CONTRIBUTION OF AGRISEARCH FUNDED RESEARCH AND DEVELOPMENT TO THE NORTHERN IRELAND DAIRY SECTOR

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I N D E X

EXECUTIVE SUMMARY

Economic benefits

The contribution of AgriSearch funded research and development to the Northern Ireland dairy industry has been undertaken following the economic appraisal guidance contained in *Appraisal and Evaluation in Central Government (HM Treasury)* – The Green Book. The financial appraisals for each of the AgriSearch programmes are based on the determination of Net Present Values (NPV's).

The key points of the financial evaluations are: -

- AgriSearch funding of dairy programmes (£1.80 million over 22 projects) at the AgriFood and Biosciences Institute, Hillsborough (formerly ARINI) has been key in maintaining and developing production research for the dairy industry in Northern Ireland.

- £2.15 of match funding has been obtained for every £1 of AgriSearch funding.

- The Net Present Value (over a 6-year period) of the 16 completed programmes part-funded by AgriSearch amounts to £29.7 million (Table 1). Overviews of each of the projects are presented in the main body of this paper, including details behind the calculation of each of the NPV's. The net benefit of one of the projects – Expanding output in environmentally friendly systems – relates to the public good. Excluding this benefit, the NPV's of the projects for the dairy industry in Northern Ireland stand at £23.4 million.

- Net Present Values have been predicted for 4 out of 6 of the projects currently being undertaken at AFBI, Hillsborough. The NPV's for these 4 programmes amount to £1.8 million (Table 2). The remaining 2 programmes are awaiting longer-term data which, when available, will be used to determine financial benefits. Again details of the projects including the determination of NPV's are presented. Projects commissioned during 2006 are listed in Table 3.

- It is recognised that the NPV's for each of the programmes are highly sensitive to the rate of adoption of the research by dairy producers. In the

current analyses, conservative rates of adoption, normally 10%, have been taken. However, in some areas for example, heifer rearing, it is recognised that uptake of research has been low and consequently an adoption rate of 5% has been used. Research to underpin improved transfer of dairy heifer research into practice is underway and has the potential to significantly increase the financial benefits of this work. Indeed it is planned that the findings from research in this area will underpin improved technology transfer for all AgriSearch funded programmes.

- To-date DARD has co-funded the majority of projects funded by AgriSearch. It is considered that without AgriSearch funding, and the endorsement from the industry that is attached, the majority of these applied programmes would not have been undertaken.

- The financial estimates in this paper indicate that AgriSearch is getting a substantial return on its investment in research. AgriSearch is interested in industry feedback to improve the estimates and explore alternative assumptions and baselines. It is intended to extend the use of quantifiable methods where suitable data and robust methods can be demonstrated.

Non-monetary benefits of research projects:

While the direct financial benefits of some research projects can be calculated, many projects result in very substantial benefits that are not financially quantifiable. These non-quantifiable elements include: -

- **Improved negotiating positions**: During recent negotiations with the EU, Northern Ireland was able to provide a scientific basis to the proposed dairy cow 'nitrogen excretion' values, and highlight that reductions in dairy cow diet phosphorus levels were already being implemented as an outcome of ongoing research. This has significantly improved our negotiating position with the EU and resulted in a more appropriate Nitrates Directive Action Programme in Northern Ireland.

- **Reducing the environmental footprint of dairying:** A primary objective of a number of the programmes is to minimise the environmental consequences of dairying e.g. expanding output in an environmentally friendly manner and reducing nitrogen outputs to the environment from dairying systems. The primary objective in other programmes is to increase production efficiency through increasing dairy cow survivability, improving winter-feeding and summer grazing systems. By increasing production efficiency, the environmental impact of dairying is reduced through improvements in nutrient utilisation thereby reducing greenhouse gas emissions (principally methane) and nitrogen and phosphorus outputs to the environment.

- **Provision of information/options that allow farmers to make informed decisions:** Each of the studies commissioned by AgriSearch has provided important information for producers on which to base decisions. Examples include: -

  A recently completed study indicated that the profitability of four different production systems (concentrate inputs ranging from 1.0–2.5 t/annum: stocking rate ranging from 2.3–3.3 cows/ha) were virtually identical, providing systems were managed appropriately.

  A study on Holstein bull beef production demonstrated that bull beef production on high concentrate diets is uneconomical without a major increase in beef prices. Results from this research highlighted that good quality meat could be obtained from Holstein bulls and that at heavier slaughter weights a high proportion of joints could achieve premium supermarket specification.

- **Improved animal welfare:** While improving welfare (for example reducing lameness) may have a direct financial benefit, the indirect benefit to the animal and to consumer perception is very real, although non-quantifiable.

- **Improvement in public good:** While the direct financial benefits of environmental improvements have been quantified, these also have an

indirect non-quantifiable ‘public good’ value – particularly in terms of reducing the impact of milk production systems on the environment.

- **Improved farmer lifestyle:** A number of studies have been conducted to examine options for reducing labour inputs on dairy farms. While these may not have a financially quantifiable benefit, their adoption will result in an improvement in farmer lifestyle.

Table 1. Estimated NPV's of completed AgriSearch projects

Project	AgriSearch Funding (£)	Total cost of project (£)	Net Present Value (£)
Research reviews			
Milk Composition Review Booklet	1 000	4 250	1 204 934
Research review – reducing the costs of milk production	8 000	8 000	747 740
Increasing dairy cow survivability			
Survivability of dairy cows	30 000	120 000	1 586 485
On-farm evaluation of Norwegian cows	258 750	517 500	
On-farm evaluation of crossbreeding	166 400	332 800	
Improved dairy herd fertility	270 000	706 500	
Optimum milk production systems			
Improved regimes for rearing dairy herd replacements	67 500	135 000	4 555 800
Comparison of 4 grassland systems	82 800	324 650	431 090
Environmental benefits			
Expanding output in environmentally friendly systems	85 975	429 875	6 241 485[2]
Reducing organic N outputs	103 150	190 000	8 357 680
Developing improved winter feeding systems			
Improved methods of rationing cattle	18 000	805 000	2 097 042
Alternative forages for dairy cattle	25 000	100 000	2 375 700
Developing improved grazing systems			
Supplements at pasture	24 000	32 400	994 364
Grass check			
Grass Check 1	60 100	195 740	1 042 400
Grass Check 2	75 000	181 860	
Holstein bull beef production	12 225	12 225	73 773
Total for 16 projects	**1 287 900**	**4 095 800**	**29 708 493**

[1] Financial benefit for the public good

Table 2. Projected NPV's of AgriSearch projects currently underway

	Cost to AgriSearch (£)	Total cost of project (£)	Predicted Net Present Value (£)
Factors affecting the development of lameness	140 000	281 700	423 844
Beef progeny from the dairy herd	71 610	574 100	221 636
Management/nutrition of neonatal calves	74 510	149 020	991 164
Alternative forages for summer slurry utilisation	54 263	108 526	144 791
Total for 4 projects	**340 383**	**1 113 346**	**1 781 435**
Optimum NI milk production systems	50 000	101 000	Not yet available[1]
Develop supplementation strategies for dairy cows	121 385	364 155	Not yet available[1]
Total for 2 projects.	**171 385**	**465 155**	

[1] Will be determined as soon as data on long-tem effects of supplementation become available

Table 3. New project proposals - agreed in 2006

	Cost to AgriSearch (£)	Total cost of project (£)
Protein for dairy cows	97 300	194 600
Grass growth and utilisation (joint Teagasc and CAFRE)	104 000	297 421
Comparison of 3 contrasting systems of milk production	208 000	596 216
Improved heifer rearing on farms	88 000	190 810
Total for 4 new projects	**497 300**	**1 279 047**

RESEARCH REVIEWS

Milk composition review booklet

Research review – reducing the costs of milk production

MILK COMPOSITION REVIEW BOOKLET

Background

Milk composition is important to dairy producers due to current milk pricing schemes. However, the composition of milk produced on Northern Ireland dairy farms is considerably lower than in many other EU countries. For example, while milk produced in Northern Ireland has a mean fat and protein content of 3.85% and 3.22%, respectively, the equivalent values for milk produced in the Netherlands is 4.43% and 3.46% respectively. The importance of this lies in the fact that farmers are paid based on the fat and protein content of the milk produced. For example, if the composition of milk produced in Northern Ireland was increased to a similar level to that in the Netherlands, this would increase the value of milk produced by Northern Ireland dairy farmers by an additional £27 million per annum.

While it is recognised that a large number of factors, such as stage of lactation, age of cow, cow health and genetics, can influence milk composition at farm level, nutritional factors are perhaps most important. In addition, this is an area that farmers have considerable control over.

To address this issue, a booklet entitled 'Improving milk composition during the winter feeding period through feeding', was produced to highlight practical nutritional techniques for improving milk composition. This booklet primarily focused on research conducted at The Agri-Food and Biosciences Institute – Hillsborough (formerly The Agricultural Research Institute of Northern Ireland).

Main findings

The booklet highlighted that there is considerable potential to alter milk composition by feeding during the winter period. For example, Hillsborough studies have shown that milk protein can be increased by up to 0.52%, from 3.04 to 3.56%, by improving silage feed value and increasing the level of starch in the concentrate. The key factors highlighted to increase milk protein content were: -

a) Maximum use of grazed grass
b) Production of high digestibility, high intake grass silage
c) Feed high starch concentrates
d) Consistent production of high starch maize silage

Similarly, the booklet highlighted the potential to reduce milk fat content in a quota situation. For example, research has shown milk fat content to be reduced by 1.5%, from 4.21 to 2.72%, by inclusion of fish oil in the diet, consequently increasing the volume of milk which can be supplied in a given quota situation by 27%. The key factors highlighted to decrease milk fat content were as follows:

a) Feed fish or soya oil in the diet
b) Supplement with high starch concentrates
c) Avoid high dry matter grass silage

Furthermore, good animal husbandry e.g. ensuring animals have free access to grass silage or well managed grass swards, and avoiding excessive changes in body condition during lactation, is the most important and least expensive factor which affects all aspects of animal performance.

Key outputs

The key output of this project was the production of a booklet entitled 'Improving milk composition during the winter feeding period through feeding'. This booklet was circulated to all dairy farmers who contribute to the dairy levy. In addition, Drs Tim Keady and Sinclair Mayne spoke at a number of farmer meetings around Northern Ireland, and to many farmer groups at the Institute, highlighting the key points covered in the booklet in relation to improving milk composition.

Assumptions made in calculating NPV

1. Although milk quality has in fact declined in the years since the booklet was produced, this is likely a consequence of changes in cow genetics, and adverse climatic conditions encountered during a number of years, rather than for nutritional reasons.

2. It is in fact extremely likely that nutritional improvements have in fact helped slow the rate of decrease in milk composition in recent years.

3. Northern Ireland milk quota in 1998 (when the booklet was produced) was approximately 1450 million litres @ 3.96% fat and 3.22% protein.

4. Shortly after the booklet was produced, the Northern Ireland milk pricing scheme was changed, so that reducing the fat content of milk in fact resulted in a financial penalty. Thus the booklet is assumed to have had no impact on milk fat content, and as such no financial impact has been assumed as a consequence of changes in milk fat content.

5. With regards to improving milk protein content, the booklet highlighted many simple options by which milk protein content could be improved. The majority of these could be easily adopted by the vast majority of Northern Ireland dairy farmers without any additional cost, and with minimal effort. However in this analysis, the assumed level of uptake by farmers is 10%. The booklet highlighted that milk protein content could be improved by 0.52% units relatively easily. However, in this analysis a much lower improvement in milk protein content (0.05%) was assumed.

6. Assuming a base milk price of 18.0 pence per litre, and based on today's pricing scheme (an additional 0.32 pence per litre for each 0.1% increase in milk protein content, above a base level of 3.18%), the value of each litre of milk produced would increase from 18.06 to 18.22 pence per litre.

7. When this increase is applied to 10% of the 1998 milk quota (145 million litres of milk), the annual benefit to the dairy industry can be calculated as £232,000 per annum.

8. The costs of the research programmes reviewed in this booklet were not taken into consideration.

9. Based on these assumptions, the NPV of the project over a 6-year period is estimated at £1,204,934 (Appendix A).

RESEARCH REVIEW – REDUCING THE COSTS OF MILK PRODUCTION

Background

Lower milk prices over the past few years have resulted in lower profit margins in dairying than during the late 1980's and early 1990's. This can be attributed to many factors, including an enlargement of the European Union, and the liberalisation of world trade. Within this context, minimising the cost of milk production is vitally important to maintain a profitable and vibrant dairy industry in Northern Ireland in the future.

High calibre research undertaken locally has played an important role in providing sound scientific and technical information which has been used to improve efficiency and reduce costs within the dairy industry. Research undertaken in other countries can also be of considerable relevance to milk producers in Northern Ireland. Consequently, AgriSearch commissioned a review of research findings which are relevant to the Northern Ireland dairy industry.

At the initiation of this project it was realised that there is often considerable variation in the results of individual experiments, depending on the type of cows involved, the management of the cows, the constraints imposed within an experiment and climatic conditions, including the variation in climate from year to year within one location. Consequently, results of an individual experiment may only be applicable to a situation with the same constraints and management which were in operation within that experiment. For this reason it was realised that it was vitally important for milk producers to have access to research information from as wide a range of experiments as possible, so as to obtain a good overall picture of what is likely to be applicable in a wide range of farm situations.

The key objective of the project was to provide a sound technical basis on which decisions can be taken to help to reduce the cost of producing milk, and thereby maximise the profitability of the dairy enterprise on most Northern Ireland farms.

Main findings

A review was undertaken by Dr Raymond Steen, former head of Beef Research at Hillsborough. In the preparation of this review, the results of approximately 600

experiments on dairying were reviewed, with the results of 350 to 400 of these (those considered most relevant to the Northern Ireland dairy industry), presented in the review. The circumstances under which different responses to various inputs are likely to be obtained was also discussed. The information presented relates to a wide range of dairying systems, ranging from those based almost entirely on grass with modest milk yields, right through to high-input systems involving cows producing 10,000 to 12,000 kg of milk/cow. Consequently, the information presented in this review was applicable to a very wide range of farm situations in Northern Ireland.

The focus of the booklet was clearly on reducing the cost of milk production across the complete dairy system. As detailed below, a 14 chapter review was produced, with the key findings of each chapter clearly summarised at the end of each chapter. Some of these key findings, with a very clear economic focus, are highlighted below:

……These findings indicate that for cows which are on grass-based systems of dairying, and given high-forage/low-concentrate diets during early lactation, aiming for a condition score of 3.0–3.5 at calving should maximise profitability (Chapter 1)

……If dry cows are given bad silage which results in a low intake so that the cows are losing body condition during the dry period, giving them sufficient concentrates to prevent this loss of condition is likely to be economically advantageous (Chapter 2)

……When medium genetic merit cows were given good quality silage with an average D-value of 71%, profitability was maximised when they were given 7.0 kg concentrate/cow/day (Chapter 3)

……Increasing the crude protein content of concentrates given to medium merit cows receiving 7.6 kg of concentrate/cow/day, from 13 to 21%, produced an economic response in milk production (Chapter 4)

……Complete diet feeding can require additional investment in buildings and can affect labour costs (Chapter 5)

……On the basis of the costings given, the cows given the higher digestibility silage and lower input of concentrates produced a higher profit margin over feed costs (Chapter 7)

……Cows which were producing less than 25 kg of milk/cow/day and which had an adequate supply of grass did not produce an economic response to concentrate supplementation (Chapter 10)

……Early grazing in spring can make a significant contribution towards reducing the cost of producing milk at this time of year (Chapter 11)

……Overhead costs for buildings are likely to be lower for high merit cows while overhead costs for machinery and equipment are likely to be higher for high merit cows (Chapter 13)

Key outputs

The main output of this review was a 102-page review entitled 'Using research to reduce the costs of producing milk'. This exceptionally high quality summary of key research findings was divided into 14 separate chapters, with each chapter examining a number of key issues. The chapter headings, presented below, emphasise the focus of the book in terms of reducing the costs of milk production. The review was produced in the form of a CD Rom, and this was circulated to all dairy farmers who contribute to the dairy levy.

Chapter headings and sub headings:

Chapter 1 Feeding dairy cows before calving to prepare for the next lactation

- The effects of level of feeding or energy intake during late pregnancy and body condition at calving on the performance of cows given high-energy diets during early lactation
- The effects of level of feeding during late pregnancy and body condition at calving on the performance of cows given high-forage diets during early lactation
- The effects of the level of feeding during late pregnancy on the performance and health of cows offered "medium energy diets" during early lactation

Summary of the main points

Chapter 14 Reducing the costs of milk production by improving dairy cow fertility

Factors affecting fertility

Chapter 15 Rearing dairy herd replacements to maximise profitability

Feeding heifers before puberty

Feeding heifers after puberty

Summary of the main points

Assumptions made in calculating NPV

1. While information contained within this review has the potential to allow every farmer within Northern Ireland to significantly improve the profitability of at least one component of their dairy business, a relatively small uptake (5%) has been assumed. The reason for this is that the information was provided to farmers in the form of a CD, and as such, the information is likely to be 'less available' than had the information been provided in book form. Informal feedback from farmers suggests that those farmers who have been relentlessly pursuing options to reduce costs, and as such, increase profitability, have found the booklet to be extremely useful.

2. The actual cost savings that farmers have made from adopting information presented in the review is impossible to determine. For inefficient farmers, the cost-cutting potential highlighted in the book is huge, while for highly efficient farmers, the potential is less. In view of the comment made above, that it is likely the highly efficient farmers who have found the information to be most useful, a saving of £10 per cow has been assumed.

3. Assuming the 5% of farmers who have adopted information from the review, represent 5% of Northern Ireland dairy cows (290,000 x 0.05), then 14,500 cows will have benefited. At a saving of £10/cow, this represents total benefit of £145,000 per annum.

4. The cost of the research reviewed has not been taken into consideration.

5. Based on these assumptions, the NPV of the project over a 6-year period is estimated at £747,740 (Appendix A).

INCREASING DAIRY COW SURVIVABILITY

Survivability of dairy cows

Improved dairy herd fertility

On-farm evaluation of Norwegian cows

On-farm evaluation of crossbreeding

INCREASING DAIRY COW SURVIVABILITY

Background to the projects

Agriculture makes a substantial contribution to the Northern Ireland (NI) economy, with dairying being one of the key components within the agricultural sector. However, the dairy sector has come under increasing pressure in recent years, with the average producer price for milk in Northern Ireland falling from 25.4 pence per litre, to 17.9 pence per litre, between 1995 and 2005.

As the profitability of dairy farming has decreased, farmers are increasingly examining all options by which costs can be reduced, and profitability increased. The costs associated with poor fertility and animal health problems have gained increasing attention in recent years. This was highlighted by the fact that dairy herd fertility and mastitis were listed as the most significant problems on dairy farms in Northern Ireland in two farmer surveys undertaken by AgriSearch (under ARDC (NI)). The costs associated with each of these problems, both direct and indirect, can be very substantial, and may have major implications on the profitability of a dairy enterprise.

The costs associated with poor fertility are many, and arise from a number of sources, including: cost of veterinary treatment, additional breeding costs, loss of revenue from lower milk outputs, fewer calves sold, increased labour costs and higher replacement costs. The direct financial cost of poorer fertility in Northern Ireland has been calculated to be approximately £50 million/annum, or £170/cow, based on Lamming *et al*. (1998). The costs associated with mastitis arise for a number of reasons, including: veterinary treatment, loss of antibiotic-treated milk, reduced milk output per cow in both the short or long term, loss of milk quality, and in severe cases, loss of a quarter or even loss of a cow. Mastitis has been estimated to cost approximately £45/cow/year (McCoy, Unpublished). In addition to these direct financial costs, there are non-monetary costs associated with a reduction in animal welfare, together with a negative impact on consumer perception associated with increased use of antibiotics.

A total of four different AgriSearch projects have either been completed, or are currently being undertaken, to examine options to improve dairy cow survivability.

The approaches adopted within these projects fall under two broad headings, namely:

1) Improved feeding and management

Poor nutritional and breeding management are two of the factors which can have a considerable impact on dairy cow fertility. The project 'Improving dairy cow fertility' was established on 19 dairy farms across Northern Ireland to examine the impact of feeding and management on cow survival.

2) Breeding

The potential of breeding to improve animal health and fertility can be examined under three broad sub-headings:

a) *Using the correct strain within a breed*: selection within the Holstein-Friesian breed in the past has focused almost exclusively on milk output, with little emphasis on animal health and fertility. The limitations of this have now been realised, with an AgriSearch project having examined options for improving the survivability of dairy cows of the Holstein-Friesian breed. This project has had a particular focus on the relevance of international dairy sire information to Northern Ireland milk production systems.

b) *Cross-breeding*: the potential of crossbreeding to improve the health and performance potential of a breed by introducing heterosis is well known. An AgriSearch-funded project is currently examining the potential of crossbreeding on 14 Northern Ireland dairy farms.

c) *Breed substitution*: refers to the use of an alternative breed which has been selected and bred for the characteristics which we desire. A major on-farm study is currently examining the role of Norwegian dairy cows in a breed substitution programme.

Main findings

Survivability of dairy cows: This project is now complete. This project highlighted that international AI sire proofs could be used as a reliable indicator for ranking animal performance within local dairy management systems. However, the potential

genetic benefit obtained from these sires varied depending on the management system employed on the farm. For example, only about 40% of the predicted improvement in milk yield for daughters of sires will be achieved in low concentrate input herds, relative to that predicted from US sire proofs. In contrast 60% of the predicted yield improvement will be achieved with high concentrate input herds (Young, 2006).

Improving dairy herd fertility. This project is now complete. The project established a target fertility level of 65% of cows in-calf by 100 days post calving. A number of key management issues were highlighted by this project, as being necessary to help achieve the target in-calf rate (Mackey, 2003).

1) Maintain good records, and make appropriate use of them.

2) Ensure good hygiene at assisted calvings, and during artificial inseminations.

3) Good heat detection is critical. Cows should be closely observed and aids to heat detection, such as teaser bulls, tail paint, kamars and pedometers used when necessary.

4) Cows should be inseminated early, from day 56 onwards, without any decrease in conception rates. Delaying AI did not improve conception rates.

5) The importance of good AI technique was highlighted, together with the need for regular retraining courses.

6) Underfeeding must be avoided in early lactation, together with abrupt dietary changes.

On-farm evaluation of Norwegian dairy cows: This project will finish in December 2006. However, a number of important findings have already been highlighted from the project (Ferris *et al*., 2005).

1) By the 5th year of the study, animals of the Norwegian breed had a higher survivability, compared to animals of the Holstein-Friesian breed (46% and 36% respectively).

2) Increased calving ease with animals of the Norwegian breed in each of lactations 1 and 2.

3) Significantly higher number of calves born dead with animals of the Holstein-Friesian breed in lactation 1 (4.5% and 13.2% for animals of the Norwegian and Holstein breed respectively).

4) Significantly higher conception rate to 1st service with animals of the Norwegian breed, as maiden heifers, and during 1st and 2nd lactations (mean of 60% and 46% for animals of the Norwegian and Holstein-Friesian breed respectively).

5) During years 1-5 of the study, a lower number of Norwegian animals culled as infertile (7.9%), compared to Holstein-Friesian animals (19%).

6) Significantly lower somatic cell counts with animals of the Norwegian breed during lactations 1 and 2 (mean, 109,000/ml), compared to the Holstein-Friesian breed (mean, 167,000/ml).

7) Significantly higher milk protein content with animals of the Norwegian breed during lactations 1 and 2 (mean, 3.31%), compared to animals of the Holstein-Friesian breed (mean, 3.25%).

On-farm evaluation of crossbreeding: This project is still in its early phase. However, a key preliminary finding is that conception rates to 1st service (during the first lactation) were 14% higher with Jersey crossbred cows, compared to pure Holstein-Friesian cows (Park, Unpublished data).

Key outputs

AgriSearch publications

Ferris, C.P. (2000). To assess the potential of the Norwegian Dairy Cattle breed (NRF) as a means of improving the fertility and health status of the Northern Ireland Dairy Herd. Introductory Report for AgriSearch, December 2000.

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Young, F. (2006). Are international dairy sire genetic evaluations relevant to milk production systems in Northern Ireland? AgriSearch Farmers Booklet, July 2006.

Scientific publications

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Ferris, C.P., Patterson, D.C. and Kilpatrick, D.J. (2006). A comparison of the hygienic quality of milk from Norwegian and Holstein-Friesian dairy cows. *Proceedings of Agricultural Research Forum of the Irish Grassland and Animal Production Association, Tullamore, Ireland,* Page 90.

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Proceedings of the British Society of Animal Science Occasional Meeting, Fertility in the High-Producing Dairy Cow, Galway, Ireland, September 1999, p. 43.

McCaughey, W.J., McCoy, M.A., Mayne, C.S., Verner, M., Lennox, S.D., Catney, D.C., Wylie, A.R.G., Kennedy, B. and Gordon, F.J. (2001). Investigation of infertility problems in dairy herds. *British Society of Animal Science Occasional Publication No. 26, Fertility in the High-Producing Dairy Cow*, pp. 485-489.

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McKeague, J.A., Ferris, C.P., Patterson, D.C. and Wicks, H.C.F. (2004). A comparison of somatic cell counts between first and second lactation Holstein-Friesian and Norwegian dairy cows, on Northern Ireland dairy farms. *Proceedings of the British Mastitis Conference, Stoneleigh*, p. 95-96.

Assumptions made in calculating NPV

1. The economic appraisal focuses on the benefits accrued from improved fertility. However, improvements in fertility observed in each of the studies were assessed via different indicators. For example, Mackey (2003) observed a 3.7% increase in 100-day in-calf rate when the research findings were implemented on a number of farms in Northern Ireland. Ferris (2005) on the other hand observed an increase in conception rate to first service with animals of the Norwegian breed, as maiden heifers, and during their first and second lactations (mean of 60% and 46% for animals of the Norwegian and Holstein-

Friesian breed respectively). As a consequence, a lower number of Norwegian animals were culled as infertile (7.9%), compared to animals of the Holstein-Friesian breed (19%). Preliminary data from the crossbreeding project suggest a 14% higher conception rate to first service with Jersey crossbred animals, compared to animals of the Holstein-Friesian breed (Park, Unpublished data). The latter would suggest a much lower culling rate with the Jersey crossbred cows, although culling data is not yet available.

2. While the options examined to improve fertility within these studies are very different (management, breed substitution and crossbreeding), based on the figures presented above, a conservative estimate across the studies might be that benefits to be gained would be, at a very minimum, a 2% reduction in culling rates and a three-day reduction in calving interval.

3. While virtually every dairy farmer in Northern Ireland is striving to improve fertility, not all of these will be prepared to adopt the 'breeding route' to achieve these benefits. However, improved management practices can be adopted by all farmers. To reflect this disparity in likely uptake rates between the outcomes of the different projects, a 10% adoption rate of the findings has been assumed. Thus it is assumed that (290,000 x 0.1) 29,000 cows are likely to benefit from the findings of this research. However, as the programmes on alternative cow genotypes and crossbreeding reach maturity, and technology transfer outputs increase, further adoption of findings is projected.

1. Calculation based on the current net replacement cost for a heifer of £850 (based on heifer rearing costs at 2 years 5 months of £1,100 (Kossaibati and Esslemont, 1997), DARD benchmark data and cull cow price at £250). The financial benefit of a three-day reduction in calving rate (£1.53/day; CAFRE Dairy Herd Fertility Challenge) estimated at £4.59.

    Thus: 29,000 cows x £4.59 = £133,110
    29,000 x 0.02 cows x £850 = £493,000
    Total annual benefit = £626,110

4. Based on these assumptions, a total NPV of £1,586,485 is estimated for these research projects (Appendix A).

5. Costs associated with a ‘do-nothing’ case (1% decline in conception rate per annum equating to 1.3 days increase in calving interval after 6-years = £1.53 per day X 1.3 days increase in calving interval X 290,000 cows) amounts to £559,062 per annum.

Additional references for assumptions

Ferris, C.P. (2005). To assess the potential of the Norwegian Dairy Cattle breed (NRF) as a means of improving the fertility and health status of the Northern Ireland Dairy Herd. Third Report for AgriSearch, June 2005.

Kossaibati, M.A. and Esslemont, R.J. (1997). Understanding the Rearing of Dairy Heifers. *National Milk Records (NMR),* 1997, 40 pp.

Mackey, D. (2003). Dairy herd fertility – examination of effects of increasing genetic merit and other herd factors on reproductive performance. AgriSearch Farmers Booklet, June 2003.

OPTIMUM SYSTEMS

Rearing dairy herd replacements

Optimum milk production systems - Comparison of four grassland-based systems

REARING DAIRY HERD REPLACEMENTS

Background

It is well established that heifer rearing has a major effect on subsequent performance in terms of milk production and health and welfare issues. Prior to this research programme heifer rearing systems in the industry were based on either (1) research carried out in North America or (2) that undertaken in the UK and Ireland, 30 years previous. Either way the data was limited. The North American work was based on survey data from the US industry and only investigated the relationship between live weight at calving and milk yield without considering other issues such as reproductive performance. The data from the UK and Ireland, 3 decades previous, was carried out with animals of very different genetic potential. Consequently the current research programme was undertaken to provide sound information for producers in Northern Ireland to base decisions on with regard to heifer feeding and management.

Outline of research programme

The research programme was carried out in direct co-operation with Northern Ireland dairy producers. Over 200 Holstein Friesian heifers supplied by 11 producers were reared at AFBI, Hillsborough on a range of heifer systems (detailed by Carson *et al*., 2002). Prior to calving, the heifers returned back to the farm of origin where milk production, reproductive performance and animal health and welfare parameters were recorded.

Main findings

Increasing weight at first calving over the range from 540-580 to 620 kg increased milk production during the first lactation (by 11%). However, this was negated by poorer reproductive performance resulting in longer calving intervals. This combined with the fact that milk yield in subsequent lactations was not affected by rearing regime meant that rearing to calve at heavier weights was uneconomic.

Diet type during the rearing period had no significant effect on subsequent performance.

Implications

In Northern Ireland there was an impetus, based on US survey data, to rear large Holstein-Friesian dairy herd replacements. This led to the adoption of rearing systems with relatively high inputs and an increased age at first calving. For example, data from benchmarked farms indicated the widespread uptake of higher input systems with an average concentrate input of 800 kg/animal and an average age at first calving of 30 months (CAFRE, 2004). The current research programme showed that producers should, rather than adopt these high cost systems, rear replacements to calve at 540-580 kg at the economic optimum of 23-25 months of age.

Reference

College of Agriculture, Food and Rural Enterprise (CAFRE) (2004). Dairy heifer benchmarking.

Key outputs:

AgriSearch publications

Carson, A.F., Dawson, L.E.R. and Gordon, F.J. (2003). Developing improved heifer rearing systems. AgriSearch Farmer Booklet.

Scientific publications

Carson, A.F., Dawson, L.E.R. and Gordon, F.J. (2000). The effect of heifer rearing regime on body size and milk production during the first lactation. In: *Proceedings of the British Society of Animal Science* 2000, pp. 13.

Carson, A.F., Dawson, L.E.R., McCoy, M.A., Kilpatrick, D.J. and Gordon, F.J. (2002). Effects of rearing regime on body size, reproductive performance and milk production during the first lactation in high genetic merit dairy herd replacements. *Animal Science,* **74:** 553-565.

Carson, A.F., Dawson, L.E.R., Wylie, A.R.G. and Gordon, F.J. (2002). The effect of rearing regime on the development of the mammary gland and claw abnormalities in high genetic merit Holstein-Friesian dairy herd replacements. *British Society of Animal Science, York*, pp. 75.

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Carson, A.F., Gordon, F.J., Wylie, A.R.G. and McEvoy, J.E. (1997). The effects of plane of nutrition and diet type on growth, lactogenic hormone levels and milk production in high genetic merit heifers. In *Proceedings of Irish Grassland and Animal Production Association Meeting,* pp. 321-322.

Carson, A.F., Gordon, F.J., Wylie, A.R.G. and McEvoy, J.E. (1998). The effects of plane of nutrition and diet type on lactogenic hormone levels, growth and milk production in high genetic merit heifers. In: *Proceedings of the British Society of Animal Science,* pp. 198.

Carson, A.F., Wylie, A.R.G., McEvoy, J.D.G., McCoy, M.A. and Dawson, L.E.R. (2000). The effects of plane of nutrition and diet type on metabolic hormone concentrations, growth and milk production in high genetic merit dairy herd replacements. *Animal Science*, 70: 349-362.

Invited conference papers

Carson, A.F. (1997). Rearing the high genetic merit heifer. *Proceedings of a seminar on Managing and Feeding the High Genetic Merit Dairy Animal, Occasional Publication No.23, Agricultural Research Institute of Northern Ireland*, pp. 55-66.

Carson, A.F. (2003). New ways of rearing heifers. In: *Proceedings of the Royal Association of British Dairy Farmers Annual Conference, Malvern*.

Carson, A.F. (2003). Rearing systems for dairy herd replacements to maximize performance in the dairy herd. In: *Proceedings of the National Dairy Conference, Teagasc, Dublin*, pp. 157-178.

Carson, A.F. and Dawson, L.E.R. (2003). Management of young stock for maximum retention in the dairy herd. *Irish Grassland Association*, **37:** 43-54.

Carson, A.F., Dawson, L.E.R. and Gordon, F.J. (2000). Effects of heifer rearing regime on milk yield and composition during the first lactation. In: *Milk Composition, Occasional Publication No. 25 – British Society of Animal Science* (ed R.E. Agnew, K.W. Agnew and A.M. Fearon).

Carson, A.F., Dawson, L.E.R., Wylie, A.R.G., McCoy, M.A. and McEvoy, J.D. (2002). Research points the way for heifer rearing. In: *Recent Research in Dairying, Occasional Publication No. 31, Agricultural Research Institute of Northern Ireland.*

Dawson, L.E.R. and Carson, A.F. (2004). Management of the dairy heifer. *Cattle Practice,* **12 (3):** 181-192.

Dawson, L.E.R. and Carson, A.F. (2005). Grazing systems for dairy herd replacements. In *Calf and heifer rearing* (Ed. P.C. Garnsworthy), Nottingham University Press, Nottingham pp. 253-276.

Assumptions made in calculating NPV

1. If all expenditure is included the total costs of rearing a heifer to the point of calving is around £1,100 – or a replacement cost of 3.4 p/litre on all milk produced by a cow during its lifetime (assuming a cull cow price of approximately £250, an average lifetime yield of a cow of 25,000 litres). Replacement costs are based on heifer rearing costs at 2 years 5 months of £1,100 (derived from DARD benchmark data) and cull cow price at £250. Effect of age on heifer rearing costs are based on data from Reading University (Kossaibati and Esslemont, 1997).

   Kossaibati, M.A. and Esslemont, R.J. (1997). Understanding the Rearing of Dairy Heifers. *National Milk Records (NMR),* 1997, 40 pp.

2. Blue-print for heifer rearing based on AgriSearch programme calving down at 23-24 months of age at 560-580 kg will reduce costs of rearing to 2.4 p/l.

3. Thus 1 p/l savings available by implementing research programme – equates to £18 million per annum for Northern Ireland industry (assuming 1,800 million litres of milk produced).

4. 5% adoption of results (5% of £18 million) equates to total benefit of £900,000 per annum.

   Based on these assumptions, the NPV of this project over a 6-year period is estimated at £4,555,800 (Appendix A).

5. A new research programme has commenced to underpin improved technology transfer in the area of heifer rearing research. This work being taken undertaken on 300 dairy farms across Northern Ireland has the potential to significantly increase the financial benefits of this work.

OPTIMUM MILK PRODUCTION SYSTEMS - COMPARISON OF FOUR GRASSLAND-BASED SYSTEMS

Background

In a research study conducted at Hillsborough almost 20 years ago, autumn calving dairy cows offered 0.9 t concentrates achieved a 305-day yield of 5460 kg milk, while more recently, a 305-day milk yield of 7850 kg was achieved from a similar concentrate input. While part of this extra milk output reflects improvements in silage feed value and grazing management, genetic improvement undoubtedly accounts for a large part of the increase. The increase in milk yield associated with improvements in genetic merit, while explained in part by higher intakes, primarily reflects differences in nutrient partitioning. For example, in early lactation high merit dairy cows are more likely to experience a more extensive and prolonged period of negative energy balance than those of lower genetic merit, while in addition, throughout the lactation high merit animals will partition more of their feed nutrients consumed to milk, rather than to tissue gain. Consequently it is likely that increased performance will only be sustained in the long term, either by increasing the DM intake potential, or the nutrient density of the diets offered. In addition, increased magnitude and duration of negative energy balance has been shown to be related to compromised health and fertility, and as such, reduced longevity and impaired animal welfare.

The development of nutritional and management practices which either increase the DM intake potential or the nutrient density of the diets offered to cows, are likely to be key issues in overcoming these problems. In view of the marginality of maize silage in Northern and Western areas of the UK, grassland systems, based either on grass silage or grazed grass, are likely to remain dominant for the foreseeable future within these areas. Thus there is a very real need to develop grassland-based management systems which will enable the higher nutrient requirements of high genetic merit dairy cows to be met.

To address this issue, a three-year systems study was established to examine four contrasting grassland-based systems of milk production (summarised in Table 4), with the systems being designed to allow increased nutrient intakes to be achieved

through incorporating the 'best practice' results of a number of component studies. In addition to the main systems study, a number of subsidiary studies and measurements were undertaken, to either examine the effects of varying a component within a system, or to provide supporting science to assist in the understanding of the responses achieved within a system.

Table 4. Key elements of four systems adopted in study

	System 1	System 2	System 3	System 4
Winter period	High feed value grass silage + 6 kg concentrate/day		Medium feed value grass silage + 12.5 kg concentrate/day	
Spring period	Early turnout	Later turnout	Early turnout	Later turnout
Summer period	Lax grazing plus 0.5 kg concentrate/day	Tighter grazing plus concentrate to yield	Lax grazing plus 0.5 kg concentrate/day	Tighter grazing plus concentrate to yield

Main findings

1. Despite the very different feeding and management regimes adopted in the study, total lactation milk outputs were relatively unaffected by system. This result clearly indicates that it is possible to achieve very similar milk outputs from very different combinations of feed inputs within grassland-based systems.

2. 5498 kg of milk was produced from forage with System 1, thus highlighting the potential of high quality home produced forages to sustain high levels of milk outputs.

3. By week 40 post-calving, the mean condition score of cows on all four systems was 2.4-2.5. Cows tended to have returned to their ‘calving condition score’ by the time they calved down in the next lactation. Thus in the long

term, the body condition of cows was not more severely depleted on any one system, compared to any other system.

4. System had no effect on dairy cow fertility.

5. Although conception rates were low (mean of 37% to 1st service, across all systems), they were in line with the 39% conception to first service recorded across 19 Northern Ireland dairy farms in a recent study.

6. 44% more land was required for System 1 compared to System 4. Alternatively, 44% more animals could be kept on a given area of land by a farmer operating System 4, compared to a farmer operating System 1.

7. The availability of land is likely to be a key factor influencing the adoption of a particular system. In addition, the proximity of grazing land to the milking parlour, together with suitability of land for harvesting silage, are additional factors which may influence the choice of system.

8. The systems examined involved very different labour requirements and management inputs. System 1 involved the highest levels of labour and management inputs, and System 4 the lowest.

9. With the availability of farm labour decreasing, simple systems involving reduced labour and reduced management inputs may become increasingly important. However this must be offset against the potential for higher capital costs associated with reduced labour systems.

10. The environmental impact of milk production systems, especially in relation to nitrogen and phosphorus, are becoming increasingly important. System 4 would fail to meet the requirements of most NVZs currently designated in the UK, namely a limit of 250 kg nitrogen/ha in the form of manure/slurry.

11. Systems involving higher concentrate feed levels are more likely to be associated with increased risk of phosphorus pollution.

12. Gross margin per ha increased from £2359 with System 1, to £3174 with System 4. This reflects the much lower land requirements associated with

System 4. However, system had little effect on either gross margin per cow or gross margin per 1000 litres of milk produced.

13. As gross margin per cow and per 1000 litres of milk produced were relatively similar for all four systems, the profitability of any of these systems will be mainly determined by the fixed costs for the individual farm. It is well known that fixed costs vary considerably from farm to farm. For example, two farms could adopt the same production system and produce the same level of milk output (e.g. 7800 kg) using the same inputs of feed, silage quality and grazing systems. However, because of very different fixed costs, the profit per litre of milk produced could be very different on each of the two farms.

Key outputs

AgriSearch/MDC publications

Ferris, C.P (1998). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. First Report for the MDC, May 1998.

Ferris, C.P (1998). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Second Report for the MDC, August 1998.

Ferris, C.P (1999). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Third Report for the MDC, February 1999.

Ferris, C.P (1999). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Fourth Report for the MDC, August 1999.

Ferris, C.P (2000). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Fifth Report for the MDC, February 2000.

Ferris, C.P (2000). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Sixth Report for the MDC, August 2000.

Ferris, C.P (2001). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Seventh Report for the MDC, February 2001.

Ferris, C.P (2002). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Eighth Report for the MDC, August 2001.

Ferris, C.P (2002). A three year comparison of four contrasting production systems with winter calving, high genetic merit dairy cows in a grass/grass silage environment. Final Technical Report for the MDC, April 2002.

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Ferris, C.P. (2000). A comparison of four contrasting milk production systems with winter calving high genetic merit cows. Second Report for the AgriSearch, December 2000.

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Ferris, C.P. (2003). A comparison of four contrasting milk production systems with winter calving high genetic merit cows. Booklet number 2, May 2003, AgriSearch.

Scientific Publications

Ferris, C.P. Gordon, F.J. and Patterson, D.C. (2002). Effect of harvesting frequency on herbage dry matter production. *Proceedings of Agricultural Research Forum of the Irish Grassland and Animal Production Association, Tullamore, Ireland*, Page 70.

Ferris, C.P. Patterson, D.C. Gordon, F.J. and Kilpatrick, D.J. (2002). Response of grazing dairy cows to level of concentrate supplementation and concentrate protein content. *Proceedings of the British Society of Animal Science, Winter Meeting*, Paper No. 112.

Ferris, C.P., Gordon, F.J., and Patterson, D.C. (2000). The effect of a period of early season part-grazing on the performance of animals managed on two contrasting systems of milk production during the winter. *Proceedings of the British Society of Animal Science, Winter Meeting,* Paper No. 147.

Ferris, C.P., Gordon, F.J., Patterson, D.C Mayne, C.S. and McCoy, M.A. (2003). A short-term comparison of the performance of four grassland-based systems of milk production for autumn-calving dairy cows. *Grass and Forage Science*, **58:** 192-209.

Ferris, C.P., Gordon, F.J., Patterson, D.C. and Mayne, C.S. (2000). A comparison of four contrasting milk production systems for high genetic merit winter calving dairy cows in a grassland based production environment. *Proceedings of the British Society of Animal Science, Winter Meeting*, Paper No. 12.

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Ferris, C.P., Gordon, F.J., Patterson, D.C. and. Kilpatrick, D.J. (2002). Response of dairy cows offered a high feed value grass silage, to concentrate feed level and concentrate crude protein content. *Proceedings of the British Society of Animal Science, Winter Meeting*, Paper No. 111.

Ferris, C.P., Gordon, F.J., Patterson, D.C. and. Mayne, C.S. (2002). A one year comparison of four contrasting grassland-based systems of milk production for autumn calving dairy cows. *Proceedings of Agricultural Research Forum of the Irish Grassland and Animal Production Association, Tullamore, Ireland*, Page 58.

Ferris, C.P., Keady, T.W.J., Gordon, F.J. and Kilpatrick, D.J. (2002). Comparison of Calan gate and easy feed systems on the intake of dairy cows. *Proceedings of the British Society of Animal Science, Winter Meeting,* Paper No. 114.

Ferris, C.P., McCoy, M.A., McCaughey, W.J and Patterson D.C. (2003). Effects of four contrasting grassland-based milk production systems on dairy cow fertility. *Proceedings of the British Society of Animal Science, Winter Meeting, York,* Paper No.77.

Ferris, C.P., Patterson, D.C. and Murphy, J. (2003). Grassland-based systems of milk production for autumn calving dairy cows: a three year comparison. In: *75th Annual Report of Agricultural Research Institute of Northern Ireland*, pp. 44-57.

Ferris, C.P., Patterson, D.C., Murphy, J. and Anderson, D. (2002). 8000 litres from grassland based systems? A three year study involving Autumn calving cows. In: *Dairy Production Seminar, Agricultural Research Institute of Northern Ireland, Occasional Publication No. 31,* pp. 41-56.

Woods, V.B., Ferris, C.P. and Gordon, F.J. (2003). The effect of four contrasting grassland and concentrate based systems on milk yield and body composition of high genetic merit dairy cows. *Proceedings of Agricultural Research Forum of the Irish Grassland and Animal Production Association, Tullamore, Ireland,* Page 113.

Woods, V.B., Ferris, C.P. and Gordon, F.J. (2005). The weight and concentration of body components in high genetic merit Holstein-Friesian dairy cows managed on four different grassland-based feeding regimes. *Animal Science*, **81:** 179-184.

Assumptions made in calculating NPV

This study highlighted that when well managed, high levels of milk outputs can be achieved with systems involving very different sets of inputs. For example, average milk outputs were approximately 8000 litres with all systems. In addition, the results of this study clearly indicated that gross margins associated with each of the four systems were very similar, and as such, each system can be equally profitable.

This project highlighted 'target' levels of performance that can be achieved within grassland-based systems. Indeed, the performance levels achieved, namely 8000 kg/cow/year, are identical to the 'optimum economic system' for autumn calving cows highlighted in an ongoing AgriSearch funded project, 'Optimum Northern Ireland milk production systems'.

The results of this study may offer farmers the assurance that their current system can be as profitable as an alternative system, provided correctly operated. However, on many farms, specific farm factors such as location/climatic/ground conditions etc, may dictate that a system other than the one being operated may in fact be more profitable. Alternatively, it is possible that an individual component of one of the systems examined may be more profitable than a component currently being used on a farm.

The following assumptions were adopted when examining the benefits of the systems:

1. As a result of the research findings, 5% of farmers (assumed to represent 290, 000 x 0.05 = 14, 500 cows) either modified their system, or alternatively modified a component of their system.

2. The benefits of modifying a system can accrue from either an increase in performance, without any additional inputs, or a reduction in cost of inputs, without a reduction in cow performance. Examples of areas highlighted by the study, where financial benefits could have arisen, include:

    - Reducing the crude protein content of grazing concentrates from 23% to 12% without any loss of performance: likely savings, £6.00/cow over the summer period.
    - Reducing the quality of silage offered with very high input systems during the winter: likely savings, approximately £12.00/cow over the winter.

- Maintaining concentrate feed level in a low milk price situation, without any loss of profitability: likely gain, due to no loss of milk output, £60.00 per year.
- Achieving high levels of performance on well managed grazing systems, without concentrate supplementation (in a situation of land availability): potential savings, £40-60/year.

Backgrounds to each of the above assumptions have been highlighted in the following publications:

Ferris, C.P., Patterson, D.C. and Murphy, J. (2003). Grassland-based systems of milk production for autumn calving dairy cows: a three year comparison. In: *75th Annual Report of Agricultural Research Institute of Northern Ireland*, pp. 44-57.

Ferris, C.P., Patterson, D.C., Murphy, J. and Anderson, D. (2002). 8000 litres from grassland based systems? A three year study involving Autumn calving cows. In: *Dairy Production Seminar, Agricultural Research Institute of Northern Ireland, Occasional Publication No. 31*, pp. 41-56.

3. In the economic evaluation, the financial benefit assumed from the adoption of a single component from any system is £10/cow/annum.

4. Thus, the total calculated benefit arising from the project is calculated as £145,000 per annum.

Based on these assumptions the Net Present Value of the project over a 6-year period was estimated at £431,090 (Appendix A).

ENVIRONMENTAL PROGRAMMES

Expanding output in environmentally friendly systems

Reducing nitrogen outputs from dairy cows and beef cattle in Nitrate Vulnerable Zones

ENVIRONMENTAL BENEFITS - EXPANDING OUTPUT IN ENVIRONMENTALLY FRIENDLY SYSTEMS

Background

Phosphates (P) represent one of the primary sources of water pollution in Northern Ireland, with eutrophication recognised as the most serious water quality issue by the Environment and Heritage Services (EHS, 1999). Indeed, P levels in both Lough Erne and Lough Neagh have increased by approximately 50% during the last 10 years, with recent measurements by DOE-DARD (2002) indicating P concentrations of 82 (eutrophic) and 145 (hypertrophic) micro-grammes of P per litre respectively.

Eutrophication has a number of adverse effects on water quality, as summarised below:

1. Risks to human and animal health associated with toxic algae and algae scums.
2. Added cost of algae removal during water treatment.
3. Loss of habitats within waterways, leading to loss of species' diversity.
4. Loss of fisheries.
5. Undesirable aesthetic impact such as odours, loss of transparency, clogging by weeds and loss of amenity value.

This problem needs to be addressed. For example, reducing the trophic status of lakes to levels approaching their natural state by 2015 is a requirement of the Water Framework Directive, while in addition, where it can be related to agricultural activities, control is also required under the Nitrates Directive

Dairying has been particularly implicated as a source of P pollution, and although data for Northern Ireland is unavailable, the Environment Agency (2000) has calculated that 33% of agricultural P pollution in GB arises from dairy farms. Options to reduce the P surplus on dairy farms include:

1) Reduce the use of inorganic fertiliser P
2) Reduce stocking rates
3) Reduce the P content of rations offered

While all three options may play a role in reducing the P surplus, it is the latter option that was examined within this research project. However, reducing the levels of P in dairy cow diets will clearly be unacceptable if animal performance, health, fertility or welfare are compromised. Thus the current research programme was established to examine the performance of high yielding dairy cows offered diets containing either 'high' or 'reduced' levels of dietary P, with the study being conducted over a number of years within grassland-based systems in Northern Ireland.

Main findings

One hundred winter calving dairy cows were managed on diets containing either 'high' (High P) or 'reduced' (Reduced P) levels of dietary P for four successive lactations. Level of phosphorus in the diet had no effect on any aspect of dairy cow performance, with these results clearly indicating that the amount of phosphorus offered to dairy cows can be reduced without any negative effects.

From an environmental point of view, reducing the levels of P in dairy cow diets in the current studies reduced the amount of P excreted in faeces by approximately 45%. In addition, recent research by Satter (unpublished) indicates that the P loss from manure produced by cows offered 'reduced' P diets was approximately 10 times lower than from manure produced by cows offered high P diets. Similarly, Ebeling *et al*. (2002) observed that reducing P in the diet of cows by 40% resulted in a 90% reduction in P losses from manures. This can be attributed to the reduction in the soluble orthophosphate fraction in manures from animals offered reduced P diets. It has been calculated by Ferris *et al*. (2004), that for a typical Northern Ireland dairy farm, reducing the level of phosphorus in dairy cow concentrates, can reduce the farm P surplus from 18.3 to 10.6 kg P/ha, a reduction of 42%. Thus at an individual farm level, reducing the P concentration of the ration offered can have a very substantial effect on the overall phosphorus balance of the farm.

References

DOE-DARD (2002). Report on the environmental aspects of the nitrates directive in Northern Ireland. DOE-DARD Scientific Working Group.

Ebeling, A.M., Bundy, L.G., Powell, J.M. and Andraski, T.W. (2002). Dairy diet P effects on P losses in runoff from land-applied manure. *Soil Science Society of America Journal*, **66:** 284-291.

EHS (1999). Eutrophication in Northern Ireland's Waters: Proposal for a strategy to control nutrient enrichment.

Environment Agency (2000). Agriculture and the Environment: An impact statement.

Ferris, C.P. and McCoy, M.A. (2004). Reducing Phosphorus output from dairy herds – effect of dietary phosphorus levels. In: Nitrogen, Phosphorus and Methane – Improving nutrient use in milk production. *Agricultural Research Institute of Northern Ireland, Occasional Publication No. 34*, pp. 38-52.

Foy, R.H., Bailey J.S. and Lennox, S.D. (2002). Mineral balances for the use of phosphorus and other nutrients by agriculture in Northern Ireland from 1925 to 2000 – methodology, trends and impacts of losses to water. *Irish Journal of Agricultural Science*, **41:** 247-264.

Key outputs

AgriSearch publications

Ferris, C.P. (2004). Expanding output efficiently in environmentally friendly systems. First report for AgriSearch, John Thompsons Ltd and Devenish Nutrition. March 2004.

Final report due November 2006, Farmers Booklet due December 2006

Scientific publications:

Ferris, C.P. and McCoy, M.A. (2004). Reducing Phosphorus output from dairy herds – effect of dietary phosphorus levels. In: Nitrogen, Phosphorus and Methane – Improving nutrient use in milk production. *Agricultural Research Institute of Northern Ireland, Occasional Publication No. 34*, pp. 38-52.

Ferris, C.P., McCann, M.E.E. and Patterson, D.C. (2006). Improving the efficiency of nitrogen and phosphorus use in livestock systems through dietary modification. In: *76th Annual Report of Agricultural Research Institute of Northern Ireland*, (In press).

Ferris, C.P. and Hopps, A.R. (2006). Achieving phosphorus 'balance' on benchmarked dairy farms in Northern Ireland. *Proceedings of Agricultural Research Forum of the Irish Grassland and Animal Production Association, Tullamore, Ireland*. Page 89.

Ferris, C.P., McCoy, M.A., Patterson, D.C. and Kilpatrick, D.J. (2006). Effect of dietary phosphorus content on the fertility of dairy cows over four successive lactations. *Proceedings of the British Society of Animal Science, Winter Meeting, York,* Paper No. 121.

Ferris, C.P., Patterson, D.C., Mayne, C.S. and McCoy, M.A. (2006). Effect of dietary phosphorus content on the performance of dairy cows over two successive lactations. *Proceedings of the British Society of Animal Science, Winter Meeting, York,* Paper No. 122.

Assumptions made in calculating NPV

Based on the results of this project, the Northern Ireland Grain Trade Association have now agreed to reduce dietary P levels, equivalent to a reduction in P input on Northern Ireland dairy farms of 312.8 t phosphorus.

This evidence was cited to the European Commission as an example of how the dairy industry in Northern Ireland has responded to water quality issues. This has enabled a delay in implementation of legislation requiring individual farm P balances, which would have had a major impact on many Northern Ireland milk producers. The decision on whether to implement this legislation in the future will be determined by changes in water quality in Northern Ireland over the next 4 years.

While the delay in the implementation of new legislation is an extremely positive outcome of the project for farmers, this project also has a very significant public good value, which arises from the reduction in costs associated with eutrophication. Using the same methodology as was adopted by Pretty *et al*. (2003) for England and Wales, the value of this reduction in eutrophication in Northern Ireland, as a direct result of reducing P level in dairy cow diets, has been calculated at £1,288,000 per annum. Full details of the assumptions and calculations used in determining this value are presented below:

No direct income benefits are assumed for the dairy farmer, with the use of reduced P rations having been assumed as cost neutral. Instead, the economic benefits associated with the project can be attributed to the positive environmental benefits which arise from offering cows reduced P diets. However, assigning a cost to a reduction in P pollution in freshwater lakes in Northern Ireland is an extremely complex issue, a consequence of the diverse uses for which these bodies of water are used. Nevertheless, by extrapolation of figures which have been applied to lakes

in England and Wales, an approximate value can be obtained for lakes in Northern Ireland.

Within England and Wales, the annual damage cost associated with freshwater eutrophication was estimated to be within the range £75-114 millions (Pretty *et al*., 2003). The key components contributing to this cost were as follows: treatment of drinking water, reduced recreational and amenity value of water courses, loss of tourism revenue and costs associated with ecological damage. Based on the methodologies used for England and Wales, an alternative figure has been calculated for Northern Ireland, as follows:

1. The 'eutrophication cost' for England and Wales includes a value of £20 million for nitrate removal. This figure is not applicable to Northern Ireland as high nitrates do not occur in surface waters of Northern Ireland (DOE-DARD, 2002).

2. A figure of £19 million is included for the treatment of drinking water in England and Wales for the removal of algae toxins and algae decomposition products. The cost incurred in treating drinking water will be directly related to population size. As the population of Northern Ireland is approximately 3% of the population of England and Wales, this figure has been reduced accordingly, to £570,000.

3. Most of the remaining costs are directly related to the 'lake area' which exists. Although the land area of Northern Ireland is much smaller than for England and Wales, the area of lakes and reservoirs in Northern Ireland is 78% of the lake-reservoir area in England and Wales (Smith and Lyle, 1981; Smith *et al*., 1991). This figure has been used as a scaling factor.

Thus the cost of damage that can be attributed to eutrophication in Northern Ireland has been calculated as follows:

- While the annual cost of eutrophication in England and Wales is estimated as £75-114 million, the lower value of £75 million has been adopted in this economic appraisal

- Less cost of nitrate removal (£20 million) = £55 million
- Less cost of water treatment in England and Wales (£19 million) = £36 million
- Scaled back by 22% to take account of reduced lake area in Northern Ireland = £28.1 million
- Plus cost of water treatment in Northern Ireland (£570,000) = £28.7 million

Thus the cost damage attributed to eutrophication in Northern Ireland is estimated as £28.7 million/year.

Current P budgets show that diffuse (i.e. agricultural sources) of P to lakes in Northern Ireland amount to approximately 75% of the total input (Foy *et al*., 2003a). This total includes the natural background loading of 25% of the total, leaving an agricultural contribution to eutrophication of 50%. Thus the true cost of agricultural damage to lakes in Northern Ireland is assumed to be 50% of £28.7 million, namely £14.3 million.

It is now necessary to calculate the potential savings that could be made by reducing the P concentration of dairy cow diets in Northern Ireland. Total P inputs to agriculture in Northern Ireland have been calculated as 18911 t, while total P outputs have been calculated as 6062 t. By difference an annual P surplus of 12849 t is derived. Of the total agricultural P input, 3025 t comes from dairy cow concentrate feedstuffs. Thus reducing the P content of this dairy concentrate will reduce the overall P balance on farms. Concentrate samples taken from 40 dairy farms around Northern Ireland were found to have a mean phosphorus concentration of 7.3 g/kg DM. Within the current project it is proposed that the P content of dairy cow concentrates will be reduced to 4.2 g/kg DM, a reduction of 42%. When this reduction in concentrate P levels is applied to the total dairy cow concentrate input in Northern Ireland, the input of P from dairy concentrates would be reduced by 1270 t, from 3025 t per annum to 1754 t per annum. With this reduction, the overall P

surplus for Northern Ireland would be reduced from 12849 t/annum to 11579 t/annum, a 9.0% reduction.

The current agricultural related cost damage associated with P pollution (£14.3 million) can be attributed entirely to the existing P surplus. While it is true that only a fraction of the current P surplus actually enters water courses and causes damage, this proportion is not known with accuracy. However in this calculation, the size of this fraction is unimportant, the total cost of agricultural P damage is still £14.3 million. Thus the assumption is made that if the overall P surplus is reduced by 9.0% as a consequence reducing the P levels in dairy cow diets, then the fraction of P entering water courses will also be reduced by 9.0%. Thus the cost associated with P pollution will be reduced by 9.0%. The cost savings associated with reducing the P concentration of dairy cow diets is thus calculated as £1.28 million/year. Consequently, the Net Present Value of the project over a 6-year period is estimated at £6.24 million (Appendix A).

References:

DOE-DARD (2002). Report on the environmental aspects of the nitrates directive in Northern Ireland. DOE-DARD Scientific Working Group.

Foy, R.H., Lennox, S.D. and Gibson C.E. (2003a). Changing perspectives on the importance of urban P inputs as the cause of nutrient enrichment in Lough Neagh. *Science of the Total Environment*, (accepted for publication).

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Smith, I. and Lyle, A. (1981). Distribution of Freshwaters in Great Britain. *Institute of Terrestrial Ecology, Edinburgh*, 44 p.

Smith, V.H. (1998). Cultural eutrophication of inland, estuarine and coastal waters. p. 7-49. In M.L. Pace and P.M. Groffman (eds.) *Successes, limitations and frontiers in ecosystem science*. Springer, New York.

REDUCING NITROGEN OUTPUTS FROM DAIRY COWS AND BEEF CATTLE IN NITRATE VULNERABLE ZONES

Background

The European Union Nitrates Directive, introduced in 1991, aims to prevent the pollution of ground water and surface water by nitrates arising from agricultural sources. A Northern Ireland-wide (total territory) approach to implementation of the Nitrates Directive was introduced on 29 October 2004 through *"The Protection of Water Against Agricultural Nitrate Pollution Regulations (Northern Ireland) 2004".* These regulations stipulate the establishment and application of an action programme to regulate farming activities throughout Northern Ireland in order to reduce and prevent water pollution from agricultural sources. The action programme will give statutory effect to a series of measures. One of these proposed measures is to limit the amount of livestock manure that may be applied to land each year to 170 kg organic nitrogen (manure N) per hectare. This limit will have very significant implications for stocking rates on livestock farms in Northern Ireland. Current values for manure N excretion of livestock within existing NVZ's in Northern Ireland are based on those published in England and Wales (DEFRA, 2002). However, the levels of production achieved from and diets offered to ruminant livestock in Northern Ireland are very different to those in England and Wales. Consequently, the objectives of this research project were to determine the level of manure N output from dairy cows and beef cattle within Northern Ireland.

Outline of programme and main findings

The work consisted of three studies:

1. Prediction of manure N output for dairy cows
2. Prediction of manure N output for beef cattle
3. Investigation of nutritional strategies to improve the efficiency of utilisation of dietary N in milk production.

Based on the scientific data presented in the final report, key conclusions of this study in relation to manure N output are summarised below. No account has been taken of nitrogen losses arising from ammonia emissions during grazing, housing, storage or spreading.

- The standard average annual manure N output for dairy cows for Northern Ireland is 91 kg/cow per year, irrespective of live weight and production level.

- The standard annual manure N output of each dairy heifer replacement over 24 months age (500 kg), each suckler cow and each growing and fattening beef animal over 24 months age (500 kg) is 54 kg/animal per year.

- Until a comprehensive dataset for manure N output for lighter weights of cattle in Northern Ireland can be developed, the standard DEFRA N output values for these animals should be used.

- Adoption of milk and beef production systems with lower manure N output should be encouraged through use of lower nitrogen (protein) intakes.

- Efficient milk production systems can be developed which produce less than 91 kg manure N/cow per year. Derogation to less than 91 kg would require farmers to supply firm evidence (e.g. adequate supporting records) to demonstrate lower manure N output values.

Key outputs

AgriSearch Publications

Yan, T., Patterson, D.C., Agnew, R.E., Frost, J.P., Keady, T.W.J., Binnie, R.C. and Mayne, C.S. (2005). Reducing Organic Nitrogen Outputs from Dairy Cows and Beef Cattle in Nitrate Vulnerable Zones. End-of-Project Report to AgriSearch and DARD. February 2005.

Scientific publications

Agnew, R. (2004). Factors influencing manure nitrogen output from dairy cattle. Paper presented at seminar held at the Agricultural Research Institute of Northern Ireland, 29 September 2004.

Agnew, R. and Yan, T. (2004). Factors influencing manure nitrogen output from dairy cattle. *Agricultural Research Institute of Northern Ireland, Occasional Publication No. 34*, pp. 3-24.

Frost, J.P. (2005). Reducing organic nitrogen outputs from dairy cows and beef cattle in nitrate vulnerable zones. AgriSearch Booklet 9.

Frost, J.P. (2005). Reducing organic nitrogen outputs from dairy cows in nitrate vulnerable zones. AgriSearch A4 flyer.

Patterson, D. (2004). Nutritional strategies to improve the efficiency of utilisation of dietary Nitrogen in milk production. Paper presented at seminar held at the Agricultural Research Institute of Northern Ireland, 29 September 2004.

Patterson, D., Yan, T and Hamleers, A. (2004). Nutritional strategies to improve the efficiency of utilisation of dietary Nitrogen in milk production. *Agricultural Research Institute of Northern Ireland, Occasional Publication No. 34*, pp. 25-37.

Yan, T., Frost, J.P., Agnew, R.E., Binnie, R.C. and Mayne, C.S. (2006). Prediction of manure nitrogen output of dairy cows from animal and dietary factors. *British Society of Animal Science Annual Meeting, York University*, pp. 41, March 2006.

Yan, T., Frost, J.P., Agnew, R.E., Binnie, R.C. and Mayne, C.S. (2006). Relationships between manure nitrogen output and dietary and animal factors in lactating dairy cows. *Journal of Dairy Science* (accepted).

Yan, T., Frost, J.P., Keady, T.W.J., Agnew, R.E. and Mayne, C.S. (2006). Relationships between manure nitrogen output and animal and dietary factors in beef cattle. *British Society of Animal Science Annual Meeting, York University*, pp. 51, March 2006.

Yan, T., Frost, J.P., Keady, T.W.J., Agnew, R.E. and Mayne, C.S. (2006). Prediction of nitrogen in faeces and urine of beef cattle offered grass silage-based diets. *Journal of Animal Science* (submitted).

Yan, T., Mayne, C.S. and Frost, J.P. (2006). Prediction of nitrogen intake from milk yield and live weight in dairy cows. *Agricultural Research Forum,* Ireland, pp. 12, March 2006.

Assumptions used to calculate of NPV

1. Research within this project clearly demonstrated that N output in manure of dairy cows in Northern Ireland was lower than in Great Britain.

2. This evidence has been critical in enabling DARD Policy Division to negotiate with the European Union and agree a lower value (91 kg manure N/cow/year) relative to that used by GB (96 kg).

3. The net value of this lower manure N output to the Northern Ireland dairy sector is 91 kg versus 96 kg over 290,000 dairy cows equates to 1,450 tonnes of organic N.

4. At limit of 170 kg organic N/ha this equates to a land requirement of 8,529 ha.

5. Standard land rental charge of £196/ha (£80/acre) equates to £1.64 m/annum.

6. AgriSearch funding has also facilitated development of a manure N output spreadsheet which enables individual dairy farmers to quantify manure N output from their dairy herd. If the value is less than 91 kg manure N per cow, this can be used as evidence to justify a lower value, and hence higher potential stocking rate, at the individual farm level.

7. Based on the assumptions outlined previously, the Net Present Value of the project over a 6-year period is estimated at £8,357,680 (Appendix A).

DEVELOPING IMPROVED WINTER FEEDING SYSTEMS

Improved methods of rationing cattle

Alternative forages for dairy cattle

IMPROVED METHODS OF RATIONING CATTLE

Background

To be sustainable, future technological developments in dairy systems need to result in enhanced profitability together with improved predictability of output in order better to meet market needs. Improved accuracy of prediction of feed requirements also has the potential to improve the welfare of the animal and reduce the loss of feed nutrients to the environment.

Feeds represent the major component of the costs of production in ruminant systems. If the efficiency of feed utilisation could be increased by 5%, and the uptake of technology was 50%, the direct benefit to the UK dairy industry would be in excess of £20 million per annum. Manipulating the diet not only influences yield and composition of milk but also can have profound effects both on the welfare of the animal and the losses of nutrients from the system with results in diffuse pollution of the environment. The Government support for strategic research in ruminant nutrition has greatly improved our understanding of the processes involved in the conversion of feed to milk. However, the lack of a framework to incorporate this knowledge into support systems which enable both the dairy farmer and the policy maker to predict the consequences of change has meant that much of the technology has not been transferred into practice in a way that can aid the sustainability of milk production systems. The aim of this project was to develop this framework and to derive an improved nutritional model to ration dairy cows that would be immediately applicable in practice. Dissemination of the information is assisted through a management consortium comprising the Milk Development Council, feed industry representative and ADAS, AFBI, and SAC as the main contractors.

Main findings

The whole project consisted of five subprojects: prediction of the voluntary intake by dairy cattle, development of an improved metabolisable energy system, protein requirements of dairy cows, the supply of protein, and the development of a decision support systems (DSS) to support the applied feeding model. A number of models for feed formulation of dairy cows were developed.

The FiM applied feeding model provides

- new robust equations to predict DM intake
- a new system to predict the relationship between ME supply and milk energy output
- a rumen model, with microbial protein synthesis predicted from estimated ATP supply which
  - agrees well with *in vivo* data and
  - performs well in a requirement based system
- Decision Support Systems for rumen stability, change in milk composition and supply of key essential amino acids to aid ration formulation
- a comprehensive feed database, appropriate methods of analysis and QC system
- diet formulation/evaluation software incorporating the whole FiM model for testing use in practice

Key outputs

Dairy rationing programme

The FiM models for ration formulations for dairy cows have been widely accepted by government advisory services, dairy industry, feed companies and farmers in UK. In Northern Ireland, the majority of the feed industry and DARD advisors now use a feed rationing programme (Feedbyte) developed from the FiM models.

Scientific Publications:

Conference proceedings

Agnew, R.E. and Yan, T. (2002). The relationship between metabolisable energy concentration and nutrient digestibility in grass silages offered to sheep at maintenance. In: *The Proceedings of Annual Meeting of British Society of Animal Science*, p. 51, York, England.

Agnew, R.E. and Yan, T. (2002). Utilisation of energy from silage based diets. In: *The Proceedings of the 13th International Silage Conference* (eds, L.M. Gechie and C. Thomas), pp. 252-267, Aye, Scotland.

Agnew, R.E., Yan, T., France, J., Kebreab, E., Beever, D.E., Gordon, F.J., Alderman, G., Porter, M.G. and Cammell, S.B. (2004). Development of a new

approach to determine the energy requirements of dairy cows. In: *The Proceedings of Annual Meeting of British Society of Animal Science*, p. 2, York, England.

Agnew, R.E., Yan, T., Murphy, J.J., Ferris, C.P. and Gordon, F.J. (2002). The development of maintenance energy requirement and energetic efficiency for lactation from production data of lactating dairy cows. In: *The Proceedings of Annual Meeting of British Society of Animal Science*, p. 39, York, England.

Keady, T.W.J., Mayne, C.S. and Kilpatrick, D.J. (2004). The prediction of food intake of lactating dairy cows offered grass silage or mixed forage-based diets throughout lactation. In: *The Proceedings of Annual Meeting of British Society of Animal Science*, p. 1, York, England.

Kebreab, E., France, J., Agnew, R.E. and Yan, T. (2002). A nonlinear approach to energy balance studies in lactating dairy cows. *Journal of Agricultural Science, Cambridge*, 139: 110-111 (abstract).

Kebreab, E., France, J., Mills, J.A.N., Crompton, L.A., Agnew, R.E., and Yan, T. (2003). Effect of forage to concentrate ratio on the efficiency of utilization of energy for milk production in dairy cows. *Journal of Dairy Science*, 86: (supplement 1) 341.

Yan, T. and Agnew, R.E. (2000). Validation of the UK metabolisable energy system and other energy systems. In: *The Proceedings of Annual Meeting of British Society of Animal Science,* p. 95, Scarborough, England.

Yan, T. and Agnew, R.E. (2002). Prediction of energy digestibility and concentration in grass silages using silage chemical composition and fermentation variables. In: *The Proceedings of the 13th International Silage Conference* (eds, L.M. Gechie and C. Thomas), pp. 298-299, Aye, Scotland.

Yan, T. and Agnew, R.E. (2003). Prediction of nitrogen degradability in grass silages using nutrient concentration and fermentation variables. In: *The Proceedings of Annual Meeting of British Society of Animal Science,* p. 108, York, England.

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Yan, T. and Agnew, R.E. (2005). Evaluation of prediction equations for metabolisable energy concentration in grass silage used in different energy feeding systems. In: *Silage Production and Utilisation*, Proceedings of the 14th International Silage Conference (eds, R.S. Park and M.D. Stronge), p. 268, Wageningen Academic Publishers, the Netherlands.

Yan, T. and Agnew, R.E. and Gordon, F.J. (2001). The prediction of digestible and metabolisable energy concentrations in grass-based diets of producing cattle using data determined through sheep at maintenance feeding level. In: *The Proceedings of Annual Meeting of British Society of Animal Science*, p. 92, York, England.

Yan, T., Agnew, R.E. and Porter, M.G. (2002). The effect of dietary and animal factors on methane production with cattle offered grass silage-based diets. In: *The Proceedings of the 13th International Silage Conference* (eds, L.M. Gechie and C. Thomas), pp. 300-301, Aye, Scotland.

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Yan, T., Ferris, C.P., Agnew, R.E. and Gordon, F.J. (2004). Short communication: effects of feeding level on energy concentration in grass silage-based diets offered to dairy cattle. *Journal of Dairy Science*, **87:** 1425-1427.

Book and Book Chapters

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Assumptions made in calculating

In calculating the NPV, the efficiency of feed utilisation was assumed to be improved by 5% with using the FiM models. This assumption is very modest and based on a number of facts, such as:

1. The FiM models use feed analytical information from the updated modern technology, such as, forage intake potential and feed nutrient contents determined using Near Infrared Reflectance Spectroscopy. This would greatly reduce the cost and analytical duration of a feed in comparison with traditional laboratory techniques.

2. The FiM models greatly improved the accuracy of feed rationing system of AFRC (AFRC, 1993) then used in UK. For example, the FiM project found that energy feeding system of AFRC (1993) underestimated metabolisable energy requirement for maintenance (ME_m) by 35% for current dairy cattle. This is because ME_m of AFRC (1993) was developed 30 years ago, and cow genetic merit in 30 years ago is much lower than current cows.

3. For a 600 kg cow, AFRC (1993) could underestimate ME_m by 20 MJ/day (approximately 1.7 kg DM feed), which could produce 4 litres milk/cow/day. If assuming milk price of 18 p/litre, mixed feeds of concentrates and silage of 12 p/kg DM and cost of producing extra 4 litres milk of 20 pence (5 p/l overhead costs), use of FiM model can increase net profit by 32 p/day per cow (4 litres X 18 p/l)–(1.7 kg DM X 12 p/kg DM) –20 p).

4. Assuming (a) a 150-day winter period (b) 40% of 290,000 cows calving September to December (c) 10% uptake of Feed Into Milk then annual benefit of £556,800.

5. Based on these assumptions, the Net Present Value of the present study over a 6-year period is estimated at £2,097,042 (Appendix A).

ALTERNATIVE FORAGES FOR DAIRY CATTLE

Background

There is currently an increasing interest in the production and use of alternative forage crops for feeding to high yielding dairy cows. This reflects both the potentially lower production costs per unit of energy associated with some alternative forage crops and the ability of some of these crops to increase total dry matter intake and improve milk yield.

High starch forage maize has become established as a forage to increase forage intake, milk yield and the protein content of milk (Keady *et al*., 2003; Patterson *et al*., 2004). High starch forage maize was included as one of the alternative forages. Earlier studies had shown that fermented whole crop wheat increased forage intake but generally had limited beneficial effect on the performance of lactating dairy cattle (Patterson *et al*., 2004). However, the new technique of milling or cracking the grain during harvesting as whole crop has enabled whole crop wheat to be ensiled at high dry matter contents (70 to 80% DM). These crops are treated with a urea plus urease product (Alkalage Home and Dry) to generate ammonia to preserve the crop. A further whole crop treatment harvested at 46% dry matter (fermented whole crop) was included as preliminary results from this type of crop suggested a small positive milk production response. Both the forage maize and whole crop wheat forages were included at 50% of total forage dry matter with grass silage comprising the remainder of the forage.

An important feature of the study was that two qualities of grass silage were used to complement the alternative forages with ME values of 10.4 and 12.4 MJ/kg DM to represent a traditional two-cut system or a high quality 3-cut approach respectively. Additionally, four control treatments were comprised of the two qualities of grass silage as the sole forage x two levels of concentrate supplementation. The overall arrangement of treatments permitted determination of both the concentrate sparing effects of the alternative forages and the grass silage quality equivalence values of the alternative forages, including high dry matter whole crop wheat.

The objectives of the study were: -

1. To measure dairy cow responses to alternative forages including high dry matter whole crop wheat.

2. To determine the grass silage equivalence values of a range of alternative forages.

3. To determine the concentrate sparing effects of a range of alternative forages.

Outline of study

The study involved a total of 40 freshly calved dairy cows with 10 treatments applied for a total of 10 weeks in a 2 period changeover design with:

1. Grass silage + 7 kg concentrates/day
2. Grass silage + 10 kg concentrates/day
3. High starch maize silage* plus 7 kg concentrates/day
4. Fermented whole crop wheat – 46% DM* plus 7 kg concentrates/day
5. High DM whole crop wheat treated with urea plus urease – 75% DM* plus 7 kg concentrates/day

All treatments applied with 10.0 and 12.4 MJ ME/kg DM grass silage

* Alternative forages at 50% of total forage DM intake

Measurements included forage intake, milk yield, milk composition, liveweight change and body condition score.

Main findings

The alternative forages were of good quality with starch contents of 33, 32 and 32% of DM for maize, fermented whole crop and high DM whole crop wheat respectively. The financial assumptions used to calculate the financial benefits are:

Grass silage (average quality)	£59.50/tonne DM
Forage maize silage	£63.00/tonne DM
Whole crop wheat silage	£59.50/tonne DM
High DM urea-treated whole crop wheat	£80.90/tonne DM

Winter milk price 18.0 ppl at 4.0% fat and 3.18% protein with composition adjustment of 0.032 p/l per 0.01% protein and 0.018 ppl per 0.01% fat.

Forage daily DM intakes were increased by 2.5 kg with fermented whole crop wheat, 2.8 kg with high DM whole crop (Alkalage) and a high value of 3.8 kg for forage maize, therefore substantial increases were obtained in total forage intake. Over a 150-day winter feeding period, the milk yield and milk composition responses represent margin over feed responses per cow of £28.50, -£22.20 and £54.00 for fermented whole crop, high DM whole crop (Alkalage) and forage maize respectively (Table 5). It is evident that the high DM whole crop was an unprofitable option due to a combination of higher cost of additive and limited response in milk yield. The fermented whole crop and forage maize increased profitability and these forages could be differentially adopted according to the suitability of local growing conditions.

Grass silage equivalence of alternative forage

This study was specifically designed to measure the magnitude of the responses to the alternative forage mixtures when compared with both low and high quality grass silages as the only forage in the diet. It is very clear from the performance results for the full set of 10 treatments that the potential for alternative forages to increase milk yield is greatly reduced when the grass silage is of high quality (Table 6). Alternatively, this outcome could be stated as high quality silage having the ability to compete with forage mixtures in milk yield potential, albeit the high intake characteristics of forage mixtures may offer longer term benefits by increasing body reserves of high yielding dairy cows. The yield of fat plus protein with the high quality grass silage on its own was fully equal to the low quality grass silage/forage maize mixture, and 15% greater than the yield obtained with the whole crop wheat/low quality grass silage mixture. These equivalence findings demonstrate the ability of high quality grass silage to have similar milk production potential to alternative forage mixtures. This important finding is of relevance to milk producers who operate in areas where the land type is more marginal and the only real forage option on the farm is the grass crop.

Key outputs

AgriSearch publications

Patterson, D.C. (2005). An examination of the effects of forage maize and whole crop silages on the performance of dairy cows offered two qualities of grass silage. AgriSearch Final Report, August 2005.

Scientific publications

Keady, T.W.J., Mayne, C.S. and Kilpatrick, D.J. (2003). The effect of maturity of maize silage at harvest on the performance of lactating dairy cows offered three contrasting grass silages. *Proceedings of the British Society of Animal Science*, p. 126.

Patterson, D.C., Kilpatrick, D.J. and Keady, T.W.J. (2004). The effects of maize and whole crop wheat silages on the performance of lactating dairy cows offered two levels of concentrates differing in protein concentration. *Proceedings of the British Society of Animal Science*, p. 4.

Patterson, D.C. and Kilpatrick, D.J. (2005). The effects of maize and whole crop wheat silages and quality of grass silage on the performance of lactating dairy cows. In: *Silage Production and Utilisation, Proceedings of the XIV International Silage Conference,* p. 165.

Assumptions made in calculating NPV

The adoption of the findings from this research could produce an increase in margin over feed of £478.5k per annum (£2.4 m over 5 years) based on the following assumptions:

1. 50:50 uptake of fermented whole crop:forage maize giving a mean increase in margin over feed/cow of £41.25 over a 150-day winter feeding period.

2. 40% of 290,000 cows calving September to December.

3. 10% uptake of the research over and above current utilisation of these forages.

It can also be assumed that the increase in DM intake obtained with the alternative forages would be conducive to increasing the levels of body tissue reserves. Although this was a short term feeding experiment, the alternative forages produced statistically significant increases in condition score which equated to approximately 0.25 units of condition score over a ten-week period. While it is difficult to put an economic value on this increase in body condition, biologically it is a very important

finding with potentially significant health/welfare and fertility implications for the feeding management of high yielding Holstein Friesian dairy cows. Furthermore, both the lower N requirements for growth and the lower N contents of the alternative forages may have beneficial implications under impending NVZ legislation.

Based on the assumptions detailed previously, the Net Present Value of the project over a 6-year period was estimated at £2,375,700 (Appendix A).

Table 5 The effects of forage treatment and concentrate level on performance[1]

	Forage type[2]							Grass silage			
	GS Low concentrate	GS High concentrate	FW	HW	MS	SED	Sig[3]	Low quality	High quality	SED	Sig[3]
Grass silage intake (kg DM/day)	9.91[d]	8.92[c]	6.11[a]	6.22[ab]	6.81[b]	0.311	***	6.83	8.36	0.173	***
Alternative forage intake (kg DM/day)	-	-	6.10[a]	6.37[a]	6.85[b]	0.210	***	3.56	4.13	0.132	NS
Total forage DM intake (kg/day)	9.80[a]	8.93[a]	12.25[b]	12.60[b]	13.58[c]	0.437	***	10.37	12.49	0.242	***
Concentrate intake (kg DM/day)	6.08[a]	8.52[b]	6.08[a]	6.06[a]	6.05[a]	0.095	***	6.60	6.53	0.059	NS
Total DMI (kg/day)	15.88[a]	17.45[b]	18.37[bc]	18.64[c]	19.61[d]	0.446	***	16.97	19.01	0.248	***
Milk yield (kg/day)	28.5[a]	30.5[b]	29.6[ab]	28.7[a]	30.9[b]	0.76	**	27.9	31.5	0.43	***
Fat (g/kg)	39.9	39.1	39.0	39.5	40.3	1.34	NS	40.7	38.5	0.73	**
Protein (g/kg)	30.6	32.0	32.0	32.0	32.2	0.64	NS	30.8	32.8	0.36	***
Fat + protein yield (g/day)	1989[a]	2129[bc]	2053[ab]	2057[ab]	2236[c]	66.0	**	1961	2224	37.2	***
Total milk energy/total DMI (MJ/kg)	5.41[b]	5.41[b]	4.83[a]	4.84[a]	5.01[ab]	0.214	**	5.12	5.08	0.144	NS
Milk energy output/total forage DMI (MJ/kg)	8.80[b]	11.01[c]	7.36[a]	7.20[a]	7.25[a]	0.534	***	8.08	7.84	0.337	NS
Liveweight change (kg/week)	0.12	0.51	2.23	1.82	1.64	1.025	NS	1.11	1.41	0.879	NS
Condition score change[4] (weekly)	-0.019[a]	0.012[b]	0.007[b]	0.008[b]	0.006[b]	0.0101	*	0.003	0.003	0.0094	NS
Concentrate sparing effect (kg/day)	0	NA	1.3	1.4	5.0	NA	NA	NA	NA	NA	NA

[1] Means within rows with differing superscripts are significantly different; $P<0.05$
[2] GS, grass silage; FW, fermented whole crop; HW, high DM whole crop; MS, forage maize
[3] Level of statistical significance; NS = $P>0.05$, * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$
[4] Scored on basis of 1 = very lean, 5 = very fat

Table 6 The effects of quality of grass silage and forage treatment and concentrate level on yield of fat plus protein (g/day) and on output of fat plus protein relative to low quality grass silage at the low level of concentrate feeding

	GS[1] high concentrate	GS low concentrate	FW	HW	MS	SED[2]
High quality grass silage	2260	2180	2144	2263	2275	
Relative yield	(126)	(121)	(119)	(126)	(127)	96.3
Low quality grass silage	1999	1798	1961	1851	2198	(5.4)
Relative yield	(111)	(100)	(109)	(103)	(122)	
Alternative forage response as % of grass silage quality response[3]	53	100	43	14	105	

[1] GS, grass silage; FW, fermented whole crop; HW, high DM whole crop, MS, forage maize
[2] Interaction probability *P*=0.097
[3] Alternative forage response is based on yield response to alternative forage with the low quality grass silage as a proportion of the yield response to the high quality grass silage as the only forage at the low level of concentrate feeding.

DEVELOPING IMPROVED GRAZING SYSTEMS

Supplements at pasture

Grasscheck 1 and 2

Supplementation at pasture

Background

It is often assumed that grazed grass is the cheapest forage available in Northern Ireland. However, recent costings suggest that grazed grass may not be as competitive as other forages, primarily as a result of poor pasture utilisation under grazing. The Northern Ireland dairy sector is characteristically a grass-based production system but two key principles have been highlighted which need to be considered in developing grass-based systems. If the grazing system adopted results in a major reduction in milk output per cow then the fixed costs per litre will increase. Alternatively, if the fixed costs of a farm are high and cannot be reduced easily then the grazing system adopted must be capable of sustaining relatively high individual cow performance. With the increased genetic potential of modern dairy cows and the high fixed costs on most NI farms, then it may be advisable to explore options that will support good individual cow performance. Furthermore, the key issue for managing high genetic merit cows is to maximise their potential milk output. This indicates that changes in grassland management for high merit cows will be in the form of trying to improve intake characteristics and/or improve the nutritional quality of the grass itself. Previous studies have shown that high herbage allowances of tall dense leafy grass in the sward maximise grass intake, however this system presents the problem of poor efficiency of utilisation of the grass herbage and may lead to deterioration in the sward. Under this management system dead material and stem fraction of the sward will increase unless the herbage remaining after grazing is reduced to a uniform short stubble height. This process is costly and wasteful and therefore a system that can utilise a greater proportion of the available herbage, e.g. supplementation, whilst maintaining a high intake and animal performance, would reduce the management costs, e.g. topping, and the actual cost of the herbage consumed.

This study involved spring-calving dairy cows with different supplementation strategies during spring and summer grazing including forage/alternative forage supplements. Both whole crop wheat and maize silage were included as supplements as they are high in readily available carbohydrate but low in protein and

were considered to be good complementary supplements for spring and autumn grass, which is high in protein but low in sugar.

The objectives of the study were to examine the effects of the supplement types on:

1. Milk yield and composition.
2. Herbage chemical, physical and nutritional properties.
3. Herbage intake and efficiency of grass utilisation.
4. Dry matter intakes and substitution rates.
5. Animal grazing behaviour.

Outline of study

The research programme involved two separate experimental studies, which are outlined briefly as follows:

Experiment 1 Effect of offering a range of forage and concentrate supplements to grazing dairy cows

The first grazing study involved 24 late winter/spring calving dairy cows offered either no supplement or one of the following supplements: (1) grass silage, (2) forage maize silage, (3) fermented whole crop wheat silage, (4) rapidly degradable concentrate 4.5 kg/cow/day or (5) slowly degradable concentrate 4.5 kg/cow/day. All forage supplements were offered *ad libitum* for a 2-hour period immediately after the morning milking only. Concentrate supplements were offered in parlour during each milking for cows offered both concentrate types.

Experiment 2 Effect of inclusion of a range of different forage supplements at two different grazing allowances to grazing dairy cows

The second grazing study involved 30 late winter/spring calving dairy cows offered either no supplement, grass silage, maize silage, whole crop wheat or a standard dairy concentrate at either low or high grass allowances (15 and 30 kg DM/day respectively measured above 4 cm). All forage supplements were offered *ad libitum* for a 2-hour period immediately after the morning milking only.

Main findings

Experiment 1 Effect of offering a range of forage and concentrate supplements to grazing dairy cows

- Supplementation with either forage or concentrates increased total DM intake and the greatest forage supplement intake was obtained with maize silage (6.3 kg DM/day). However, grass intake decreased with supplementation therefore incurring a substitution rate which was 0.56, 0.63, 0.53, 0.28 and 0.18 (DM basis) for cows offered grass silage, maize silage, whole crop wheat, rapidly degradable and slowly degradable concentrates respectively.

- Of the cows offered forage supplements, only cows offered maize silage had a higher average milk yield than unsupplemented cows, which was also associated with improved milk compositional quality. The compounded effect of these two responses obtained with maize silage produced an energy corrected milk (ECM) yield similar to that of concentrate supplemented cows.

- Cows offered concentrate supplements produced a significantly higher milk yield than any other treatment, but concentrate type had no effect on milk yield or milk composition.

- Animals offered maize silage had an improved N efficiency compared to any other treatment, primarily as a result of the combined effects of a reduced N input, coupled with an increased yield of milk protein. In addition, cows offered maize silage had a reduced blood plasma urea N and milk urea N concentration.

- The financial effects of the supplement treatments are shown in Table 7.

Table 7. Financial effects of supplement treatments†

Supplement	No supplement	Forage			Concentrate	
		Grass silage	Maize silage	Whole crop wheat	Rapidly degradable	Slowly degradable
Milk value (£/day)	3.10	3.33	3.60	3.26	3.96	3.85
Total feed cost (£/day)	0.48	0.59	0.73	0.62	1.45	1.19
Margin over feed costs (£/cow/day)	2.62	2.73	2.87	2.64	2.51	2.66
Margin over feed costs (ppl)	15.3	14.8	14.5	14.7	11.5	12.5
Margin over feed over grazing period (£/cow)‡	393	410	431	396	377	399

† Assumed costs: grazed grass £37.10/t DM, grass silage £59.50/t DM, maize £63.00/t DM, whole crop wheat £59.50/t DM and slowly degradable concentrate £189/t DM (Kilpatrick *et al*., 2002). Rapidly degradable concentrate £259/t DM. Base milk price of 18.1 pence/l, with a bonus of 0.018 and 0.032 pence/0.01% for additional increases in milk fat and protein above the base (4.0 and 3.18% respectively).

‡ Assumes 150-day grazing period

- Supplementation with grass silage, maize silage and whole crop wheat improved margin over feed by £17, £38 and £3 respectively over a 150-day grazing period, versus £6/cow with 4 kg slowly degradable concentrates/day.

Experiment 2 Effect of inclusion of a range of different forage supplements at two different grazing allowances to dairy cows

- Cows on the high herbage allowance had a higher herbage intake and lower voluntary intake of forage supplement but had a considerably lower efficiency of grass utilisation than cows offered the low herbage allowance (0.46 vs. 0.74 kg grass DM consumed/kg grass DM offered respectively).

- Forage supplement intake was higher with cows offered whole crop wheat than maize silage or grass silage (5.4, 4.3 and 2.8 kg DM/cow/day

respectively), resulting in a total DM intake which was higher with whole crop wheat and concentrate supplemented cows, compared to cows offered no supplement, grass silage or maize silage. Cows offered no supplement or the concentrate supplement treatments grazed for longer than cows offered forage supplements, resulting in cows offered these treatments having the highest herbage DM intake.

- Cows on the high herbage allowance produced a higher milk yield than cows offered the low herbage allowance. Cows offered concentrates produced a higher milk and ECM yield than cows offered any other treatment. However milk fat concentration was noticeably lower with cows offered concentrates. Cows offered no supplement had similar ECM yield to cows offered any of the alternative forages.

- Cows offered maize silage had a higher dietary nitrogen utilisation efficiency for milk production compared to cows which were unsupplemented or offered concentrates. Blood and milk urea-N concentrations were lower with cows offered maize silage and whole crop wheat than any other treatment, indicating improvements in efficiency of nitrogen utilisation within the rumen.

- The financial effects of the supplement treatments are shown in Table 8.

Table 8. Financial effects of supplement treatments†

		Supplement			
	No supplement	**Grass silage**	**Maize silage**	**Whole crop wheat**	**Concentrate**
Milk value (£/day)	4.10	4.07	4.22	4.17	4.66
Total feed cost (£/day)	0.84	0.90	1.00	1.09	1.55
Margin over feed costs (£/cow/day)	3.26	3.17	3.22	3.08	3.11
Margin over feed costs (ppl)	14.4	14.1	13.8	13.4	12.1
Margin over feed per cow over grazing period (£)‡	489	476	483	462	467

† Assumed costs: grazed grass £37.10/t DM, grass silage £59.50/t DM, maize silage £63.00/t DM, whole crop wheat £59.50/t DM and concentrate £189/t DM (Kilpatrick *et al*., 2002). Base milk price of 18.1 pence/l, with a bonus of 0.018 and 0.032 pence/0.01% for additional increases in milk protein and fat above the base (4.0 and 3.18% respectively).

‡ Assumes a 150-day grazing period

- In the second experiment, offering the forages reduced the margin over feed, while concentrate supplementation reduced it by a further £7 per cow. However, the effect of supplement on grass utilisation and hence subsequent cost of grazed grass has not been factored into the margin calculation, therefore making interpretation of the financial results difficult.

Implications of the findings

1. For all the home-grown forages used in this study, total DM intake increased and maize silage and whole crop wheat gave the greatest increase. Although substantial increases in milk yield were obtained, particularly in year 1, the milk yield response was modest with forage supplements. However, the additional energy supplied by the increased DM intake with maize silage and whole crop wheat supplemented cows may result in improved body condition, which may have beneficial implications for cow fertility and longevity.

2. Of all the forage supplements offered the inclusion of maize silage in the diet of grazing dairy cattle does appear to offer financial benefits but financial returns

will be dependent on good grass utilisation and are likely to be greatest at times within the grazing season when grass supplies are limited.

3. Increasing the grass allowance reduced efficiency of grassland utilisation with increased wastage, which if left unmanaged without intervention would lead to sward deterioration. Additionally, poor efficiency of utilisation will increase the cost of grazed grass and therefore impact on the profitability of the dairying system. Although maximal individual animal performance was achieved at the higher herbage allowance (+7% in milk yield compared to low herbage allowance), milk production per hectare was markedly reduced by 47%.

4. With incoming Nitrates Directives and Water Framework Directives, nutrient management is of critical importance. The efficiency of nitrogen utilisation with grazing dairy cows was improved with maize silage supplementation in both years. This primarily resulted from a reduced nitrogen intake by the animal and consequently a reduced level of nitrogen excretion.

Assumptions made in calculating NPV

It is considered that the positive responses in financial margin to forage supplementation in the first experiment derived from greater milk production responses to the supplements, which responses were linked to a relatively tight grass supply, arising from difficult weather conditions during that summer period.

It is, therefore, concluded that positive responses in financial margin can be obtained with supplementation of grazing using either grass silage or forage maize silage where either grass supply is tight or a simplified grazing management system based on low grass allowances is practiced. In contrast, supplementation with whole crop wheat or concentrates were of marginal benefit.

Adoption of the findings from this research could produce an increase in margin over feed of £17 per cow with grass silage over the grazing period (maize silage would increase the margin to £38/cow), which could equate to £197k per annum based on the following assumptions:

1. Grass silage offered for 2-hour period after morning milking.

2. 40% of 290,000 cows calving January to April.

3. 10% uptake of supplementation with grass silage.

It should also be noted that low allowances of grass give higher utilisation rates of available forage and therefore lower cost per kg of grass DM consumed. Furthermore, where maize silage can be fed successfully instead of grass silage the improvement in financial margin will be greater (up to £38/cow). In addition, supplementation of high protein grazed grass with low protein forages such as forage maize or whole crop wheat may offer potential benefits under impending NVZ legislation.

Based on the assumptions detailed previously, the Net Present Value of the project over a 6-year period is estimated at £994,364 (Appendix A).

Key outputs

AgriSearch publications

Morrison, S.J. and Patterson, D.C. (2005). Supplements for grazing dairy cows. AgriSearch Farmer's booklet.

Morrison, S.J. and Patterson, D.C. (2006). End of project report - Supplements for grazing dairy cows February 2006.

Scientific publications

Morrison, S.J. (2005). *The effect of the type of dietary supplement on the performance of the grazing dairy cow.* PhD Thesis, Queen's University Belfast, April 2005.

Morrison, S.J. and Patterson, D.C. (2004). Supplements for grazing dairy cows. *76th Annual Report, Agricultural Research Institute of Northern Ireland (2003-2004)*, p. 17-18.

Morrison, S.J. and Patterson, D.C. (2006). The effect of a range of supplementary feeds on performance of grazing dairy cows offered a high or low grazing allowance. *Proceedings of the British Grassland Society Eighth Research Conference* (4-6 September). p. 97-98.

Morrison, S.J. and Patterson, D.C. (2006). The effect of inclusion of a range of forage and concentrate supplements on milk production and dry matter intake of grazing dairy cows. (Submitted for publication in Grass and Forage Science).

Morrison, S.J. and Patterson, D.C. (2006). The effect of inclusion of a range of supplements at two grazing allowances on milk production and dry matter intake of grazing dairy cows. (Submitted for publication in Grass and Forage Science).

Morrison, S.J., Hameleers, A.J. and Patterson, D.C. (2006). The accuracy of alkane-controlled capsules in estimating intake in dairy cows. (Submitted for publication in Animal Science).

Morrison, S.J., Patterson, D.C. and Dawson, S. (2005). Grazing behaviour of cows offered a range of supplements and a high or low grazing allowance. *Proceedings of Agricultural Research Forum, Tullamore, Co. Offaly, Republic of Ireland* (14 and 15 March). p. 91.

Morrison, S.J., Patterson, D.C. and Dawson, S. (2005). The effect of inclusion of a range of supplementary feeds on herbage intake, total dry matter intake and substitution rate in grazing dairy cows. *Utilisation of grazed grass in temperate animal systems.* Ed J.J. Murphy. *Proceedings of a satellite workshop of the XXth International Grassland Congress, Cork, Republic of Ireland.* p. 230.

Morrison, S.J., Patterson, D.C. and Dawson, S. (2006). Dry matter intake of dairy cows offered two grazing allowances and a range of supplements. *Proceedings of Agricultural Research Forum, Tullamore, Co. Offaly, Republic of Ireland* (14 and 15 March). p. 88.

Morrison, S.J., Patterson, D.C. and Kilpatrick, D.J. (2004). Meal eating behaviour of cows offered a range of forage supplements during the grazing season. *Proceedings of Agricultural Research Forum, Tullamore, Co. Offaly, Republic of Ireland* (1 and 2 March). p. 80.

Morrison, S.J., Patterson, D.C. and Kilpatrick, D.J. (2004). The effect of inclusion of a range of supplementary feeds on milk yield and composition of grazing dairy cows. *Proceedings of the British Society of Animal Science, York*, p. 48.

GRASSCHECK 1 AND 2

Background

Profitability of milk production systems has declined markedly within the past 6-10 years, which reflects reductions in milk price, and the value of cull cows and calves. A reduction of production costs offers the primary means of survival for many dairy farms given the current low milk price. Increased reliance on grazed grass offers a real opportunity to reduce milk production costs, as demonstrated in a previous review of the costs of a range of forages on Northern Ireland dairy farms by Kilpatrick *et al*. (2002). This review indicates that grazed grass costs can be reduced to <£60/t DM at a utilised yield of 10 t DM/ha, in comparison to costs of £90-100/t DM for grass silage. However, at low utilised grass yields (e.g. 6 t DM/ha), costs of grazed grass can be similar to or higher than those for grass silage.

Successful utilisation of grass under grazing requires frequent decision making in order to accommodate fluctuations in the pattern of grass growth both between and within years, in addition to changes in grass quality and nutrient demands by the cow/herd over the season. Furthermore, grazing is often associated with low and variable herbage intake and animal performance. As a consequence of these factors, the full potential of grazed grass is not being realised on many farms throughout Northern Ireland. To maximise the potential of grazed grass it requires knowledge of grass growth rates through the season and use of these data in effective grass budgeting.

However, there is relatively little information on actual growth rates achieved on Northern Ireland farms, which is essential for informed decision-making. The GrassCheck project includes grass growth and quality assessments established on controlled plots and also on dairy farms around Northern Ireland.

Main findings

Results of three years (1999, 2000, 2001) of monitoring of grass growth indicate major variation in the pattern of grass growth between years and also major differences in growth rate between sites. Variations in grass growth between years was equivalent to ±11%, which clearly creates major problems in grazing

management, given the need to adjust the grazing area both within and between seasons to maintain a constant grass supply. This highlights one of the key advantages of having a grass growth monitoring system within Northern Ireland, to provide farmers with an 'early warning' system, highlighting either very good or bad grass growing seasons.

There were major changes in grass chemical composition through the grazing season, particularly in terms of crude protein and sugar contents of grass. Crude protein contents of grass were very high in early spring (>30%) and in late autumn (>20%). Grass sugar content increased in early season to a peak of approximately 25% and then declined to less than 5% in late season (Mayne *et al*., 2002). These changes in grass composition have considerable impact on cow performance and indicate the need for changes in supplement type through the season, in order to balance nutrient supply and improve animal performance. The GrassCheck system provides a basis for informed decision making on the most appropriate type of supplement to feed at different times during the season.

The on-farm results obtained indicated that there is a considerable opportunity to improve grass utilisation through reducing pre-grazing sward heights and yields, thereby improving grass quality in mid season. Overall estimated utilised yields under grazing on the two farms assessed were 9.8 and 10.5 t DM/ha. This equates to a grass cost of £60 and £56/t DM on the two farms (Mayne *et al*., 2002).

Main outputs

AgriSearch publications

Mayne, C.S, Patterson, D and Rankin, W.S.A. (2002). On farm monitoring of grass growth, grass quality and herbage intake of dairy cows in Northern Ireland. End of project report to AgriSearch, July 2002.

The grass growth information was reported weekly in the farming press, with results outlined to groups of farmers visiting the Hillsborough site throughout the duration of the project.

Other outputs

The monitoring of depressed grass growth throughout the 2002 growing season provided the EU Commission with the required evidence to approve the 'Weather Aid' application. The GrassCheck data played a critical part in securing the £1.42 million weather aid package for dairy farmers (correspondence published at: www. ec.europa.eu/community_law/state_aids/agriculture-2003/n545-03.pdf).

Assumptions made in calculating NPV's

Although this project does generate financial returns through a proportion of dairy farmers actively acting upon the growth information to enhance their grazing management, this benefit was excluded from the economic appraisal until more data can be obtained on the utilisation of data from this project on the decision making process on farms.

The financial benefit therefore attributed to GrassCheck was the Northern Ireland Weather Aid (2002) Scheme. The aim of this scheme, administered by DARD, was to compensate producers for losses to production that occurred as a result of abnormally wet weather conditions in Northern Ireland in 2002. This state aid required approval from the European Commission, the securing of which would not have been possible without the accurate identification of the depressed grass growth during 2002 (correspondence published at: www. ec.europa.eu/community_law/state_aids/agriculture-2003/n545-03.pdf).

In total the budget for the Weather Aid payment was £4,575,000 for farmers in Northern Ireland. In the economic appraisal for the current project, the payment to dairy farmers (£1.42 million) alone was used. On this basis the Net Present Value for the project was estimated at £1,042,400 (Appendix A).

BULL BEEF PRODUCTION

HOLSTEIN BULL BEEF PRODUCTION

Background

With the continuing trend for increased use of Holstein genetics in dairy herds, the number of Holstein-Friesian bull calves produced as a by-product within the dairy industry has increased. These calves have been bred for dairy traits which are negatively correlated with many important beef traits e.g. carcass conformation and food conversion efficiency. The traditional system for finishing Holstein male cattle in many parts of the UK has involved intensive feeding, with animals offered concentrates *ad libitum* with a limited amount of straw as a source of roughage. This type of production system has become more attractive in recent years as the cost of cereals relative to that of forage has decreased. With the current lack of manufacturing beef within the processing sector, for which the majority of Holstein carcasses are destined, many abattoirs have been keen to promote the fattening of young bulls to help meet market requirements. These factors, and the potential for a quick turnover in terms of capital invested, have increased the popularity of intensive dairy bull beef production across Northern Ireland. However, profitability is the key determinant of the viability of any production system, and with the decoupling of subsidies from agricultural production, a more economical approach to rearing Holstein male progeny will be required if the system is to remain viable. On this basis the objective of this study is to undertake an economic evaluation of Holstein bull beef production.

Main findings

1. At a base beef price (U3 = 202 p/kg, January 2005) and concentrate cost (£120/t) margin over total costs (excluding labour) was negative for all bulls, regardless of slaughter weight (bulls slaughtered from 300 to 500 kg live weight).

2. Beef prices need to increase to 245 p/kg for U3 grades to return margins over total costs (excluding labour), approximating to £100 per head for heavier bulls.

3. Break-even food conversion ratio was achieved by slaughtering bulls at 515 kg live weight.

4. Finishing Holstein male cattle as steers on intensive diets results in considerably higher losses compared to bulls slaughtered at the same live weight.

5. Results from this research highlighted that good quality meat can be obtained from Holstein bulls. For example, across all slaughter weights, sensory panellists considered only 8% of sirloins from bulls as unsatisfactory, 50% were considered everyday quality, 30% better than everyday quality and 12% were assessed as premium quality.

Overall, the data demonstrated the lack of profitability of Holstein bull beef production in a subsidy-free, market driven economy.

Key outputs

AgriSearch publications

Kirkland, R.M., Keady, T.W.J. and Anderson, D. (2005). Economic Evaluation of Holstein Bull Beef Production. End of Project Report to AgriSearch, January 2005.

Kirkland, R.M., Keady, T.W.J., Patterson, D.C., Steen, R.W.J., Moss, B.W. and Anderson, D. (2006). Holstein Bull Beef Production. AgriSearch Farmers Booklet, August 2006.

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Assumptions made in calculating NPV

The results of this study demonstrated that, at prevailing market prices and costs of production, Holstein bull beef production is unprofitable. As a consequence, this study has potentially saved the beef industry £165,000 per annum through the cessation of unprofitable production systems. It is assumed that 10% of producers will base their decisions on information presented from this study, thus potential loss saving of £16,500 per annum may be attributed to this study.

<u>Assumptions</u>

Total number of dairy cows in Northern Ireland = 290530 (DARD, 2005)

Number of cows producing a calf = 232424 (80% target set by Mackey *et al.*, 2003)

Number of bull calves produced = 232424 x 50% = 116212

Number of Holstein bull calves produced = 116212 x 80% = 92970 Holstein bull calves (assume 80% are sired by Holstein bulls and 20% by Beef bulls (DARD 2005))

Number of calves finished as bulls = 92970 x 20% = 18594 (LMC Yearbook, 2005, 20% of animals slaughtered were bulls)

Average price at slaughter = 173.3 p/kg carcass weight (LMC Bulletin, January 2005)

Average carcass weight = 223.5 kg (Kirkland *et al.,* 2006)

Total value of output = £7.2 m

Variable costs (£/head) = £349.5 (Kirkland *et al.,* 2006)

Total variable costs (£) = £6.5 m

Fixed costs (£/head) = £46.7 (Kirkland *et al.,* 2006)

Total fixed costs (£) = £0.9 m

Margin over total costs (fixed and variable) = -£0.165 m

Based on the assumptions presented above the Net Present Value of the current study over a 6-year period amounts to £73,773 (Appendix A).

PROJECTS CURRENTLY BEING UNDERTAKEN

Factors affecting the development of lameness

Maximising returns from beef progeny sourced from the dairy herd

Management/nutrition of neonatal calves

Alternative forages for summer slurry utilisation

Identifying optimal Northern Ireland milk production systems

Developing supplementation strategies for dairy cows

FACTORS AFFECTING THE DEVELOPMENT OF LAMENESS

Background

Lameness occurs at an average incidence of 24 cases per 100 cows per year in UK dairy herds (Kossaibati and Esslemont, 1996). The cost of an average case of lameness is calculated to be approximately £140 (O'Callaghan, 2002). Therefore, lameness is likely to cost Northern Ireland dairy farmers in the region of £10 million per annum, which is approximately 10% of the total cost of milk production (The Agricultural Census in Northern Ireland, 2002).

The culling rate of high yielding dairy cows in the UK is estimated to be approximately 25% per annum (Farm Animal Welfare Council, 1997). A recent large scale DARD/AgriSearch survey found that 13.4% of cows culled in Northern Ireland were culled because of lameness (Mayne *et al*., 2002). Therefore, lameness not only contributes to reduced on-farm efficiency (Webster, 2001), but is also likely to become of increasing ethical concern to consumers.

In view of this background, research to reduce levels of lameness in Northern Ireland dairy cows has been initiated in order to maintain viability and competitiveness. This type of research is also important in terms of creating a "welfare friendly" image of Northern Ireland dairying.

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Current Objectives

1. To assess the relationship between internal and external hoof structures and the development of solar lesions in dairy cows.

2. To manipulate historical data from AFBI, Hillsborough to assess the relative importance of genetic, management and nutritional factors on the development of lameness in cows.

3. To carry out on-farm survey work to identify the main factors preventing farmers dealing with lameness problems at an early stage.

Progress in relation to objectives

Objective 1

Solar lesions account for a significant proportion of lameness in dairy cows. The aim of this part of the study is to assess which of the following factors has the greatest influence on development of solar lesions:

- Laminitis
- Flexor tendon strength
- Size and fat content of digital cushion
- Level of heel erosion

Hooves from 100 high genetic merit Holstein-Friesian heifers reared under different nutritional regimes have been examined. Data analyses underway.

Objective 2

Work to-date on the unique datasets suggests that genetic effects are more important in determining lameness problems than management or nutritional effects.

Objective 3

A major survey on lameness is being carried out on dairy farms across Northern Ireland. Provisional data indicates that a simple on-farm recording system would be

beneficial. There is a strong relationship between knowledge level of producer and the level of lameness recorded in the herd. Cubicle size and overstocking are also key factors influencing lameness.

Key outputs

AgriSearch Publications

Baird, L. and O'Connell, N. 2005. Strategies for reducing lameness in northern ireland dairy herds. Agrisearch Progress Report, March 2005

Scientific publications

Baird, L.G., O'Connell, N.E., Carson, A.F., McCoy, M.A. and Logue, D.N. (2006). An investigation into factors affecting internal hoof structures in dairy heifers. *International Society for Applied Ethology, Annual Conference, Bristol*, August 2006 (accepted).

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Assumptions made in calculating NPV

1. Benefits are dependent on uptake of research findings by producers. No financial benefits are likely to occur during the initial part of the research (i.e. during the first 2 years of the trial).

2. Evidence suggests that uptake of research findings will lead to a reduction of approximately 20% in lameness problems (Clarkson *et al*., 1996). In the current appraisal, it is estimated that research findings will be adopted by 5% of farmers in year 3, 6% of farmers in year 4, and 7% of farmers in year 5.

3. As stated previously, lameness has an average cost of £140 when it is treated promptly. This cost varies widely depending on type of lameness and the promptness of the treatment. It is anticipated that this research will lead to an increase in rapidity of treatment, and also to a reduction in the development of lameness. It is assumed in these calculations that each reduced incidence of lameness will save the farmer £140.

4. In year 3, if 5% of farmers adopt research findings, this would involve approximately 14,500 dairy animals. If lameness occurs at an average annual incidence of 24 cases/100 cows/year, this will equate to approximately 3480 cases of lameness. If lameness is reduced by 20% then this equates to 696 less cases of lameness and a saving of £97,440.

5. In year 4, if 6% of farmers adopt research findings, this would involve approximately 17,400 dairy animals. If lameness occurs at an average annual incidence of 24 cases/100 cows/year, this will equate to approximately 4176 cases of lameness. If lameness is reduced by 20% then this equates to 835 less cases of lameness and a saving of £116,928.

6. In year 5, if 7% of farmers adopt research findings, this would involve approximately 20,300 dairy animals. If lameness occurs at an average annual incidence of 24 cases/100 cows/year, this will equate to approximately 4877 cases of lameness. If lameness is reduced by 20% then this equates to 976 less cases of lameness and a saving of £136,416.

7. In year 6-8 it is assumed that 10% of farmers adopt research - calculation as before.

Based on the assumptions detailed above the Net Present Value of the project over a 6-year period is estimated at £423,844 (Appendix A).

MAXIMISING RETURNS FROM BEEF PROGENY SOURCED FROM THE DAIRY HERD

Background

Currently 52% of prime cattle slaughtered in Northern Ireland come from the suckler herd and 44% from the dairy herd. It has been predicted that the decoupling of subsidies from production will result in a reduction in suckler cow numbers, but the dairy herd will increase slightly. The predicted decrease in beef production from the suckler herd, coupled with the desire by dairy producers to increase income from calf sales is likely to result in an increased proportion of beef from the dairy herd. Whilst beef cross dairy calves from the dairy herd command a significant premium in price in the market place relative to Holstein bulls calves, it is essential that the actual additional value of the beef cross dairy calves is determined, i.e. is the increased premium for beef cross calves actually translated into value of beef produced? When moving from a suckler cow system, where the cow is responsible for rearing the calf, to a dairy-beef system it is also important to consider the significant additional labour input associated with rearing calves. If there is to be a move to sourcing more calves from the dairy herd for beef production, research into labour efficiency and the associated economics of cattle rearing/finishing must be considered. The objectives of the study are to:

1. Develop low labour input systems for rearing beef bred calves from the dairy herd.

2. Evaluate the effect of using genetically superior beef sires to cross within the dairy herd on performance, food conversion efficiency and meat quality of progeny when finished as either steers or bulls.

3. Determine the value (economic and production) of a beef cross calf relative to a Holstein bull.

4. Assess the impact of using semen from genetically superior beef bulls in the dairy herd on calving difficulty and subsequent cow performance and fertility.

Assumptions made in calculating NPV

1. Benefits are dependent on uptake of research findings by producers. No financial benefits are likely to occur during the initial part of the research (i.e. during the first 2 years of the trial).

2. The benefits are estimated on the basis that due to the research findings, there is a 2% increase in the number of beef bred calves sired by genetically superior beef bulls in year 3, 4% in year 4, and 5% in year 5.

3. PRIOR TO ADOPTING RESEARCH PROGRAMME

   (a) Total number of dairy cows in Northern Ireland = 290,530 (DARD Census, 2005)

   (b) 80% of these cows produce a calf = 232,424 calves (80% target set by Mackey, 2003)

   (c) 50% of the calves are bulls = 116,212

   (d) Assume 85% of the calves are reared to finishing = 98,780 (assume mortality of 15%

   (e) Assume average price for finishing cattle = £1.70/kg dead weight (based on DARD, 2004)

   (f) Average carcass weight for all cattle slaughtered in 2005 was 316 kg (DARD, 2005), assume average carcass weight for dairy bred steers is 311 kg (Steen *et al.*, 1995, Keane and Allen 2002)

   (g) *TOTAL VALUE OF OUTPUT PRIOR TO ADOPTING TRIAL* = 52.2 m

4. ADOPTION OF RESULTS OF RESEARCH TRIAL = YEAR 3

   (a) There is a 2% increase in calves sired by genetically superior beef bulls = 98,780 * 0.02 = 1,976 calves

   (b) Assume price increase of 5 p/kg due to improved carcass grade classification (currently there is approximately 5 p/kg differential between conformation grade classifications (LMC, 2005)

   (c) Assume carcass weight increase of 20 kg due to crossing with genetically superior beef breeds (Steen *et al.,* 1995)

   (d) Total value of output by adopting findings of research trial = 331 x 1.75 x 1,976 = £1.1 m

(e) Remaining 98% of calves from dairy herd did not benefit from results of research programme = 98,780 x 0.98 = 96,804 calves

(f) Price and carcass weight remain as before therefore value of output = 96,804 x 1.70 x 311 = £51.2 m

(g) *TOTAL VALUE OF OUTPUT THROUGH ADOPTING RESEARCH* = 1.1 + 51.2 = £52.3 m

(h) *OVERALL BENEFIT OF RESEARCH PROGRAMME* = 52.3 – 52.2 = £99,867

5. ADOPTION OF RESULTS OF RESEARCH TRIAL = YEAR 4

(a) There is a 3% increase in calves sired by genetically superior beef bulls = 98,780 * 0.03 = 2,963 calves

(b) Using assumptions listed under point 4(b) to 4(h) overall benefit in year 4 = £149,800

6. ADOPTION OF RESULTS OF RESEARCH TRIAL = YEAR 5

(a) There is a 4% increase in calves sired by genetically superior beef bulls = 98,780 * 0.03 = 3,951 calves

(b) Using assumptions listed under point 4(b) to 4(h) overall benefit in year 4 = £199,733

In total, the Net Present Value of this project over a 6-year period is estimated at £221,636 (Appendix A).

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MANAGEMENT/NUTRITION OF NEONATAL CALVES

Background

Successful calf rearing underpins both dairy and beef production enterprises. The success of calf rearing can be defined as the maintenance of healthy calves and ensuring adequate growth rates. However, if the objective is to provide replacement heifers for the dairy herd then ensuring a fit and productive heifer at first calving must be the overall goal. Over the last twenty to thirty years it has been recommended that calves be fed to attain growth rates of 450-600 g/day during the period from birth to weaning. This has been achieved by feeding a fixed level of milk replacer (500-600 g milk powder/calf/day) between day 7 and day 56 of age. In addition, calves have normally been given access to concentrate feed and water during this period (Fallon, 1992). North American workers (Van Amburgh *et al.,* 2001 and Drackley, 2005) have recently questioned whether this practice of restricted feeding is the correct biological approach to achieving optimum calf growth and health. On the back of this work, it has been proposed that calves should be fed high levels (X2 standard levels) of milk replacer. Also, it is proposed that the milk replacer should contain a high protein content (30% versus the standard 23%). This theory has begun to be put into feeding practices in Northern Ireland without any supporting data on the implications of moving to high input milk replacer systems.

In view of this background, this research programme was initiated to investigate:

1. The effect of increasing the level of milk replacer feeding and crude protein content of the milk replacer on calf growth and development during the pre-weaning phase of life.

2. Residual effects of increasing level of milk replacer feeding and crude protein content on heifer growth, health, fertility (and ultimately first lactation production).

Outline of study

- One hundred and eleven autumn born high genetic merit Holstein-Friesian (57 heifers, 54 bulls) and one hundred and three spring born predominantly

Holstein-Friesian calves although including cross-bred (63 heifers, 40 bulls) were used in the study.

- A 2 X 2 factorial design was used involving two levels of milk replacer feeding: 5 or 10 l/day (120 g of milk replacer powder per litre of water); and two milk replacers with standard (230 g CP/kg DM) or high (300 g CP/kg DM) crude protein (CP) contents respectively.

- Individual milk replacer intakes were recorded on 5 days per week from day 5 until weaning at day 56. Live weight was recorded weekly, and height at withers, body length and heart girth were recorded fortnightly throughout the pre-weaning phase of the study. Post-weaning live weight, skeletal size and body condition were recorded at monthly intervals until entering the milking herd. Full performance records during the first lactation were analysed.

Main Findings

1. Calves offered 10 l milk replacer per day grew faster from birth to weaning compared with calves offered 5 l/day. However, by 9 months of age there was no difference in live weight or skeletal size of calves offered the high versus the standard intake of milk replacer.

2. Calves offered the 10 l/day consumed less calf starter concentrate from birth to weaning.

3. Milk replacer crude protein content had no effect on growth and development of calves.

4. Calf rearing regime had no effect on subsequent performance of dairy herd replacements in the milking herd.

Implications

This programme dispelled the hypothesis from North America that calves should be fed increased levels (50 versus 25 kg/calf) of milk replacer. The programme also

refuted the recommendations, based on North American advice, that the protein content of milk replacers should be increased from 23 to 30%.

Assumptions made in calculating NPV

In Northern Ireland approximately 260,000 calves sourced from the dairy herd are reared annually (DARD, 2005) with an estimated 50% of calves reared on milk replacer.

In recent years there has been an impetus, led by the animal feed industry, to move to higher levels of milk replacer of 30% protein content. Moving to this feeding system adds approximately £50/head to rearing costs (assuming milk replacer at £1,000/tonne).

It is assumed that 5% of milk replacer fed calves would have been moved onto this higher input system over a 3-year period without the clear recommendations derived from the current research programme. Consequently cost savings of £50/calf for 13,000 calves have been estimated equating to a cost saving of £325,000 per annum.

In total, the Net Present Value of this project over a 6-year period is estimated at £991,164 (Appendix A).

ALTERNATIVE FORAGES FOR SUMMER SLURRY UTILISATION

Background

Impending water quality legislation, coupled with continual pressure to reduce production costs will require livestock farmers to make more efficient use of the nutrients contained within animal slurry. These changes are also likely to result in an extensification of land use in Northern Ireland agriculture (Moss *et al*., 2003), and land will have to be kept in 'an agricultural state'. Possibly, levels of part-time farming and the use of contractors will increase. Dairy farming will stay intensive in terms of land use near to the farm with more extensive land use, further away from the farm.

Dairy farmers, on the basis of the AgriSearch questionnaire (2003), identified that one of the main problems currently encountered was using slurry nutrients during the grass growing season, and the need to have areas available to which slurry can be applied. Areas near the farm are used for grazing and/or intensive silage cutting routines and give little opportunity for slurry application during the growing season. It is therefore proposed to investigate what role low input extensive forage crops could play in terms of producing forage and integrating this with environmentally responsible use of slurry on areas of land that have to be kept in "an agricultural state". It is proposed to investigate the potential of different perennial forage crops with high nutrient absorption capacity, high yield potential, and low labour requirements. The research would allow farmers to make informed decisions on how to use slurry in an environmentally responsible way using different forage crop options. The forages included within the study are: Italian ryegrass, tetraploid ryegrass, hybrid ryegrass, diploid ryegrass, red clover, low input grass mixture, ryegrass and white clover mixture and lucerne. Cattle slurry will be applied using the trailing shoe technique on three occasions during the growing season, with the slurry applied at 4 different application rates.

Main findings to-date

This project is ongoing, with two of the four growing seasons completed. Results at this stage remain preliminary, although a summary paper is being prepared for a poster presentation at a conference in Spring 2007. Of the 8 perennial forage crops

selected, lucerne has been dropped from the project due to it failing to establish successfully within the plots. All remaining forages demonstrated a good response to increased levels of slurry application, with the exception being red clover. The red clover herbage yield was not influenced by slurry application, with biomass production of over 17 t DM/ha at all slurry levels.

Project outputs

The first year's data are currently being prepared as a summary for a conference entitled 'High Value Grassland', which is being organised jointly by the British Grassland Society and the British Society of Animal Science.

The preliminary results of this project have been outlined to a number of visiting farmers groups. In addition, the study was presented at the beef open day at AFBI, Hillsborough in September 2006.

Assumptions made in calculating NPV

The expected benefits of this project include reduced use of fertiliser inputs, improved efficiency of slurry utilisation and reduced nitrogen emission to the environment. The financial benefits within the economic appraisal are based solely on the potential saving of inorganic nitrogen fertiliser, and this saving was established at 75 kg N/ha/year. The additional utilisation of nitrogen from slurry applied by the trailing shoe method as opposed to the splash plate has been established by a number of studies at Hillsborough (Binnie and Frost, 2003a,b). This additional utilisation associated with the trailing shoe combined with the fact that slurry can be effectively applied throughout the growing season generates the annual saving potential of inorganic N of 75 kg/ha. Previously, research has shown that the same quantity of slurry applied by trailing shoe compared to splash plate can improve the utilisation of slurry N equivalent to 79 and 60 kg/ha of inorganic N fertiliser (Frost and Mulholland, 2006; Frost, 2006).

In summary, the expected benefits from this programme include: -

- Reduced mineral fertiliser inputs into ruminant production systems
- Increased efficiency of slurry utilisation in ruminant production systems.

- Reduced nitrogen emission to the environment.
- Reduced dependence of one forage crop (perennial ryegrass)

1. It is assumed that through this research mineral fertiliser saving of 75 kg N/ha/year is achievable. Cost of 1 kg N is estimated at £0.5.

2. In year 3 it is assumed that 5% of dairy farmers (total 4058) will apply technology on 5 ha. In year 4 it is assumed that 6% of dairy farmers will apply technology on 5 ha. In year 5 it is assumed that 7% of dairy farmers will apply technology on 5 ha. In year 6-8 it is assumed that 10% of dairy farmers (total 3500) will apply technology on 5 ha.

   Increasing interest in the trailing shoe technique is already evident within the industry. Farmers are increasingly becoming aware that improving the efficiency of use of slurry nutrients will be integral in order to meet the legislative constraints within the Nitrates Directive, whilst still maintaining good levels of grassland production and minimising the costs of production. Whilst the Republic of Ireland has included slurry application equipment within its Nutrient Management Grant Scheme, no such scheme exists for Northern Ireland farmers. Nonetheless, a recent slurry event highlighting the range of slurry application techniques available was attended by around 500 farmers, indicating the interest that is building in this technology. Therefore, it is expected that from next year (Year 3 of this project) there will be an increasing number of farmers using the trailing shoe technique to apply slurry, especially as the Nitrates Directive is expected to commence January 2007.

Based on the assumptions presented above the Net Present value of the project over a 6-year period is estimated at £144,791 (Appendix A).

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IDENTIFYING OPTIMAL NORTHERN IRELAND MILK PRODUCTION SYSTEMS

Background

One of the mantras of EU agricultural policy is that farmers must become more competitive. However, it is not always clear what milk production system farmers should operate in order to achieve this goal. In this research project a profit maximising whole-farm model is being developed. Work will be undertaken to demonstrate how this model can play a decision support role in helping farmers to choose their optimal system.

A range of alternative milk production systems have been incorporated into a representative dairy farm model involving variations in date of calving, quantity of concentrate fed, and nature of forage utilised. Milk supply pattern and quality have been assumed to vary with calving date and diet. Milk marketing contract options have also been incorporated into the model. These milk marketing contract options are structured in line with the milk pricing arrangements that currently predominate in Northern Ireland, that is, they incorporate the interaction of four key parameters, namely, average annual price, seasonal price variation, butterfat content and protein content.

The influence of changes in key variables on the optimum milk production system is discussed. Moreover, particular attention is being given to how these models could be used as a decision support tool to help farmers in their business strategy decisions. Agricultural researchers, agribusiness advisers and agricultural policy makers may also be better informed as to when it is appropriate for farmers to adopt a particular production system.

An economic appraisal of the project will be undertaken when the model is developed fully for use as a decision support tool.

DEVELOPING SUPPLEMENTATION STRATEGIES FOR DAIRY COWS

Background

Supplementation of forage with concentrates is an important management tool to achieve improved efficiency and economic sustainability of dairy cow production systems. The current approach to rationing of dairy cow diets is to evaluate the basal forage, combine this with target milk yield and formulate a diet according to nutrient demands. Genetic merit has improved dramatically, possibly changing also the utilisation of energy reserves. These two factors might explain the current problems being experienced by dairy farmers in terms of health and fertility with the high production dairy cow. Conception rates as low as 38% have been reported with major implications for lifetime productivity. Recent AgriSearch and MDC studies have shown that fertility is the single largest culling factor in dairy cows in Northern Ireland and the UK.

Lactation is a natural process, which has developed after a long period of evolution, associated with taking care of the recently born and subsequent reproduction. It may therefore be assumed that certain processes like utilisation of body reserves are genetically driven. However this is normally ignored in current rationing systems and this might explain the great variability found in responses to supplementation. Current fertility and health problems are indicating that we are not responding to the needs of the dairy cow in terms of feeding. On the other hand, with the automation of the milking process (and in some cases the feeding process) information is generated on a daily basis, which could improve the feeding of the average cow whilst also enabling feeding of cows individually. New rationing systems should not only consider the current state of the dairy cow but also incorporate long-term objectives. This will not only result in more efficient use of feeds but also could improve herd life of the dairy cow. Recent work in the project “Improved methods of rationing cattle”, has provided us with excellent instruments to predict nutritional needs. It is, however, necessary to start incorporating long-term objectives in feed rationing programmes.

The objectives of the present study are to investigate responses of dairy cows to supplementation and determine the relationship with the use of body reserves,

fertility and health aspects in high productive dairy cows. This will involve a series of studies:

1. The effect of supplementation during different stages of lactation and parities and its relation with productivity and indicators of health and fertility.

2. The effect of supplementation of cows being offered high and low energy density diets and its relation with productivity and indicators of health and fertility.

3. The development of a cow response model on the basis of the two studies mentioned above.

Experiments initiated and results to-date

In year 1 of the study a permanent increment of concentrate feeding (4 kg/day) was superimposed on top of a good quality diet from weeks 2, 6 or 10 post-calving in a study involving 40 cows and 40 first lactation animals of high genetic merit. The milk yield response to this increment of supplementation to 29 weeks post-calving, averaged 1.6 kg milk/day over the first 29 weeks. While the immediate milk yield response to this increment of concentrate feeding was uneconomic on the basis of the immediate milk yield/feed cost calculation, potential long term benefits of improved fertility, health and welfare will be assessed at which point the indirect financial benefit of these aspects can be assessed.

A further study involving 40 cows and 40 heifers, was set up to examine the effects of high and low energy diets given pre-calving to produce high and low body condition score at calving, followed by high and low energy lactation diets. Preliminary data from this study indicate that while pre-calving energy content of the diet had no significant effect on milk yield, the high energy lactation diet produced significantly higher milk yield, but neither pre-calving or post-calving energy content of the diet had a direct effect on any of the fertility parameters. However, assessment of individual animals in terms of body condition score at calving, degree of negative energy balance at peak lactation etc, appears to explain differences in fertility performance between individual cows and heifers. The analysis of the results from this study is ongoing. The conclusions from the results of these first two studies

will be used to develop a cow response model and the model will be validated in a specifically designed final milk production study using high yielding animals.

Financial assessment

This study is too preliminary for meaningful financial assessment.

APPENDIX A

SPREADSHEETS DETAILING MONETARY COSTS AND BENEFITS OF PROJECTS