital at 14 percent. No charge for housing or labour was included in the calculations.

Single suckling systems

Continental sires were used and the progeny taken to slaughter at 20 (heifers 290 kg carcass) and 24 (steers 390 kg carcass) months of age. The following three sets of circumstances were examined:

A.	*Grassland/cow unit*	=	*1.9 acres*	*Present prices*
B.	*Grassland/cow unit*	=	*1.9 acres*	*Prices following proposals*
C.	*Grassland/cow unit*	=	*2.2 acres*	*Grazing area (nitrogen for early grass only)* *Prices following proposals*

The incomes per cow unit and per acre are shown in Table 3

Assuming the existing system qualified for the premia following application of the proposals then receipts are reduced but so also are viable costs and interest on working capital. Gross margin per cow is reduced from £430 to £407. Overall, income per cow is reduced from £131 to £117 (from £69 to £62 per acre) indicating that the premia are insufficient to offset the 15% price reduction. This does not include, however, any compensation for reduction in the value of the cow herd. If a reduction in stocking rate is necessary to meet the extensification requirements (and avail of the premia), then one option (Option C) is to restrict

Table 3
Incomes (£) from single suckling systems

	Per cow (£)			Per acre (£)		
System	A	B	C	A	B	C
Variable costs	370	349	335	195	184	152
Receipts - Animals	731	621	621	385	327	282
Cow premium	52	83	83	27	44	38
Beef premium	17	52	52	9	27	24
Total receipts	800	756	756	421	398	344
Gross margin	430	407	422	226	214	192
[1]Overhead costs	133	133	133	70	70	60
Margin less overhead costs	297	274	289	156	144	131
Interest on working capital	167	157	156	88	82	71
Income	131	117	133	69	62	60

[1]Where stocking rate was reduced (C) overhead costs per animal remained the same.

nitrogen on the grazing area to usage for early grass only (saving the equivalent of 200 kg of calcium ammonium nitrate per acre on the grazing area). While receipts are reduced so also are costs. The reduction in income per acre is small (reduced from £62 to £60 per acre). This indicates that reductions in stocking can be made without detrimental effects on income. It should however, be pointed out that this applies to conditions of heavy borrowing (all livestock and other variable and overhead costs) with interest payments on working capital varying from £71 to £88 per acre.

Artificial rearing calf to beef systems

Continental calves are purchased in March, artificially reared and sold at 25 months of age (carcass weights 380 kg). The following three sets of circumstances are examined:

A1. Grassland per animal = 1.2 acres Present prices

B1. Grassland per animal = 1.2 acres Prices following proposals, i.e. 15% reduction

C1. Grassland per animal = 1.2 acres (nitrogen for early grass only on grazing area)
Prices following proposals

The incomes per animal and per acre are shown in Table 4. Assuming the present system meets extensification requirements then due to increases in the special beef premium incomes are improved following application of proposals. If reductions in stocking rate are required in order to avail of the special beef premium, and this could be achieved by reducing nitrogen usage on the grazing area then there is a relatively small reduction in income per acre (£77 to £73). It is again important to point out the major effect of borrowing on incomes which varied from £84 to £114 per acre. The full special beef premium is obtained with 45 animals slaughtered yearly (i.e., 45 weanlings and 45 finishing animals).

Table 4
Incomes (£) from artificially reared calf to beef systems

	Per animal			Per acre		
System	A1	B1	C1	A1	B1	C1
Variable costs	613	543	534	511	453	381
Receipts - Animals	863	733	733	719	611	524
Beef premium	35	105	105	29	87	75
Total receipts	898	838	838	748	698	599
Gross margin	285	295	304	238	246	217
Overhead costs	84	84	84	70	70	60
Margin less overhead costs	201	211	220	168	176	157
Interest on working capital	137	119	117	114	99	84
Income	64	92	102	53	77	73

Winter and winter/summer finishing systems

Continental cross animals are purchased in autumn at 500 kg liveweight and sold in spring (six months feeding period and 380 kg carcass) or the following autumn (11 months feeding period 315 kg carcass). The following three sets of circumstances were examined:

A2. Grassland (for silage) per animal = 0.32 acres Present prices

B2. Grassland (for silage) per animal) = 0.32 acres Prices following proposals

C2. Grassland (silage and grazing) per animal = 0.90 acres Prices following proposals

In A2 and B2 animals are fed silage plus 4.5 kg of concentrate daily, whereas in C2 (grazed) silage only is fed in winter. It is assumed that no special beef premium is available to those involved in winter finishing and the payment made at 28 to 34 months (£52-43) is available to those finishing off grass. At any rate those involved in winter finishing would find it difficult to meet the extensification requirements and because of the restriction to 90 animals, even if they were eligible they would only receive payments for the equivalent of 29 acres of grassland in the example used.

The incomes per animal and per acre are shown in Table 5. In the absence of the special beef premium, incomes from winter finishing before and following reform are –£50 and –£77 per acre, respectively. Finishing off grass (C2) following a winter period on silage alone provides an income of £53 per acre which is somewhat lower than the suckling and calf to beef systems. It should be pointed out that interest on working capital (no repayments on buildings and no labour) amounts to £155 to £180 per acre in winter finishing, thus indicating the substantial effect of borrowing on incomes in this system of production.

Importance of premia

To indicate the importance of premia the effect of availability of the special

Table 5
Incomes (£) from winter and winter/summer finishing systems

	Per animal			Per acre		
System	A2	B2	C2	A2	B2	C2
Variable costs	209	185	150	653	577	167
Purchase price	590	502	502	1844	1567	557
Total	799	687	652	2497	2144	724
Receipts - Sale price	863	733	801	2696	2292	890
Beef premium	–	–	53	–	–	59
Total receipts	863	733	854	2696	2292	949
Gross margin	64	47	202	200	148	225
Overhead costs	22	22	63	70	70	70
Margin less overhead costs	42	25	139	130	78	155
Interest on working capital	57	50	92	180	155	102
Income	–16	–25	48	–50	–77	53

beef premium on financial retruns from the calf to 2-year beef system is shown in Table 6. Non availability of the premium would reduce gross margins from £246 to £158 per acre and incomes from £77 to –£11 per acre. In the example used the full special premium is obtained on 54 acres (i.e., 45 animals finished yearly) which provides inadequate income for a beef producer with no other livestock (dairying or sheep) enterprises. It is thus essential that the number of eligible animals for the special beef premium be increased for those producers confined to beef production. Because of the importance of heifer production and the indirect effect of the reduction in intervention prices on heifer price, inclusion of heifers for the special beef premium merits consideration.

Table 6
Effect of special beef premium on incomes from calf to 2-year-old beef system

	Special Beef Premium			
	Available		Not available	
	Per animal	(Per acre)	Per animal	(Per acre)
Gross margin	295	(246)	190	(158)
Income	92	(77)	–13	(–11)

IMPORTANT CONSIDERATIONS FOR BEEF PRODUCTION

Two major considerations are:

1. *The increased importance of suckler cows as a source of calves for those involved in beef production only and,*
2. *Distribution of cattle slaughterings throughout the year.*

1. Importance of suckler herd

Since the introduction of milk quotas, we have advocated at Grange the increased importance of the suckler cow herd as a source of calves for those involved in beef production. Suckler cow numbers have increased from 0.42 million in 1984 to 0.69 million in 1991 and now account for almost one-third of the total cow population. During the same period, dairy cow numbers declined from 1.65 to 1.45 million and this decline is likely to continue with further milk quota reductions. Thus, the suckler herd is now more important than previously and we must consider the possibility of future quota restrictions on suckler cow numbers. It is therefore, important that beef producers give greater consideration to suckling systems. In addition to an improved suckler cow premium economically viable systems involves efficient low cost production of quality beef; e.g., Limousin x Friesian cows crossed as mature cows with the larger continental breeds of bull (Charolais, Simmental, Blonde D'Aquitane).

2. Distribution of slaughterings throughout the year

If there is to be less reliance on intervention then for orderly marketing it is essential to have an even distribution of disposals throughout the year. The present uneven distribution of slaughterings with a large proportion in autumn is undesirable; one-third of total steers slaughterings were in the October/December period in the seventies, this has increased to one-half in recent years. In a predominantly spring calving herd payment of the final moiety of the special beef premium from 22 months of age (as opposed to the suggested 28 to 34 months) would improve the economic returns from winter finishing and thereby increase disposals in spring. It is thus essential that those specialising in winter finishing are eligible for the special beef premia.

Conclusions

Where animal performance is high (not attainable by all producers), acceptable incomes can be achieved following reform provided premia are available. The important indicators are:

* *Premia essential for viability*
* *The proposed suckler cow premium needs to be increased*
* *Special beef premium – increase number of eligible animals on beef only farms*
* *Extensification requirements are excessively severe particularly in the disadvantaged areas*
* *Extensification – implications re stock relief*
* *In absence of a premium winter finishing (and heifer beef) systems are not viable*
* *To improve seasonality of disposals – final moiety of special beef premium should be from 22 months of age (will increase disposals in spring).*

It is important to point out that due to the decline in cattle prices in recent years the incomes calculated using present prices are already lower than previously. In addition, there is no compensation for decrease in value of livestock (e.g., a suckler herd) and no allowance for inflation.

Hygienic Nature of Grass Produced Beef

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Introduction

Hygienic beef is beef that is produced from healthy animals, uncontaminated by harmful bacteria, wholesome and free from residues. The consumer expects a product that is safe (i.e. does not adversely affect the health of the consumer), is free from infectious agents, free from toxins and chemical residues. The consumer also expects the product to be free from bacterial contamination, free from disease defects and to have the characteristics the consumer requires.

The purpose of this paper is to show that beef produced from cattle that spend the majority of their life on pasture can more readily meet the consumer's demands for a wholesome product than beef produced from cattle raised under more intensive systems of production.

With the exception of parasitic disease, cattle produced at grass suffer from fewer infectious diseases than housed animals. The fact that animals at grass are in their natural environment, are less stressed and are stocked at much lower density means that their resistance to infection is at a maximum and that under normal conditions they are unlikely to be exposed to high levels of infection. The consequences of this for meat hygiene is twofold – (a) cattle coming from pasture are less likely to be infected with potentially harmful micro organisms and (b) the use of chemotherapeutic substances will be less in these animals with less risk of residues in the meat.

The use of antibiotics in meat producing animals has been of concern for a number of years. In particular, concern has been expressed regarding the possibility of residues entering the food chain and the risk of antibiotic resistance being transferred to the human population from treated animals either directly through the transfer of resistant strains of pathogenic bacteria or through transferable drug resistance. Traditionally antibiotics have been used in beef production either as a means of preventing disease during a critical period or as growth promoters.

Research findings

(1) *Antibiotics*

Two experiments have been carried out at Lyons to investigate the effect of feeding antibiotics to beef calves on the pattern of resistance of bacteria isolated from the digestive tract of the treated calves.

In the first experiment 250 mgms of chlorotetracycline (Aureomycin: Cyanamid) was fed daily in liquid feed for eight days after purchase to 30 autumn born and 36 spring born beef calves. The sensitivity pattern of *E. coli* isolated from the digestive tract of these animals was monitored regularly. The sensitivity pattern to chlorotetracycline is shown in Figure 1 and the sensitivity pattern to a number of common antibiotics is shown in Tables 1 and 2. The results of this experiment show that while the calves harboured *E. coli* showing a high level of resistance to a number of antibiotics and an exceptionally high level of resistance to chlorotetracycline during the initial housing period the bacterial population of

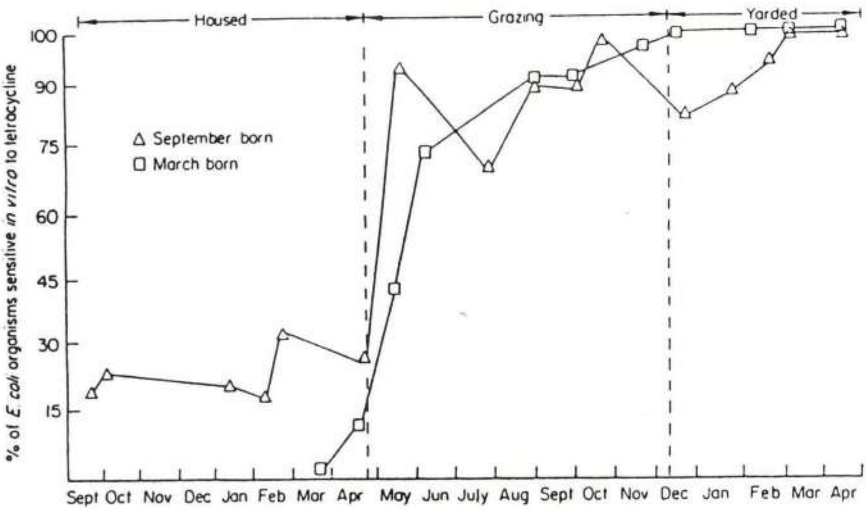

Fig. 1 – Season pattern of *in vitro* sensitivity to tetracycline of *E. coli* isolated from March and September born calves

Table 1

In vitro sensitivity (%) of E. coli isolated from 30 autumn born calves

	C.'	Amp.'	Ne.'	Fr.'	Nf.'	Ps.'
September (after treatment)	60	60	47	87	100	97
April (turnout)	80	83	80	100	97	97
August (grazing)	100	100	97	90	97	100
October (housing)	100	93	77	100	67	100
March (slaughter)	100	97	97	100	97	97

Table 2

In vitro sensitivity (%) of E. coli isolated from 36 spring born calves

	C.	Amp.	Ne.	Fr.	Nf.	Ps.
March (after treatment)	3	3	33	36	94	100
April (turnout)	67	69	78	86	97	100
August (grazing)	97	100	100	100	100	100
November (housing)	100	94	89	100	94	97
April (turnout)	100	89	100	100	97	100

'(C-Chloramphenicol, Amp-Ampicillin, Ne-Neonycin, Fr-Framycetin, Nf-Nitrofurazone, Ps-Potentiated sulphonamide)

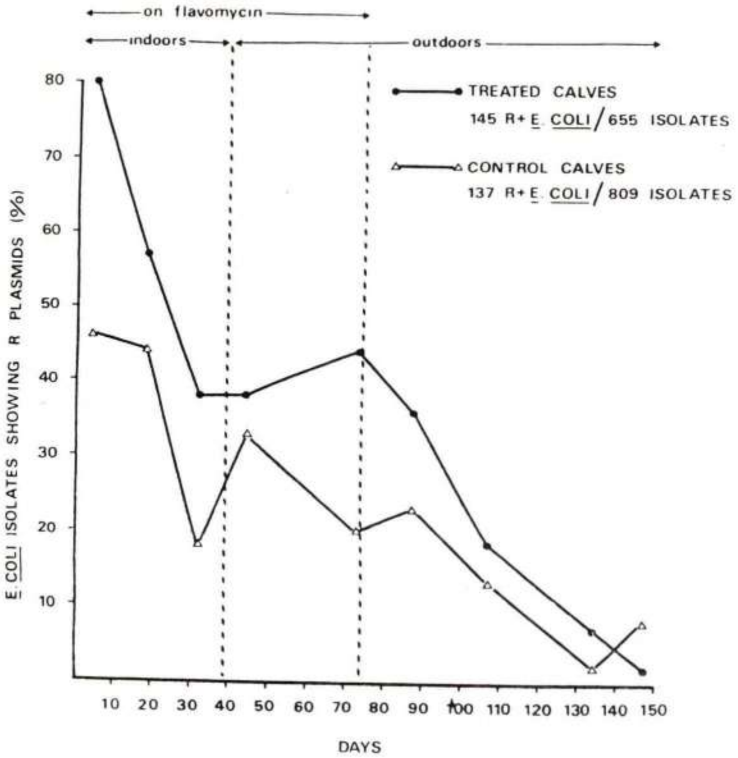

Fig. 2

these animals lost this resistance very rapidly after turnout to pasture and a high level of sensitivity persisted throughout the remainder of the experiment.

The second experiment investigated the effect of feeding a feed additive antibiotic Flavomycin (Hoechst) to beef calves on the pattern of resistance of *E. coli* isolated from these calves. In this experiment half of the group of calves (36) received Flavomycin both in the milk for 28 days and in the meal for a further 35 days after turnout. Rectal swabs were taken on nine occasions over the experimental period of 150 days. The sensitivity pattern and incidence of R plasmids (transferable resistance factors) in the *E. coli* isolated was monitored. The results of this experiment are shown in Figure 2. These results show that the feeding of Flavomycin resulted in a significant increase in the incidence of R plasmids in isolates from the treated calves and that the incidence of the plasmids fell off dramatically after the cessation of feeding outdoors.

However this experiment would also suggest that the feeding of non therapeutic feed additive type antibiotics to housed finishing cattle might present a risk of increased incidence of R plasmids in intestinal bacteria at slaughter and this warrants further research.

These experiments suggest that any antibiotic resistance that may develop as a consequence of feeding antibiotics will be lost when cattle are turned out to pasture and that beef from grazing animals is unlikely to be a source of antibiotic resistance to the human population.

(2) Parasites

The most common diseases of grazing cattle are caused by internal parasites viz. parasitic gastrointeritis, parasite pneumonia and fluke. These are primarily diseases of young cattle and do not present a problem to the human population. However most control procedures are based on the use of chemicals i.e. anthelmintics – a fact that could lead to concern about residues. The availability of highly effective anthelmintics has resulted in a more or less complete reliance on chemicals as a means of control of parasite disease at the present time.

However, efficient parasite control can be achieved by combination of grazing management and strategic dosing which will significantly reduce the amount of anthelmintics used during the finishing period.

Work at Lyons over the years has repeatedly shown that effective control of parasite gastroenteritis and hoose can be achieved in a beef production system with a dosing regime that requires only two doses, one at mid season move and one at housing for first season grazers combined with a leader/follower grazing system and a conversion programme that provides clean pasture in mid season. This management system also eliminates the necessity to dose the finishing animals thereby minimizing the use of anthelmintic and eliminating the risk of residues in the meat.

The control of fluke grazing cattle can also be achieved without the widespread use of chemicals. The elimination of snail habitats from grazing land by drainage, the control of flooding and the prevention of access to permanent snail habitats by fencing and judicious pasture management at high risk periods will achieve an effective level of fluke control. Efficient fluke control will result in more healthy livers, a product that is a rich source of nutrients and should be highly attractive to the consumer. It is important to realise that the liver is the organ which stores many of the substances absorbed from the digestive tract and because of this can be a potent source of harmful residues.

Beef can be produced from grass with minimal use of anthelmintics and if the need arose it could be possible to devise a management system that would control internal parasites of grazing cattle without the use of anthelmintics.

Another condition of concern to the beef producer is infestation with external parasites particularly lice. Grazing cattle do not normally suffer from lice and beef animals finished from grass do not need treatment. This means that these animals should be free from contact with organophosphates for a long period before slaughter, a situation that must be attractive to the consumer.

Comments

A potential source of concern to the consumer is the risk of contamination of the carcase at slaughter particularly when the hide is being removed. Modern methods of pulling hides have reduced this risk, nevertheless contamination of the carcase can be perceived as a problem. In this respect the much cleaner hides of cattle coming from grass would suggest a much reduced risk from grazing animals than from animals finished indoors.

Welfare considerations can influence the consumers opinion of animal products. Beef produced from grass gives a very favourable impression of animals living in their natural environment.

Beef is an expensive product to produce and must be marketed as a prime product. Consumer confidence in the product is most important in achieving premium prices. The producer has a major role to play in maintaining this confidence. The producer of the finished animal can only be in control of the product for the length of time the animal is under his control. Ideally a calf to beef system is the system of choice to give complete control of the product. Unfortunately this system is not really practical in most Irish farm situations, however the beef producer can improve his control over the final product by a more judicious purchasing policy and by ensuring he knows the origin of his purchases. To achieve this beef producers should be encouraging the development of a computerized system to monitor the movement of cattle – a system that is being proposed for another reason but which could be very beneficial in improving the hygienic standard of the beef we produce.

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External Parasites of Cattle

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The incidence of external parasites in housed cattle has been of considerable concern to cattle farmers over the years. Their major concern has been in relation to the effect these parasites may have had on animal performance and to a lesser extent the consequential damage to skin and hides that may result from scratching. The main external parasite of housed cattle is lice, followed to a lesser extent by mange mites and warbles. However, no discussion on this topic would be complete without including ringworm, although as it is caused by a fungus it cannot strictly be classified as an ectoparasite.

Basically two types of lice occur on cattle in this country, biting and sucking lice, sucking lice being the more common type. Both cause irritation of the skin resulting in restlessness, scratching, excessive licking and hair loss. If the infestation is severe considerable damage can be done to the skin causing abrasions and cuts. In young animals excessive licking can lead to hairballs. The constant scratching and uneasiness can also cause damage to partitions, barriers, etc. The skin damage can result in reduced value for the hide which may be of significance. Sucking lice have been implicated in causing anaemia particularly in younger animals although the level of infestation required to cause clinical anaemia would need to be very high.

Lice infestation is primarily a problem during the winter months reaching its maximum intensity during late winter and early spring, as the reproductive performance of lice increases in cold weather. Other factors which influence levels are density of hair coat, condition of coat, nutritional status, environmental conditions, temperature, crowding and other stress factors. Levels start to decrease in early summer as a result of shedding of winter coat, increase in temperature, improving nutritional status and reduction of contact between animals. A form of "self cure" phenomenon has been reported for lice in cattle in early winter. This is probably an immune response and may contribute to the fact that well fed animals are less likely to have high infestation levels. Outbreaks develop in late autumn from very low levels carried over the summer on a few carrier animals. These carrier animals infest clean in-contact animals and levels increase rapidly under favourable conditions due to the short life cycle of the louse. The introduction of infected animals into a clean group can also result in a dramatic increase in the level of infestation.

In general the available evidence from this part of the world would suggest that in well fed healthy adult cattle low to moderate levels of infestation have little if any measurable effect on performance. A report from the U.S.A. has mentioned an improvement in performance of a small number of cattle after treatment for lice while another report from that country suggests losses of up to $126 million per annum due to lice in cattle. I suspect that in these cases the level of infestation was high and there may have been other contributing factors.

In younger cattle, particularly if they are under-nourished, the effects of lice infestation may be more obvious and heavy infestations may contribute to reduced performance and even anaemia in poorly managed growing cattle. It has been suggested that a sudden increase in lice levels in young cattle might be suggestive of the presence of subclinical disease, e.g. internal parasitism.

Prevention of the seasonal build up of levels in housed cattle is the most efficient way of dealing with lice. This is best achieved by treating all cattle at the start of the winter housing period. All animals must be treated at the same time and care must be taken to ensure all new animals are treated before mixing. There are many different drugs and types of preparations available for delousing cattle. These include powders, sprays, washes, pour-ons and injectables. All work effectively but 'in contact' products such as powders and sprays, although cheaper, require considerable attention during application as direct contact must be achieved for maximum results. The systemic drugs such as organophosphates, used as pour-ons, and ivermectin, by injection or recently available as a pour-on, are both very effective and easy to use. However, one must be conscious of the toxicity risk with organophosphates to both man and animals. These products all have significant withdrawal times particularly for meat and ivermectin should not be used in lactating dairy cows. The fact that ivermectin is effective against other parasites is also a consideration. Choice of drug should be based on suitability to the particular enterprise and cost. At Lyons we have always found one treatment with an organophosphate pour-on to be effective in keeping lice under control.

Mange

There are four types of mange that may affect cattle; sarcoptic, psoroptic, chorioptic and demodectic. Sarcoptic and psoroptic mange are both scheduled and notifiable diseases in this country but not in the United Kingdom. All forms of mange are spread by contact although grooming utensils can also transmit infection from animal to animal. Like lice, mange mites are host specific although there have been reports of humans becoming infected with sarcoptic mange in America.

Neither sarcoptic nor psoroptic mange have been reported in this country for many years. Sarcoptic mange has occurred sporadically in the United Kingdom while psoroptic mange has not been seen for many years save for one recent isolated outbreak. There is always a risk of imported cattle bringing mange into this country and any suspicious skin lesions should be investigated thoroughly. Both types of mite can cause widespread lesions with intense itchiness, thickening of the skin and crust formation. Chorioptic and demodectic mange are very mild conditions with slight if any clinical signs. Chorioptic mange which is the commonest type of cattle mange usually causes scab like lesions on the udder, scrotum and at the base of the tail, areas free of hair. Demodectic mange has been implicated as a cause of nodules in hides.

Mange responds well to treatment with common insecticides although infestations of sarcoptic mange may require a number of treatments to achieve satisfactory results.

Ringworm

Ringworm is of course a widespread disease of cattle particularly young stock. The following points are worthy of attention:

a) Young poorly nourished animals are more susceptible than well-fed stock.

b) Infection in the form of spores can live off the animal, in sheds, for years resulting in the transfer of infection from year to year.

c) Clinical infection in a group suggests that in contact animals maybe incubating the disease.

d) Local topical treatment may give disappointing results as new lesions may develop elsewhere on the same animal.

e) Crusty scales may protect the fungus.

f) Ringworm is zoonotic, i.e. it can infect humans.

g) Ringworm can occur outdoors particularly in wet weather.

h) Treatment: Indoors – griseofulvin in feed.
Outdoors – contact fungicides.

Warbles

Warbles are rarely seen in cattle nowadays. However, any suspected case of warbles must be reported to the local District Veterinary Office.

In conclusion lice are the most common ectoparasite of cattle and while their effect on performance may be insignificant, humane and welfare considerations dictate that they should be controlled by routine treatment. Any abnormal skin lesions in housed cattle should be investigated thoroughly and any suspicion of sarcoptic mange, psoroptic mange or warbles must be reported to the authorities.

The Prevalence and Control of Leptospirosis in cattle

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Serological prevalence

Leptospirosis infection is widespread in the Irish cattle population with most infections due to serovar *hardjo*. Approximately 34% of sera from cows that have aborted contain antibodies to *hardjo* (Egan & Yearsley, 1987). A survey of dairy herds carried out at Moorepark revealed that 25% of sera tested were positive for *hardjo* antibodies and 2% were positive for infection by other serovars. The cattle tested in this survey had no history of abortion problems in most cases and it is therefore not surprising that the prevalence is less than that obtained by Egan & Yearsley. A significant finding of this survey was the fact that 87% of herds tested had at least one animal positive for *hardjo*. This is similar to the results of a study in Britain in which 85% of herds and 24% of animals were positive for *hardjo* antibodies (Allsup, 1989). A survey of beef herds only has not been conducted in Ireland but in the U.K. a survey found antibody to *hardjo* in 72% of beef herds. Therefore, serovar *hardjo* infection is widespread in beef and dairy cattle populations.

Foetal infection

Abortions due to *hardjo* infection in cattle are confirmed by demonstration of the organism in the foetus. This is usually done using a fluorescent antibody test (FAT) as culture of the organism is difficult and slow (Ellis, O'Brien, Ferguson and Hanna, 1992). Leptospires were identified using the FAT in 13% of 362 aborted foetuses submitted to the Vetetrinary Research Laboratory, Dublin in 1987 and in 15% of aborted foetuses examined during the months of January and February, 1990 (O'Reilly & Egan, 1987; Anon, 1990). Leptospiral infection has been identified in a much higher percentage of foetuses in Northern Ireland. Leptospires were demonstrated in 57% of foetuses aborted by dairy cows and in 39% of foetuses aborted by beef cows (Ellis, O'Brien, Bryson and Mackie, 1985). The reason for the greater number of abortions in dairy cows than in beef animals may be management related. In beef herds, unlike dairy herds, calves and replacement animals are usually not reared separately from the main herd. Younger animals are therefore exposed to infection before breeding and become immune. Later exposure to leptospires when the animals are pregnant causes no clinical signs because they are protected by their prior immunity. This type of infection pattern with resultant protection in breeding animals was noted in herd studies carried out by Ellis and Michna (1976) and is the probable reason why so few clinical problems are observed with *hardjo* infection in New Zealand (Hathway, 1981).

Serological tests are not of great value in the diagnosis of *hardjo* abortions because cows with infected foetuses may have no titres to *hardjo*. Twenty-three per cent of cows that aborted *hardjo*-infected foetuses had no detectable antibody to *hardjo* in one study (Ellis, O'Brien, Neill and Hanna, 1982). However, if no foetus is available, a blood sample from the dam can help provide evidence of infection as the same authors found that 80% of aborting cows that had a titre of ≥1 : 1000 also had *hardjo*-infected foetuses.

Clinical signs

Abortion is the principal sequel to *hardjo* infection, particularly in beef herds where milk drop syndrome may pass unnoticed. Abortion usually occurs from the sixth month of gestation onwards though it may occur as early as the third month (Ellis *et al.*, 1985). Serovar *hardjo* is also an important cause of stillbirths and weak calves and has been associated with infertility. Hanson, Tripathy and Killinger (1972) observed a decrease in repeat breedings in cattle following vaccination with a *hardjo* bacterin and increased returns to service have been reported in herds experiencing outbreaks of milk drop syndrome (Ellis *et al.*, 1985).

Spread of infection

The most important method of spread of *hardjo* infection is through the shedding of organisms in the urine carrier animals. Work in Moorepark has shown that some animals can shed leptospires in urine for up to a year and this finding is in agreement with those of other authors (Hellstrom, 1987; Thiermann, 1982). There are conflicting views on whether leptospires are shed intermittently and whether shedding is influenced by season of the year (Hellstrom, 1978; Hathaway and Little, 1983). The results of trials carried out at Moorepark indicated that shedding is not intermittent, that animals shed continuously for variable lengths of time and then stop, apparently due to increased levels of local antibody in the urine. There is evidence, however, that greater transmission of *hardjo* infection takes place during the summer months (Ellis *et al.*, 1985) and this may be important in the control of leptrospirosis.

Control

Control of *hardjo* infection in cattle is through the use of antibiotics and vaccination. The most commonly recommended antibiotic for use in leptospire-infected animals is dihydrostreptomycin. This drug greatly reduces the number of organisms persisting in the genital and urinary tract of carrier animals though it does not eliminate them completely (Ellis, Montgomery and Cassells, 1985). It may be used in combination with vaccination in herds experiencing abortion storms. Other antibiotics such as amoxycillin may be more efficient than dihydrostreptomycin in the control of leptospirosis in animals because of cost.

There are two vaccines available for the control of leptospirosis in cattle in Ireland. Both contain killed leptospires as is usual for leptospiral vaccines worldwide. Vaccination of the entire herd including bulls and replacement heifers greater than six months of age is the best method of controlling *hardjo* infection. Where endemic infection is present in a herd, protection of the younger animals which are at a greater risk of aborting, can be achieved by vaccinating these animals only. All females and breeding bulls between the ages of six months and two and a half years must be vaccinated at least annually. This is still an acceptable method of control in beef herds where the risk of human infection is less than in dairy herds. In dairy herds, where milkers run a high risk of infection vaccination of the entire herd should always be carried out in order to eventually eliminate *hardjo*-infection from the herd and prevent human infection (Marshall, 1987).

The frequency of booster vaccinations necessary to ensure protection has not been definitely determined. General recommendations are for annual boosters to be given in spring to provide protection before the period of maximum transmission in summer. Recent work on pentavalent vaccines carried out in the U.S. showed that these vaccines did not give protection six months after the last vaccination (Bolin, Thiermann, Handsaker and Foley, 1989). Though the monovalent vaccines available in this country probably provided better protection, further trials are necessary to evaluate the longterm protection provided by these vaccines. Boosters at more frequent intervals than every year may be needed, particularly in problem herds.

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Copper and Iodine Deficiency in Cattle

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Cattle, except those on high-concentrate or root diets, obtain 90-95% of their feed dry matter from herbage, fresh or conserved. In the absence of supplements, 90-95% of their mineral supply is influenced directly by forage composition and intake.

Deficiencies of copper (Cu) and/or iodine (I) are common in Irish cattle. They often occur in dairy cattle (cows, replacement heifers and calves). Beef cattle (suckler cows, calves and growers) usually receive less mineral supplements than dairy cattle and are more likely to have these deficiencies. Deficiencies of trace-elements may arise singly or in combination. For instance, cattle on peat-land farms may have combined deficiency of Selenium (Se), Iodine and Cobalt (Co), plus Molybdenum (Mo) induced copper deficiency. These are the important trace element deficiencies in Ireland.

This paper outlines the requirements of cattle for trace elements. It discusses the effects of Cu and I deficiency and productivity and methods of diagnosis and control [1].

COPPER DEFICIENCY

Feed copper: Cu is needed for animal amine oxidase and super-oxide dismutase enzyme systems. Cattle diets need at least 10 mg Cu/kg feed DM to maintain normal Cu status in the animal. If Cu antagonists are present, dietary Cu may need to be 20-35 mg/kg DM to maintain normal Cu status. Cu antagonists reduce the absorption of Cu and increase the loss of Cu from the body. Soil ingestion, high dietary Mo, S, iron (Fe) and lush grass (high N, high K) are Cu antagonists. Even in the absence of Cu antagonists, net absorption of dietary Cu by cattle at pasture is a very low (3-5% of Cu intake) and antagonists can reduce net absorption to 1-3% of Cu intake,

Average Irish herbage is sub-optimal in Cu (9 mg//kg DM) and is high in Mo (5 mg/kg DM), N (3.1 % DM) and K (3.1 % DM). While mean herbage sulphur (S) is 0.25% DM, many samples are high in S (>0.3 % DM). Also, cattle at pasture or on soil-contaminated silage or roots, may ingest up to 5-15% of their feed DM as soil. Thus, Cu intake from average Irish forage is sub-optimal and Cu antagonists (Mo, high intake of soil/Fe, S and lush grass) are present to a moderate or high degree.

Symptoms: 10-60% Calf mortality (non-specific abortion, still-birth, neo-natal calf deaths); infertility (repeat-breeders and sub-oestrous); illthrift in calves, yearlings and fattening cattle; faded rough coats; straight and swollen fetlocks in suckler calves; scourng (especially in Mo-induced Cu deficiency);

(1) Sheep are poisoned easily by Cu. Methods of Cu supplementation in cattle should not be used in sheep without professional advice.

reduced milk yield; low immunity to infections; sometimes illthrift, emaciation and death in adult cattle.

Diagnosis is based on the history, clinical signs and sometimes, post-mortem findings. It is confirmed by blood, liver and feed tests and by a dramatic response to Cu supplementation. Cu absorbed in excess of current requirement is stored in the liver which releases Cu back into the blood in periods of Cu shortage. At blood Cu in the normal range, liver Cu may range from 30-300 ug/g DM or more. Blood Cu levels remain between 0.71-1.20 ug/ml until the liver reserves fall below 30 ug/g DM. Then blood Cu levels begin to fall below 0.7 ug/ml. Therefore, a normal blood Cu level in cattle is defined as 0.71-1.20 ug/ml of whole blood. Blood Cu levels less than 0.40 ug/ml are defined as very low.

Blood Cu: From the late-1960s to date, samples from many thousands of cattle herds in Ireland have been tested for blood Cu. In the early 1980s, 40-80% of herds showed mean blood Cu at 0.7 ug/ml or less. Today, the incidence of low blood Cu is less, as many feed compounders and mineral mix suppliers have increased the Cu level in their products. However, in the absence of Cu supplements at pasture, it can be expected that 40-80% of herds will have subnormal blood Cu in *autumn*. The incidence in *spring* is lower, especially in dairy cows, normal Cu status is partially or fully restored by adeqate mineral supplementation (in ration or mineral mixes) in winter.

Control and prevention of Cu deficiency: An oral supplement of 150-450 mg Cu/day (equivalent to 10-30 mg/kg total feed DM) should ensure normal Cu status in adult cows. The lower amounts suffice in marginal Cu deficiency but the higher amounts may be needed on high-challenge farms, i.e. those with very high levels of Mo in herbage/silage. For example, 100 g/cow/day of a mineral mix containing 3000 mg Cu/kg would supply 300 mg Cu/cow/day. Doses for other stock are as in Table 1. Alternatively, trough water could be medicated with chelated Cu (guaranteed to stay in solution) to provide 150-450 mg Cu/cow/day. Doses for other stock are shown in Table 1.

Veterinary Cu supplements: Include injections, boluses and bullets containing Cu compounds. Because Mo challenge is high in Ireland, the annual Cu dose needed to control diagnosed Cu deficiency is greater than is the case in the U.K.

(a) *Cu injections:* there are many Cu compounds for injection. Intramuscular injections are not recommended as they may damage meat. Cu injections should not be given within 4-6 weeks before mating, as the pain or swellings may reduce conception rates. (Cu bullets, boluses or oral Cu supplements are preferable during the mating period).

Cu-EDTA (sub-cutaneous) is very effective. The dose for cattle is 100 mg Cu repeated as required. In Irish cattle, one infection lasts 6-12 weeks depending on the challenge to Cu status. On high-Mo farms young-stock and yearlings may need 3-4 injections per year. In marginal deficiency, 2 injections/year may suffice. The number of injections per cow depends on the clinical problems in the cows. If abortions, stillbirths and infertility are due to Cu deficiency, at least three infections are needed: one in mid pregnancy, one about 5 weeks before calving and one very soon after calving.

(b) *Cu boluses:* These gelatin capsules, containing Cu oxide particles, are given orally with a special bulleting gun. Optimum doses for Irish cattle in moderately to severely deficient herds are 10-15 g Cu oxide/100 kg liveweight annually. Longer protection can be achieved by 2-3 doses per year at 5 g/100 kg liveweight each time than from the whole dose given at one time.

(c) *Cu bullets:* Glass bullets which supply Cu are available (COSECURE; ALLTRACE). The bullets(2) are given orally by a special bulleting gun. The special glass matrix is slowly soluble in the reticulo-rumen and releases its supplement over a period of about 6-10 months. COSECURE (2 bullets to calves to 108 kg at the start of the trial) gave satisfactory Cu levels in cattle on an Irish high-Mo farm for at least 6 months. The daily release of Cu from 2 ALLTRACE bullets (160 mg Cu/day compared with 149 mg Cu/day from 2 COSECURE bullets) should also be adequate for calves in severely Cu deficient herds and for stores in marginally deficient herds. Cows or adult cattle in severely Cu-deficient herds may need 4-5 COSECURE or 4-5 ALLTRACE bullets per year.

IODINE DEFICIENCY

Feed iodine: I is needed for synthesis of thyroid hormones. Goitrogens (I-antagonists) reduce the uptake of I by the thyroid and synthesis of thyroid hormones is disturbed. Cattle diets need at least 0.4-0.8 mg I/kg DM to maintain normal I status in the animal but if goitrogens are present, dietary I may need to be 2-4 mg/kg DM to maintain normal I status. Average Irish herbage is low in I (<0.2 mg/kg DM) and goitrogenic feeds (rape, kale, linseed, turnips, beet products, etc.) are often used.

Symptoms: 10-60% Calf mortality (non-specific abortion, still-birth, neonatal calf deaths); thyroid enlargement (also in Se deficiency) in calves; greater than 10% retained placenta; infertility (especially sub-oestrus); lower milk yield, illthrift in calves and yearlings; lowered herd immunity to infections.

Diagnosis is based on the history, clinical signs and post-mortem findings. It is confirmed by blood, milk and feed tests and by a dramatic response to I supplementation.

During the period 1978-1988, many different tests in cattle blood were attempted: Total I, plasma-bound I (PBI) and thyroid hormones (T3, T4). These tests were abandoned because they were too difficult to interpret. Now the tests are for Milk I (MI) or Plasma Inorganic I (PII).

Mineral mixes high in I can control or mask I deficiency. Most calved cows on commercial rations or high I mineral mixes receive some supplementary I. For example, calved cows on commercial mineral mixes may get 12-90 mg I/cow/day from the mix. The I status of pregnant cows, which often receive no mineral supplement, may differ from that of calved cows. Therefore, PII values in calved dairy cows on winter rations usually are higher than in pregnant dry cows or cattle on maintenance rations. PII values in calved cows may be higher

(2) COSECURE: Cooper Pitman-Moore, contains 13.4% Cu by weight, average weight 100 g/bullet. ALLTRACE: Agrimin, contains 22.6% Cu w/w, average weight 85 g/bullet.

than in supplememted dry cows. Therefore, in investigating problems of late abortion/stillbirth/neonatal mortality/retained placenta, samples from dry cows are required. In investigating infertility or illthrift, samples should be taken from the "at risk" group during the problem period. Delay in sampling may cause an increase or decrease in I level, depending on I intakes in the days before sampling. PII levels vary between samples from the same group of animals. Thus, it is preferable to test 10 plasmas for a good assessment of herd I status.

Milk I (MI): Milk samples from the bulk tank are used. This is a good test if the farmer can guarantee that no I containing teat dips or disinfectants have contaminated the milk. (It is safer to remove I disinfectants from the dairy for 3-4 days before bulk milk is sampled for the MI test).

Normal values are greater than 50-500 ng/ml. Values less than 20 ng/ml are classed as very low. However, normal NI values in supplemented cows (such as those on balanced rations) may not reflect a much lower I status in unsupplemented dry cows or other stock.

Plasma Inorganic I: PII is very reliable and repeatable. However, it is a slow, tedious test, requiring 2 full days of skilled technician time to complete 4-5 herd tests (40-50 blood tests). Normal values are 100-300 ng/ml. Values less than 20 ng/ml are classed as very low. PII is very sensitive to recent I intake. After oral supplementation PII levels rise within 24 hours. After removal of supplement, levels fall to less than 25% of peak value within 3 days and fall back to control levels inside 15 days.

In the past 2 years, PII in cattle from many counties has been analysed including Carlow, Cavan, Clare, Kerry, Kilkenny, Meath, Sligo, Tipperary, Waterford, Wexford, Wicklow. In the absence of I supplements, 33-70% of cattle herds had low to very low PII.

Control and prevention of I deficiency: An oral supplement of 8-12 mg/day (equivalent to 0.53-0.80 mg I/kg total feed DM) should ensure normal I status in adult cows in the absence of goitrogens. For cows on goitrogenic feeds, I supplements may need to be increased to 30-60 mg I/day (equivalent to 2-4 mg I/kg total feed DM). For example, 100 g/cow/day of a mineral mix with 500 mg I/kg would supply 50 mg I/cow/day. Alternatively, trough water could be medicated with 0.5-1.0 ml of 5% tincture of iodine/cow/day (7 ml/cow/week) or with chelated I (guaranteed to stay in solution). This would provide 25-50 mg I/cow/day. Doses for other stock are shown in Table 1.

Oral supplements as stated above or 4-7 ml of 5% tincture of I painted or sprayed onto the thin skin of the pocket of the flank fold once per week for 5 weeks before calving or breeding in cows, are the preferred options.

Veterinary I supplements include I bullets and I injections. These are not recommended for cows for the following reasons:

I bullets: Special glass bullets are available commercially[(3)]. The bullets are given orally by a special bulleting gun. The special matrix is slowly soluble in

(3) - ALLTRACE: Agrimin, contains 0.3% I by weight, average weight 85 g/bullet. The latter also contains 16.7% Zn, 10.4% Mn and vitamins A, D3 and E.

the reticulo-rumen and releases its supplement over a period of about 6-10 months. The daily release (2.2 mg I/day) from 2 ALLTRACE bullets would not be adequate for stores or adult cattle under Irish conditions. To provide 25 mg I/cow/day, about 22 ALLTRACE bullets would be needed. Addition of 0.5 ml of 5% tincture of iodine/cow/day to the trough water would supply 25 mg I/cow/day.

I injections: The injection of oil-based I compounds in ewes in early pregnancy has reduced the incidence of goitrous lambs in some trials abroad. The product is slow-acting and there is little published evidence that it prevents neonatal problems in cows.

OPTIMUM SUPPLEMENTATION LEVELS OF TRACE-ELEMENTS

Levels of mineral supplements advised by different National Advisory Groups (such as ADAS, Scottish Agricultural Colleges, DANI, NRC (USA), etc.) vary considerably. These have been adapted to Irish conditions.

Because of the higher requirements of Irish cattle for Cu and Se suggested levels of these are higher than "international standards". The rates given below are guidelines for Irish conditions. The higher levels are advised in groups at risk of severe deficiency. The lower levels are for routine use if supplements are thought to be needed, with the following exceptions:

* Ionophores (monensin, etc.) increase the retention rate of Cu and Se by ruminants. If ionophores are fed, avoid the higher levels of Cu and Se supplements unless blood test suggests that higher levels are needed. Within 5 miles of known Se toxic farms, the Se supplement should be reduced to about 50% of the lower level unless blood test confirms Se deficiency in the group.

**ZN supplement of up to maximum is advised if high Ca diets are fed.

Table 1
Suggested optimum supplementation levels of trace elements for stock

	(mg supplied/head/day)						
Type of animal	CU*	Se*	I	Co	Mn	Zn**	Fe
Dry cows	150-450	3.6-7.2	12-60	5-10	335-415	335-750	0-300
Suckler cows	150-450	3.6-7.2	12-60	5-10	335-415	335-750	0-300
Cows in milk 650 kg	150-450	3.6-7.2	12-60	5-10	335-415	335-750	0-300
Cattle 550 kg	150-400	3.6-7.2	6-60	5-10	225-415	335-750	0-300
Cattle 400 kg	109-291	2.6-5.2	4-44	4- 7	240-300	240-545	0-220
Cattle 250 kg	68-182	1.6-3.3	2-28	2- 4	150-188	150-341	0-138

In the absence of other mineral sources, such as in compound ration or as veterinary medication, supplements for long-term routine use which provide less than the minimum amounts of trace-elements in the daily intake are inferior.

SUMMARY OF CONTROL OF Cu AND I DEFICIENCY IN CATTLE

	Cu	**I**
Increase amount in total diet DM by the following amount	10-30 ppm	1-4 ppm Dm
Water medication (*)	+	+
Cu oxide Bolus	+	–
Cosecure/Alltrace bullets	+	–
Injection	CuEDTA	– (?)
Skin application (flank-fold pocket)	–	+
Soil fertiliser	–	–

(*) Chelated minerals in solution

The main methods of supplementation are : (1) veterinary products; (2) oral supplements.

(1) **Veterinary products:** If the correct doses are used, most veterinary products give fast control of existing clinical or subclinical problems. They are reliable supplements for animals fed no concentrates at grass. Cu injections or CuO boluses can be economically cost-effective if only one deficiency exists (say Cu only) but the cost of using combinations of veterinary products would be expensive for routine prevention of multiple trace element deficiency. Once the problem is stabilised, dietary supplements (in the feed, water or mineral mixes) can be used especially in winter or in animals fed some concentrates at grass.

As a means of treating an existing clinical or sub-clinical I deficiency, oil-based I injections are controversial. They can be slow to act. I-glass bullets could be effective orally if they could release 25-60 mg I/day in cows but 22-54 ALLTRACE bullets would be needed to supply that amount/cow/day. Oral I compounds are the most practical and effective means of treatment and long-term prevention of I deficiency.

(2) **Oral supplements:** Inclusion of adequate amounts of minerals in the ration or sprinkled on the feed is the cheapest method but this may not suit some clients. Free access to (but fixed-rate provision of) well balanced mineral mixes is the next cheapest method. Oral minerals can be supplied in the diet (in concentrates, in carriers, in the silage), in the water (if formulations can be designed to remain in soluble form), or in mixes, blocks or licks. Supplementation of concentrates is the best method but farmers may not want to feed concentrates and it presents problems for compounders. It is impossible to formulate one ration which will meet different feeding levels.

To cater for varying feeding rates, compounders would need to stock at least two rations for cows: one ration with twice the mineral and vitamin levels of the other. For example, dairy Ration A could contain 75 ppm Cu and 13 ppm I. Dairy Ration B could contain half of those levels (37.5 ppm Cu and 6.5 ppm I). Farmers feeding 3-5 kg/cow/day could opt for Ration A, supplying 225-375 mg Cu and 39-65 mg I/cow/day. Farmers feeding 7-9 kg/cow/day could opt for Ration B, supplying 263-338 mg Cu and 45-59 mg I/cow/day. Notice that at the middle feeding level of each ration (4 kg of Ration A; 8 kg of Ration B), the Cu and I supplies/cow/day are identical, 300 mg Cu and 52 mg I/cow/day respectively.

Farmers feeding a 6 kg ration could buy a 50:50 mix of Ration A and B. This 50:50 mix would contain 56.3 ppm Cu and 9.75 ppm I and 6 kg would supply 338 mg of Cu and 59 mg I/cow/day.

The "double strength principle" can be applied to all mineral-vitamin supplementation rates, i.e. one ration (to be fed at 3-5 kg/day) could contain twice the mineral-vitamin levels of the other ration (to be fed at 7-9 kg/day) and farmers feeding 6 kg could feed 50/50 of each. In this way, the actual amounts of mineral-vitamin fed per head per day can be brought much closer to the desired amounts. Double strength rations should be clearly marked: "High in minerals and vitamins. Feed only to ... (specific animal type). Feed only at ... to ... kg/head/day (the recommended feeding rate)".

FREE CHOICE (ad libitum) INTAKE OF MINERAL-VITAMIN SUPPLEMENTS

Self-service from a range of mineral mixes or ad-libitum intake of one mix or block is undesirable. Free choice intake is in the interest of suppliers and manufacturers rather than of farmers. It greatly increases intake and intake by some animals can be too high.

A high mean intake figure can mask wide cow-to cow variation in intake. Mean intake of a molassed high-Cu (2000 ppm) block may be 150 g, supplying a mean of 300 mg Cu/cow/day. This looks ideal for control of copper deficiency. However, individual cow-to-cow intakes may vary from 0-400 g/cow/day, with no plateau or clumping around 150 g. Even allowing cut-off points for maximum variation of 20-380 g, cow-to-cow variation in intake can be up to 19-fold. As the ratios of all components in a given block are fixed, a 19-fold variation in block intake means a 19-fold variation in intake of each mineral and vitamin component. For instance, in cows eating 20-380 g of block/day, the range of Cu intakes by individual cows would be 40-760 mg/cow/day. Those getting less than 150 mg Cu/day would be under-supplied with Cu (not fully protected) and those getting > 450 mg Cu/day would be over-supplied with Cu (at risk of chronic Cu poisoning after some months).

Unless cow-to-cow variation in intake can be held in a 2-4 fold range, free choice intake of licks, blocks, mixes or other oral sources is against the farmer's best interest on the basis of cost and on the basis of precision of control on min/vit intake.

The role of mineral blocks: The main role of blocks is to act as carriers of minerals, etc. to cattle at pasture. Unrestricted access to blocks can lead to very high intakes in spite of very wide cow-to-cow variation in intake. The use of blocks is not the best way to supplement housed/yarded animals. More even intake of minerals can be ensured by incorporating mineral mixtures into concentrates, sprinkling a half day's allowance twice daily on easy-feed silage, or using a small amount of palatable carrier. The fixed rate intake system of mineral mixes is cheaper than blocks and can give more precision in the control of intake of supplement.

FIXED RATE INTAKE OF MINERAL SUPPLEMENTS

In this system, the supplement is prepared so that the desired amount of each individual is present in a pre-determined amount of mix. The correct amount of mix is fed to individual animals (or on a group basis to the herd) each day.

Carriers for mineral/vitamin supplements: If concentrate rations are not fed to ruminants at grass, min/vit supplements may be fed in small amounts of a palatable carrier, for example, molassed rolled or crushed barley, grassmeal, beetpulp or pollard. Cows, adult cattle and yearlings could be fed 458 g/head/day of medicated carrier. Weanling cattle could be fed 229 g, ewes and yearling sheep 140 g and weaned lambs 70 g.

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Understanding Probiotics

R. J. FALLON

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The importance of maintaining and regulating the balance of intestinal micro-organisms in young calves has been recognised for many years. There are approximately 1000 million bacteria per gram of intestinal contents in a healthy calf. Research has shown that nutritional or environmental stresses can create an imbalance in the population of micro-organisms present in the intestine allowing pathogenic bacteria such as coliforms to multiply and overwhelm beneficial bacteria such as lactobacilli. When this occurs disease and/or poor performance may result. Over the past number of decades the common practice has been to minimise the causes of stress and at the same time use antibiotic preparations to suppress non-desirable micro-organisms. In recent years concern over antibiotic residues in milk and meat and bacterial resistance to antibiotics has led to interest in using probiotics to maintain or regulate the balance of intestinal micro-organisms.

The probiotic concept

The term probiotic was first used in 1974 and is derived from two Greek words meaning "for life". Probiotics encourage beneficial bacteria to grow and multiply. In contrast the aim of antibiotics are to kill the pathogenic bacteria. It has been proposed that probiotics will increase the population of "desirable" micro-organism in the gut. Most probiotic preparations are based on viable micro-organism of *Lactobacillus* and/or *Streptococcus faecium*. Both of these are referred to as the lactic acid producing bacteria. Probiotic preparation may also be based on spore forming *Bacillus subtilus*.

Finding a successful probiotic

The EC is currently preparing regulations controlling the use of probiotics in calf and other young animals. It is expected that only probiotics showing positive effects on animal performance will be allowed. For a probiotic to exert a positive response it must successfully grow and colonise the intestine. A successful probiotic must have the bacteria with the ability to adhere to cells which form the lining of the stomach and small intestine thereby preventing coliforms inhabitating the same site. The probiotics must have the ability to secrete adequate quantities of lactic acid. For successful colonisation of the intestine the micro-organism present in the probiotic must have the ability to tolerate low pH in the stomach and high contractions of bile in the upper small intestine and multiply rapidly in the intestinal environment. It is essential that the probiotic contains sufficient numbers (approximately 10 billion per gram of product) of viable bacteria capable of consistently demonstrating a positive response when given to young calves.

Following colostrum feeding in the new born calf a successful probiotic given orally should be capable of populating the calf stomach and intestinal tract with the beneficial lactic acid producing bacteria such that the coliform bacteria capacity to grow is retarded.

Probiotics and calf performance

Currently there is a wealth of commecial literature which claims that feeding probiotics to calves and other young mammals will overcome digestive disorders due to stress and improve feed efficiency or growth rate. In contrast scientific trials using probiotic organisms have often failed to demonstrate their beneficial effects by controlling diarrhoea or by enhancing growth. Studies at Grange Research Centre have evaluated probiotic use in skim based milk replacers over the past number of years, the results of which are summarised in Table 1.

Table 1

Effect of the inclusion of probiotics based on lactic acid producing bacteria in calf milk replacer on growth rate (kg/day)

Product	Year	Feeding Method	No. of Calves	Control	Probiotic	% Response to Probiotic
A	1984	Ad lib	36	0.71	0.67	– 5.6
A	1984	Bucket	20	0.62	0.65	+ 4.1
B	1985	Bucket	30	0.53	0.56	+ 5.1
C	1988	bucket	40	0.71	0.72	+ 1.4
D	1988	Bucket	60	0.55	0.59	+ 7.3
E	1989	Bucket	20	0.49	0.54	+10.2

It is evident from the above results that the responses obtained from the inclusion of probiotic preparation based on lactic acid bacteria in milk replacer diets offered to calves have been inconsistent and failed to live up to expectations.

Why probiotics may not show benefits

There are several reasons why probiotics may not show clear benefits.

1. ***Some contain inadequate numbers of viable bacteria or non-ideal strains of bacteria.*** A survey in the United States in the early 80's found that only 2 of the 15 commercially available probiotic preparations examined had the expected numbers of viable bacteria per gram. More recently a report stated that "some probiotics are supposed to be full of organisms but in reality contain none, many examined were virtually sterile, others have micro-organisms in them but are of the wrong type".
2. ***Inability to survive in the stomach and small intestine.*** The presence of viable micro-organisms in a probiotic is not in itself an indicator of probiotic effectiveness The viable bacteria may be killed by acid conditions in the stomach or by bile excreted in the small intestine.
3. ***Failure to competitively exclude harmful bacteria.*** In order to exert this effect it is necessary that the micro-organisms present in a probiotic prepara-

tion can adhere to the intestine thereby preventing coliforms from adhering at the same site. Acidification of the milk diet offered to calves will normally potentiate the activity of lactic acid bacteria as it creates conditions more favourable for their growth. Coliforms do not grow favourably at a low pH. Alternatively the probiotic micro-organisms could achieve competitive exclusions if they have the ability to multiply rapidly in the intestine.

4. Responses to probiotics are not expected in animals which already have a correct microbial balance between the lactobacilli and coliforms in the intestine tract. In the upper regions of the small intestine of a healthy calf the proportion of lactobacills to coliforms is in the order of 1000 to 1. The corresponding values for a calf suffering from diarrhoea is less than 10 to 1.

CBF Beef Quality Assurance Scheme – A Marketing Opportunity

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The immediate problems facing the beef industry can be summarised under the following main headings– Production, Consumption, Stocks, and Policy. In addition to discussing these problems, I wish to comment on the changing consumer values in Europe and the implications of this for the beef export industry, and to discuss the CBF Beef Quality Assurance Scheme which was launched earlier this year.

Production

Beef production in Europe is high and is likely to remain so for several years to come. This is due to a combination of factors including imports from Eastern Europe, heavier finishing weights, a progressive switch from veal and beef production and of course dairy quotas. The EC is now 107% self sufficient in beef. This can be best illustrated if we take Germany which 20 years ago had a deficit of 10% and now has a surplus of 15%. It is clear that trying to sell beef commercially in these conditions is not easy.

Consumption

Demand for beef in Europe is static or declining. Beef is being challenged by white meats, fish and other protein sources. This is due in part to changing consumer lifestyles and well hyped health issues but more recently it is due to genuine consumer concerns about the safety of what they eat.

Stocks

There are huge stocks of beef overhanging the EC market. Stocks are currently around 800,000 tonnes and are likely to reach 1 million tonnes by the end of the year. Clearly an industry with 1 million tonnes in stock for which there is no ready market cannot be in a healthy state.

Policy

One of the main effects of the proposed CAP reforms in the beef sector is likely to be reduced Intervention support on which the Irish beef industry has been so dependent. It is becoming clear that the era of large scale selling of beef into Intervention is over and that the future viability of the Irish beef industry will increasingly depend on its ability to sell more beef in Europe. We are not saying that we are going to be able to sell all our beef in Europe. There will continue to be a role for Intervention and Third Country trade for some time to come. But we must make an effort to sell more in Europe. In this regard CBF recently set a target that the Irish beef industry should aim to sell at least 60% of its production in Europe and reduce dependence on Intervention and Third Countries to 40%

by 1995. The achievement of this target against the background I have just described will not be easy. It will be especially difficult to attain, given that only 20% of steer production is sold in Europe.

Regarding consumer values, there is ample evidence that the consumer in Europe is changing. The market environment in which we are now operating is radically different from that of even a few years ago. Price, although important, is not necessarily at the top of the list of consumer priorities. What matters more today are the naturalness of the product, its eating quality, safety and the method of rearing and treatment of the animals. Supermarkets are leading the way in this, and not just abroad but in Ireland as well. They want to reassure their customers about the wholesomeness of the product and about how or where it was produced.

The importance of this aspect was emphasised to me in Germany by an advertisement on TV for Herta which is the biggest sausage and processed meat manufacturer in Europe. The AD might well have been set in the West of Ireland – indeed it probably was set in the West of Ireland. The AD said a lot more about the quality of the production environment than it did about the sausage. This is what could be called Quality by association. These are the kind of developments that are taking place in Europe and if we want to sell more beef there we must take them into account.

The CBF Beef Quality Scheme is our strategic response to the issues I have raised. The main purpose of the scheme is to give Irish beef exporters a marketing edge in Europe. We hope to do this by offering a product that has come through a quality assurance procedure and by promoting it vigorously using the positive imagery which Ireland and Irish beef still enjoys abroad. The scheme is based on the belief that the clean green image of Ireland can be a powerful selling point provided we put in place quality systems to demonstrate that we live up to and honour the image that we portray. I want to highlight some of the main areas of the scheme particularly those that are of direct concern to farmers.

THE SCHEME

Membership

Membership of the scheme is voluntary and is open to all beef processing companies operating E.C. approved plants and their overseas customers. Processing plants must pass a pre-admission inspection in order to be eligible for the scheme.

Product

Eligibility for the scheme is confined to steers and heifers only within the classification range EURO/234L. Animals must be less than 30 months old, free from disease and sourced in the Republic of Ireland.

Who can supply?

Any farmer can supply cattle to the scheme provided he/she signs the Producer Register in any participating meat plant and observes a Code of Practice that has been specially drawn up for the scheme (see over). It is designed so as to reassure the customer as to the origin and integrity of the product.

I would like to refer in particular to two aspects of the producer register form, i.e. Code of Practice and Testing in Meat Plants.

- *Code of Practice*

  Farmers who sign the supplier register form in their meat plant should normally receive a copy of the Code of Practice. If this is not done they will get a copy at a later stage from Teagasc. Every farmer who signs the register will in due course have his/her farm inspected by the local Teagasc advisor. The advisor will follow a standard procedure/questionnaire covering the main aspects of the Code of Practice i.e. stockmanship, pasture management, housing, water and diet, animal welfare, lighting, veterinary care, farm safety and records. The Code of Practice is not difficult and is no more than what any good farmer should be doing. If a farmer fails an inspection he/she may be re-inspected a second time.

- *Testing in Meat Plants*

  When a farmer signs the supplier register form he/she is undertaking not only to observe the Code of Practice but is also acknowledging that he/she may be subject to increased levels of residue testing in meat plants. The testing that is carried out as part of the CBF Scheme is in addition to that being done routinely by the Department of Agriculture. If a sample fails a residue test the supplier in question is removed from the producer register. The Department of Agriculture will be informed and appropriate action will be taken. Analyses of animal tissue are being carried out on behalf of CBF by the National Food Centre.

  Both the farm inspections and the residue testing are vital to the credibility of the scheme as we want to be able to reassure the customer that the product we are promoting has come from a producer who has opened his/her farm and livestock to independent inspection and testing.

  These are the main aspects of the scheme that concern the farmer. I would like to refer briefly to what happens in the meat factory and beyond.

- *Meat Plant*

  In the meat plant carcases from registered suppliers are specially identified. The factory must follow strict procedures especially in regard to handling, chilling, boning, packing, and labelling. In particular carcases for the scheme must be chilled slowly to avoid cold shortening and so ensure that the meat is tender. In the boning hall (whether in Ireland or with a customer abroad) carcase numbers are code recorded and special code numbers are assigned to each batch. These code numbers are recorded on the boneless cuts by means of a special label that goes inside the vacuum packed bag.

  In this way boneless cuts can be related to the carcass from which they were derived and in turn right back to the farm. This aspect of traceability of the product is an essential element of the scheme as retailers are beginning to demand that the product can be traced back to its source if necessary. The product must be stored and transported subject to rules laid down in the scheme.

– ***Retailer***

Retailers who are part of the scheme must, like factories and farmers undergo inspections to make sure their outlets reach a certain standard. They are required to dedicate a special section of the meat counter to Quality assured Irish product. They must identify the product at the point of sale with our new Quality Irish logo which has been registered in all target markets.

– ***Promotion***

Quality assured beef from Ireland will be vigorously promoted (is already being promoted in those chains that are members of the scheme) highlighting the standards the product has achieved. A comprehensive promotional package has been assembled to create an awareness of Quality Irish beef and hopefully boost sales.

The main elements of this promotional package include

– In-store sampling and consumer competitions;

– Intensive public relations compaign to promote Quality Irish Beef amongst key trade publications, food writers, and other relevant correspondents;

– Butcher training on better and more attractive meat presentation and specially designed high quality P.O.S.

– ***Monitoring and Control***

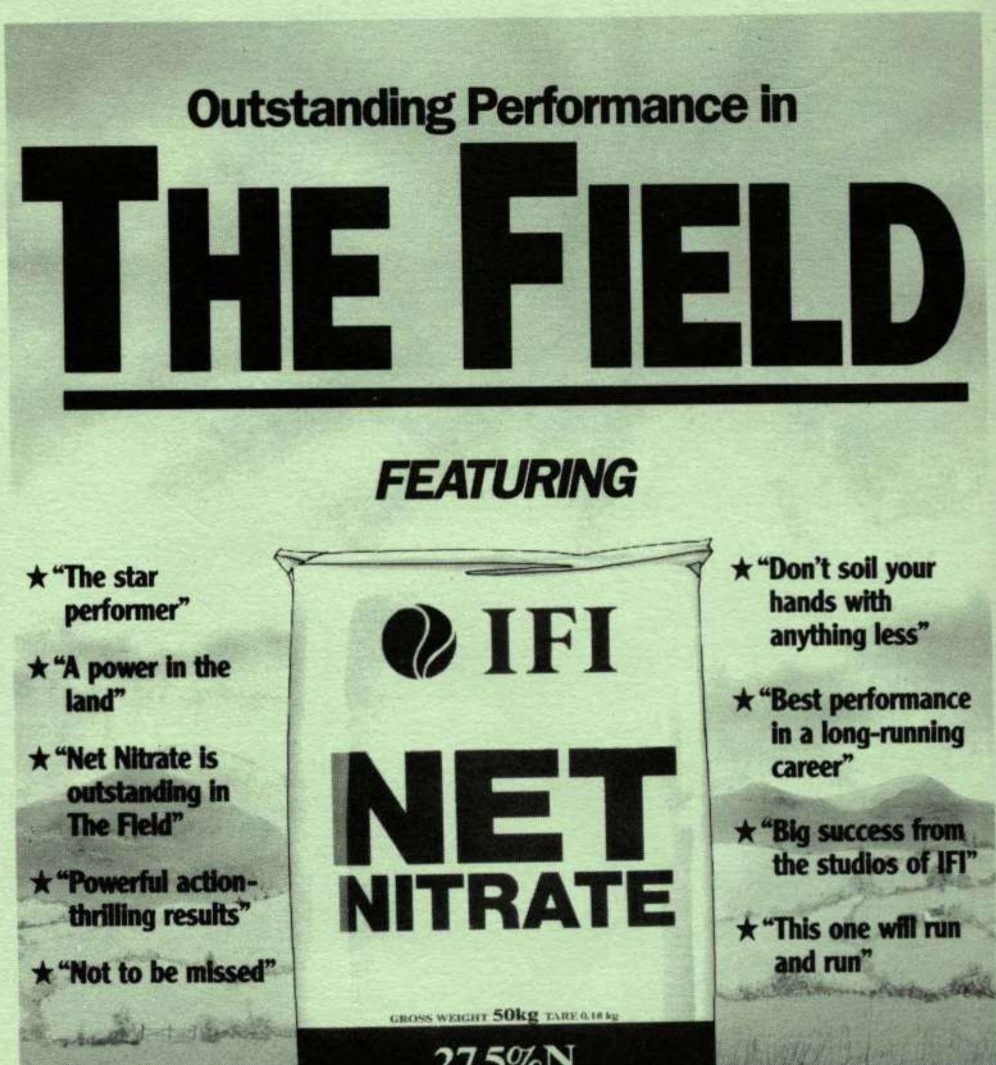
The Beef Quality Assurance Scheme is administered by the Quality Assurance Division within CBF. All the critical control points are policed by the CBF Inspectorate. If a meat plant or a retailer breach any of the rules they may forfeit membership of the Scheme and the use of the Quality Mark will be withdrawn.

Conclusion

The CBF Beef Quality Assurance Scheme is a partnership between the farmer, the meat factories and the retailer. We want it to be a relationship where the partners will be loyal to each other and build their business together over time. The farmer however is the key to the success of the scheme as he controls the quality of the livestock and the environment in which they are reared.

The scheme presents us with an opportunity to turn adversity into advantage. We all know that our island location removed as it is from the European mainland results in extra transport and other costs. The challenge now is to turn this commercial obstacle into a monetary advantage by demonstrating that our claim to be a clean island producing natural wholesome food is not just a subjective claim but an objective reality.

NOTES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