Moorepark'15

IRISH DAIRYING – SUSTAINABLE EXPANSION

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Teagasc,
Animal & Grassland Research and Innovation Centre,
Moorepark,
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Co. Cork

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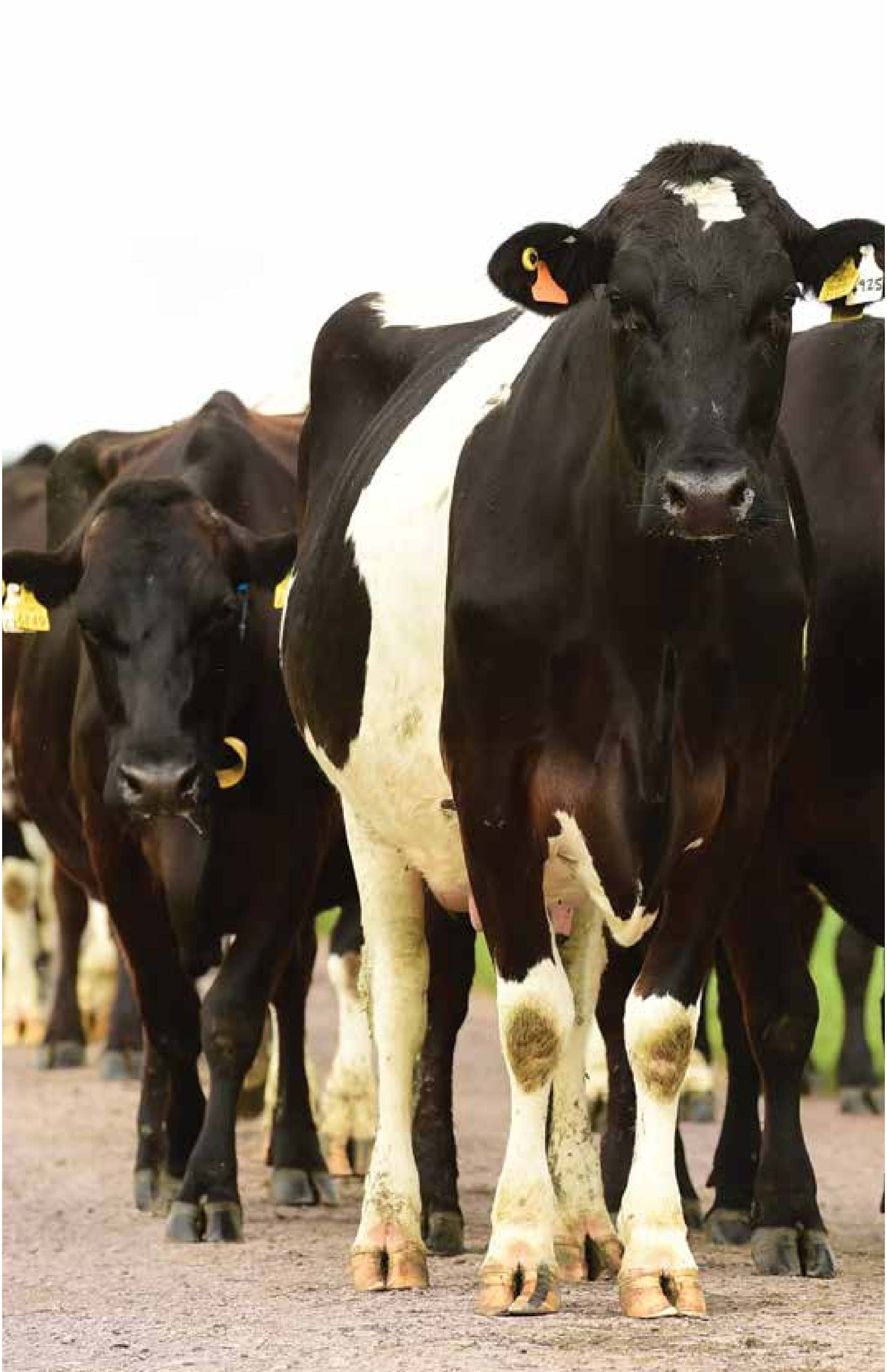
HEALTHY HERD - HEALTHY MILK

MANAGING EXPANSION



Introduction

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The abolition of milk quotas on the 1st of April this year has been the most fundamental change to the Irish dairy industry in a generation. Ireland can now plan to exploit our competitive advantage in pasture-based milk production built on a natural and environmentally sustainable production model. Increasing milk production will increase the value of exports and will result in increased employment and investment in rural areas. The increased output will be exported, and demand will be driven by changing global demographics: increasing population, greater affluence and urbanisation in developing countries. The abolition of milk quotas also bring challenges; especially in terms of milk price volatility and the requirement for additional investment in farm infrastructure to facilitate expansion. Teagasc Moorepark'15 Open Day will provide dairy farmers with the opportunity to view and discuss the latest developments in key dairying technologies that will help dairy farmers cope with these challenges

Prior to 2004, the variation in annual milk price was +/- 2 cents/litre, but this increased fourfold to +/- 8 cents/litre since then. This situation has arisen due to tight world supply/demand conditions on global markets, and current indications are that this will continue into the future. Expansion entails risk as the additional infrastructural investment must be financed by the existing dairy enterprise(s). This will put significant additional pressures on the existing dairy farm business and should not be considered without careful consideration of repayment capacity and the impacts on the family unit. Even with excellent management, expanding dairy farms rarely achieve high levels of productive efficiency during the initial years of expansion. Henceforth, dairy farmers will need a broader range of skills. Greater understanding of technical efficiency (grassland and stock management), people management (staff supervision, communication and delegation) and business skills (cash flow, business planning and goal setting) will be required to successfully develop their farming operations in this increasingly uncertain environment.

Systems of milk production in Ireland are competitive because they are pasture-based. Key components of the dairy systems post-quota will be the use of high EBI genetics and increased grass production and utilisation per hectare. The two key performance indicators will be 6-week calving rate and tonnes of pasture utilised per hectare. The evidence is overwhelming that combining genetic improvement (EBI +/- crossbreeding) and application of best practice fertility management can result in the herd fertility target of 90% of cows calving in 6-weeks being achieved. Pasture production will be maximised on farms where soil fertility status is high, adequate N fertilizer is applied, pastures are predominately ryegrass/white clover and soils are adequately drained. A large proportion of soils on farms are below optimum for pH and P and K status (Index 1 and 2). This significantly reduces potential grass production. Therefore farmers must place a much greater emphasis on soil fertility management. Pastures that are predominately ryegrass/white clover will significantly increase total annual grass production, especially during the shoulders (spring/autumn). In the longer term, dairy farms need to grow more grass for the increased stock numbers on expanding farms.

Irish pasture-based systems of milk production are more sustainable than most other milk production systems throughout the world. A recent study has shown that Irish milk production is the most efficient in terms of greenhouse gas emissions in the EU. Furthermore, Irish pasture-based systems have better animal health and welfare, milk composition, biodiversity and water quality. We must ensure that our post-quota systems of production continue to set the highest international standards for food safety and quality, animal welfare and environmental sustainability. Moreover, Irish dairy farmers must be prepared to adjust production systems and practices in the future to meet the changing requirements of discerning international customers.

The next generation of dairy farmers will require additional education, training and experiential learning in advance of taking control of larger dairy units. Already, there is an increasing demand for technically skilled farm managers to meet the skills gap on expanding dairy farms. To meet this growing demand, Teagasc, in conjunction with UCD and industry stakeholders, has developed the Professional Diploma in Dairy Farm Management. It is expected that more farm families will avail of this programme in the coming years to provide suitably skilled and experienced dairy farmers and managers with the best possible start in their farming careers. New business structures (e.g., share farming) will also be required to encourage land conversion into milk production and creating a progression pathway that will attract new people to a career in dairy farming. With this in mind, Teagasc in consultation with the Professional Diploma in Dairy Farm Management Steering Group and the support of Ulster Bank have developed 'Stepping Stones to a Career in Dairy Farming'. This guide shows the progression route for future dairy farmers by highlighting the essential skills and training needed to run a successful business.

A summary of the most recent results from the comprehensive dairy research and development programme at Teagasc are provided in this booklet. Teagasc Moorepark'15 Open Day provides dairy farmers the opportunity to meet research and advisory personnel to discuss the latest developments in key dairying technologies that will help them cope with future challenges. The financial support for the research programme from state grants and dairy levy research funds is gratefully acknowledged. Similarly the support of FBD Trust, the overall sponsors of Teagasc Moorepark'15, is greatly appreciated.

SUSTAINABLE EXPANSION

Principles of sustainable dairy expansion

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Summary

- Setting overall business goals is the first step when developing plans for the expansion process and will allow the development of strategic plans aligned to objectives
- Expansion should only be considered at farm level when the farm business plan is completed and suggests that expansion is a viable option
- The abolition of milk quotas and subsequent expansion of the Irish dairy industry will be judged a success only if the expansion is economically, socially and environmentally sustainable
- Sustainable expansion can be achieved if the extra milk produced comes from increased grass production and utilisation using a fertile herd on a low capital cost infrastructure
- The two key technical performance indicators for pasture based milk production are 6-week calving rate and grass utilised per hectare
- Managing cost during the expansion process is central to successfully managing the dairy business in the future

Introduction

In 2015, Irish dairy farmers can expand milk production without the shackles of milk quota for the first time in over 30 years. There will undoubtedly be success for many; for some, however, expansion may lead to increased workloads and increased stress without any real long term benefits. The key requirement for the expansion process is that it is sustainable from all aspects of the business perspective. In practice, this means that the business should focus on the efficient conversion of home grown feed to saleable products that are recognised as high quality and safe to consume. It is also necessary that the production system minimises nutrient losses to water (nitrate, phosphorous) and emissions to the atmosphere (GHG, ammonia), and that the production system operated is broadly perceived to be acceptable by society as a whole (i.e., good animal welfare, preservation of the ecosystem biodiversity). The production system must be profitable, afford a good work-life balance and provide a good working environment for the farmer and any staff that are directly employed in the business (Figure 1).

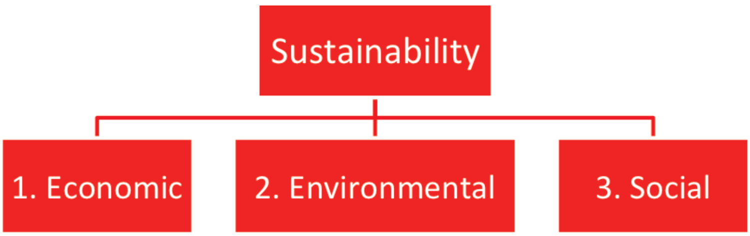

Figure 1. *The three pillars of sustainability: economic, environmental and social*

The competitive advantage of Ireland's dairy industry lies in the ability to utilize grazed grass as the major feed source. If the expansion process is to be successful, it will need to build on that advantage by growing and utilising more grass per hectare, converting that grass as efficiently as possible into saleable product with a low capital cost and labour efficient system of milk production. This paper will discuss sustainable expansion and the key drivers of sustainability in the system.

1. Economic sustainability

The first and most important steps in planning the expansion process are to identify the objectives of the business and to determine if expansion is the correct pathway. Until that question can be answered, there should be no expansion on farm. Clearly if one is going on a journey, the first decision is the destination followed by the development of a plan to reach that destination. Setting the goals and objectives for the business will allow a clear focus to be developed, and allow a strategy to be put in place to achieve these goals. The business plan should focus on achieving these objectives. On farms that are undergoing expansion, there will be significant capital investment associated with the expansion process. A reduction in animal productivity can be expected as a consequence of increased stocking rates, a less mature herd, animals walking longer distances and less voluntary culling. To fully understand the implications of undertaking any expansion, a comprehensive farm business plan is required. This should test resilience against milk price volatility, feed costs, interest rates and should include detailed costs for all additional investments such as livestock, milking and housing infrastructure, grassland productivity, and grazing infrastructure. As well as profitability and return on investment, the plan should put strong emphasis on cash flow. As the herd grows and the farm is generally reinvesting, there will be significant pressures on available cash.

The medium and long-term outlook for dairy farm profitability is positive because of increased global demand and the competitive position of our grass based production systems. However, the average milk price paid to Irish dairy farmers over the period 2005 to 2014 was 31 cents/l, but ranged from 22 cents/l to 38 cents/l (CSO, 2014). It is anticipated that this volatility will be a feature of dairy market returns in the future, with less market support and supply control restrictions. The dairy farm business must be robust enough to survive this milk price volatility and other challenges (e.g., adverse weather events), while still providing an adequate family farm income each year. A risk management plan should be put in place that identifies the key risks that put the business at risk and risk mitigation strategies should be put in place to manage the important risks. Strategies such as creating a cash sink fund, building a reserve of feed or investing in additional grazing infrastructure should be targeted to manage risk on the farm.

Blueprint for profitable milk production post quotas

Table 1 outlines a target budget for a 40 ha farm operated at optimum productivity using a milk price of 29 c/l (base price excluding vat). The farm is assumed to grow 15 t DM/ha with 80% utilised at a stocking rate of 2.80 cows per hectare. To achieve this level of grass production, 250 kg N are applied and soil fertility is maintained at optimum levels. The target milk production per hectare is 1,260 kg MS/Ha (450 kg MS/cow) using 400 kg supplemental concentrate per cow. The herd mean calving date is February 14th with over 90% of the cows calved in six weeks. Average cow liveweight is 550 kg, male calves are valued at €30 and annual herd replacement rate is 18% resulting in a mature herd structure. Overall labour requirement is 18.5 hours per cow per year and it is assumed that the farm development costs were €3,000 per cow.

Based on these assumptions the target net profit from the farm is €2,388/Ha or €1.92/Kg MS. For each 1 c/l change in base milk price the farm profitability increases or decreases by €150/Ha. Cost control is a key feature of the target budget, with net profit including labour approximately 40% of the gross output. These returns ensure that the business is robust against potential milk price movements, safeguarding the sustainability of the business even at low milk prices.

In commercial farm situations there are many different scenarios in relation to land rental, labour, debt and depreciation. Therefore, evaluating the business from a cash flow perspective to determine the source and usage of funds allows the farmer to determine the ability to meet the cost of drawings, hired labour, debt servicing and land leases. In Table 1 the cash surplus is defined as all receipts less all cash costs and is essentially the money available for capital repayments, family drawings, savings and reinvestment.

Table 1. Target budget for a 40 ha dairy farm

		Farm	/Ha	/kgMS
Target Receipts	Milk	221,080	5,527	4.45
	Livestock	23,526	588	0.47
Total sales		**244,606**	**6,115**	**4.92**
Target costs	Concentrate	12,039	301	0.24
	Fertiliser	14,852	371	0.3
	Heifer rearing	21,036	526	0.42
	Contracting	8,775	219	0.18
	Vet & AI	12,208	305	0.25
	Miscellaneous	1,117	28	0.02
	Car/ESB/Admin/Insurance	11,672	292	0.23
	Machinery operation	7,768	194	0.16
	Labour	30,266	757	0.61
	Bank Interest & charges	7,070	177	0.14
	Total costs	**126,803**	**3,170**	**2.55**
Target Cash surplus		**117,803**	**2,945**	**2.37**
	Depreciation	22,271	557	0.45
Net Profit		**95,532**	**2,388**	**1.92**

Key performance indicators

The two most important technical key performance indicators (KPIs) for any dairy business are the amount of grass utilised per hectare and the six week calving rate of the herd: the targets for these two KPI's are 12 t DM/ha and 90% calving in six weeks, respectively. Nationally, the average Irish dairy farmer is utilising approximately 7.3 t DM/ha and the average six week calving rate is 58%. Increasing these two KPIs from their current national position to the target would be worth €1,450/ha per year while significantly increasing output from the farm. Figure 2 outlines the key strategies required to achieve 12 t DM utilised/ha and a six week calving rate of 90%.

Grass utilised per hectare

A selection of farms that completed both weekly grass measurements on PastureBase Ireland and a Profit Monitor in 2014 were used to compare the effect of increasing milk output by increasing grass utilisation or by increasing purchased feed. These farms were on average stocked at 2.35 cows/ha, producing 404 kg MS/cow (950 kg MS/ha) and were utilising 9.6 t DM/ha. The analysis included an allowance for the farmers own land and labour. Each tonne of additional grass utilised increased farm net profit by €267/Ha with 56% of the variation in net profit explained by grass utilised per hectare. The effect on milk output of providing 1 tonne of purchased feed per cow was lower than the effect of 1 extra tonne of grass DM utilised per hectare. This suggests that there is a significant substitution effect from purchased feed (i.e., purchased feed displaces grazed grass in the diet). The cost increase associated with the additional purchased feed was larger than the increased revenue. Hence, there was an associated reduction in profitability when there was an increase in the levels of purchased feed even in a high milk price year like 2014. The analysis suggests that the cost increase associated with bought in feed are greater than the feed cost alone, which is in agreement with previous studies. There was no relationship between milk yield per cow and profitability, which suggests that milk yield per cow should not be used as a KPI when evaluating the dairy business.

Table 2. The impact of a range of intensifying strategies on output and profit

	Milk solids sales (kg)	Gross output (€)	Costs (€)	Net profit (€)
1 tonne extra concentrate/cow	+71	+432	+590	-157
1 tonne extra bought in feed/cow[1]	+58	+366	+493	-126
1 tonne extra grass DM utilised/ha	+97	+518	+252	+267
1 cow/ha increase in stocking rate	+394	+2,111	+1,197	+923

[1]*Bought in feed includes silage bought and purchased concentrate*

Adjusting the stocking rate to match feed demand with grazed grass supply from the milking platform will result in a system that is robust against external input and output price fluctuations. This will, over time, result in the most consistent overall farm profitability. Increasing grass utilisation will result in increased profitability even at low milk prices, whereas an extremely high milk price is required to justify increased bought in feed

Six week calving rate

Research shows that each 1% increase in six week calving rate is worth €8.22/cow. The two key drivers affecting six week calving rate are submission and conception rates for both the cows and replacement heifers (Figure 2). These two KPIs will drive herd mean calving date, overall herd replacement rate and the number of inseminations required to get a cow in calf. Improving the herd EBI fertility sub-index will create a herd genetically predisposed to establishing pregnancy more quickly. Excellent management of the herd is also necessary to achieve a high six week calving rate (body condition score management, heat detection, etc.)

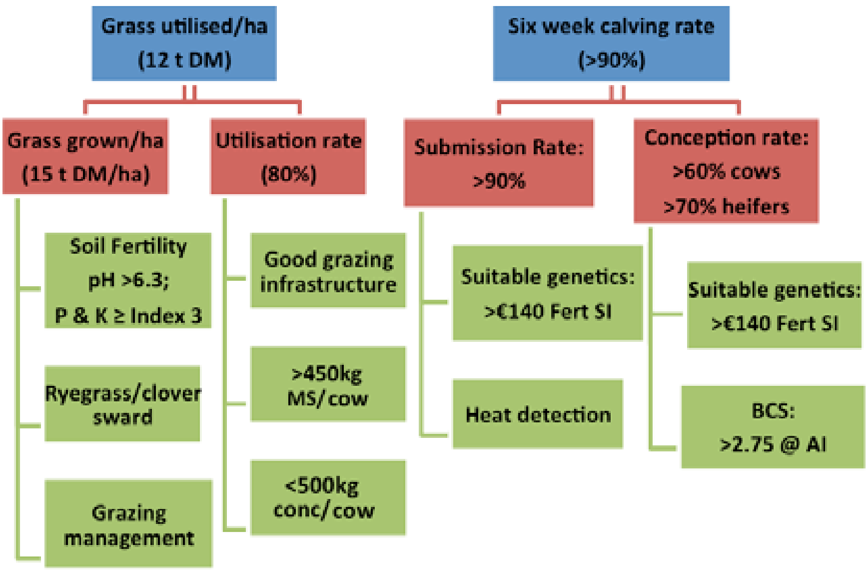

Figure 2. *Key performance indicators and targets for a robust dairy farm system*

2. Environmental sustainability

Environmental policy has the potential to prevent the Irish dairy industry from realising its potential. How policy is formulated and structured can have the opposite effect to the intended effect. Clear examples exist in the areas of GHG emissions, where national reduction targets planned for 2020 in the non-emissions trading sector (which includes agriculture) will result in increased global GHG emissions if these policies restrict milk output increases from Ireland. Therefore how policy is formulated must be very carefully managed at EU and national levels to avoid undesirable side effects. At farm level, it is necessary to consider nutrient losses from the system, as these nutrients will have to be replaced with purchased nutrients. Therefore, efforts should focus on minimising nutrient loss. Many studies have shown grass based systems of milk production are in general more environmentally sustainable (across a whole range of metrics) than non-grass based systems. The expansion targets outlined in the Food Harvest 2020 report must be underpinned by a clean, green, sustainable image. Sustainable intensification in grass-based systems requires a two-pronged approach. Firstly, there must be an increase in productivity and efficiency from the system. Secondly, there must be an increase in output driven by increases in grass growth. Any deviation in system choice from the focus of converting grass to saleable product will not only reduce the economic sustainability but also the environmental sustainability of the systems. The Irish dairy industry has made many claims in relation to its environmental credentials, but in the past there has been little focus on measuring and verifying the environmental credentials of pasture based systems. This is now changing, and many studies are being undertaken that focus on the development of methodologies that will allow the overall environmental sustainability of the business to be verified. At the same time, research is needed to increase the overall environmental sustainability of the business. Recent international studies have shown that Irish grass based dairy systems have the lowest GHG emissions intensity across the EU. Other studies have shown that temperate grass-based systems have the lowest GHG emissions per unit of milk product globally. The key technologies that will further increase the environmental sustainability of grass based systems include cow genetic selection (EBI), increased productivity from grazed grass, a higher proportion of grass in the diet and a more targeted approach to slurry and fertiliser management.

3. Social sustainability

Social sustainability directly deals with societal acceptance of dairy farming as well as the quality of life of the individuals that are engaged in the farming process. It encompasses a wide range of factors that affect the perception of dairy farming from outside by consumers and society as a whole, and from within by farm staff and potential successors. The key factors affecting societal acceptance are animal welfare, environmental concerns and food safety issues. The overall social sustainability of the industry centres on how the industry is viewed both from within the farming community and from outside by the general society. At present, there is a general positive disposition towards the Irish dairy industry. With expanding herd sizes, however, increased focus on how the industry is viewed from within and from outside is required. There are many examples where this has not been the case internationally, resulting in a disconnect between the dairy farming industry and local society. Ultimately, this results in a poor perception of the industry. The industry as a whole must focus on advancing communication and transparency with society at large. As the industry expands there must be greater focus placed by individual farmers on animal welfare. While pasture based systems provide an environment where animals have the potential to behave more naturally and have a generally positive perception, there are areas that will require attention during the expansion process, including animal health, lameness and body condition score. The best strategy to ensure the animal welfare credentials are achieved is to match the animal for the system. This can be achieved through genetic selection, which is a key feature of the EBI.

Highly trained, motivated and experienced people are a key driver of success in any industry. Milk quotas have prevented significant entry of new highly trained and enthusiastic farm business managers into dairy farming. This has resulted in an older population of farmers with a current average age of 53. To motivate and attract new well trained individuals into the industry, a progression pathway that could eventually lead to herd and farm ownership is necessary. This will motivate people from both existing farms and also those from non-farming backgrounds to enter and progress as dairy farmers. For young trained farmers who are planning to return to the family farm, they should plan this process carefully. It is essential that they take over some of the responsibility for the decision making process. In the situation where the farm owner is not in the position to relinquish control of the decision making process, the individual should consider farming elsewhere for a period of time.

Conclusion

The Irish dairy industry is in a stage of significant change. This will create significant opportunities for all, but will also result in increased risk on farm. The key drivers of sustainable expansion must be based on two KPI's: grass utilised per hectare and six week calving rate. All farms should put strategies in place to increase productivity in these areas. Planning for the expansion process must be driven by clearly stated business goals. The overall farm plan should include reductions in productivity and efficiency in the initial years of the expansion process. Cost control during the expansion phase will ensure that the overall business is robust against different milk price movements.

Building management capabilities for resilient farming businesses

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Summary

- Today's dairy farmers need a broader range of skills and experiences and an increased focus on business management to be successful
- Farm business expansion must be based on healthy, low stress, profitable family farming that provides a good standard of living for the farmer and their family. Every farm business should have a family farm plan that aligns the families' goals with realistic goals for the farm
- To create time specifically for management, dairy farmers will have to reduce the time spent on operational jobs
- Every dairy farm family should participate in a discussion group. Together with an excellent support network of professionals (adviser, accountant, vet etc.), this will bring a much larger pool of experience and skills to bear on the analysis of the farm business

Developing resilient farm businesses for turbulent times

Volatility

In addition to climatic risk and input cost inflation, which frequently impact farm profits, Irish dairy farmers are now producing milk in an environment of unprecedented milk price volatility. Figure 1 illustrates how Irish milk prices have become increasingly volatile. In the decade preceding 2004, annual milk price received by farmers averaged 30 cents/litre with little variation between years (+/- 2 cents/litre). During the decade since 2004, however, milk price averaged 31.2 cents/litre but with much greater variation (+/- 8 cents/litre). Milk price volatility provides a competitive advantage for the low cost, grass-based farm systems that are traditional to Ireland, but turbulent markets result in highly unstable family farm incomes. The impact of price volatility is evident in 2015: a 70 cow herd is likely to receive €30,000 less from milk sales than in 2014. This underlines the need for more careful management of farm expenditure (both short and long term) and profits to be prepared for low milk price years.

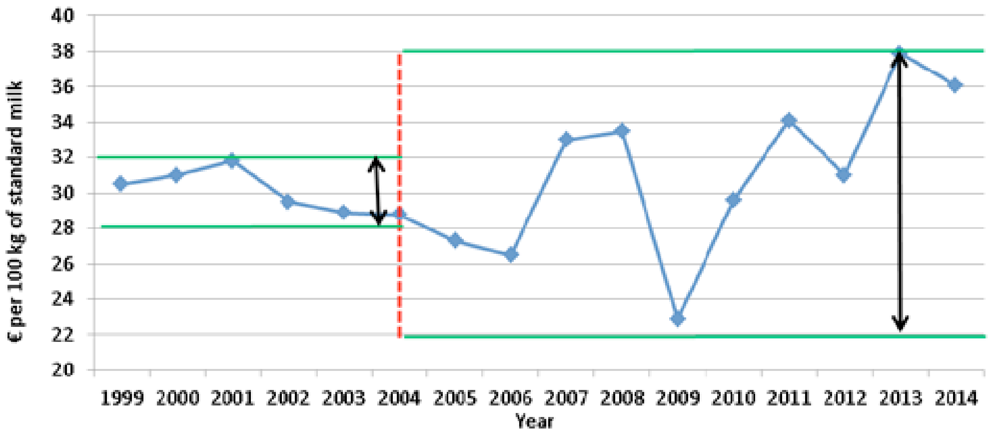

Figure 1. *Glanbia milk price 1999 to 2014 (LTO-International Milk Price Comparison 2013)*

Workload

Dairy herd expansion has the potential to increase farm profitability over the medium and longer term, but initially places added physical and financial pressures on the farm family. Figure 2 illustrates the influence of increasing herd size on both the average annual and seasonal spring workload requirements on dairy farms. Average herd size has increased from 25 cows per farm in 1990 to 74 cows in 2015, and is anticipated to further increase to 84 cows by 2020. This would correspond to a 3-fold increase in labour requirement during the same period (25 to 75 hours per week). The increased operational workload during expansion and the need for excellent technical performance places an added management burden on increasingly busy farmers. At the same time, the marginal profitability of milk production (€/kg milk solids) and free cash availability are reduced during the initial expansion years. **Consequently, todays dairy farmers need to spend more time managing (planning, monitoring, evaluating and adjusting) their farm businesses in this new environment. Irrespective of the planned level of farm expansion, dairy farms will need additional hired labour and non-family farm business supports to ensure that the physical and financial targets of the farm are realised each year.**

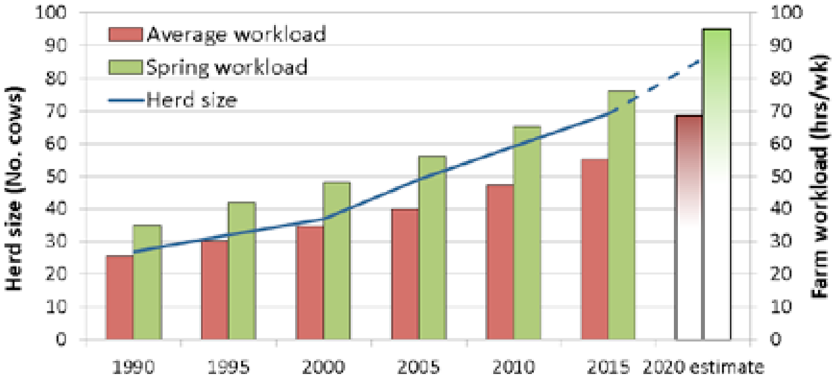

Figure 2. *Trends in herd size and dairy herd workload on Irish dairy farms (1990 - 2015; 2020 estimated)*

Is your farm business ready to meet these challenges?

To cope with a turbulent environment, dairy farmers need to build the capacity of their businesses to withstand periods of adverse conditions (including low milk prices and adverse weather). Physical performance must still be met during these periods to allow the business recover quickly when conditions improve. Resilient businesses are technically and financially efficient, generate surplus cash, consistently achieve financial expectations and are simple to operate. In Ireland, resilient dairy farm systems must have a low cost base to insulate the business from low milk prices and allow family based farms to generate sufficient funds at higher milk prices to fund family and farm requirements (e.g., children's education, family trips, finance expansion, farm development, etc.). To that end, there are four principal management considerations to develop resilient farming businesses.

1. The sustainable family farm plan

One of the core strengths of the Irish dairy industry is the central role the family plays in the farm business. To meet the sustainable expansion challenge during the next phase of farm development, each farm family should create a written shared farm family plan incorporating both business and personal goals. The development of a farm business plan is an essential process to define realistic goals and create a viable future enterprise. While many dairy farmers may have created plans outlining physical and financial targets, these plans are frequently overly simplistic, defining success purely in terms of operational scale, production and income and, rarely if ever, include the personal goals of family members. Unlike a specific farm business plan, a clearly written and shared family farm plan for the next seven to 10 years should provide the chance for family members to articulate their individual goals both within and outside farming. This plan will then highlight what is needed from the family farm, will build commitment among family members and will ensure future decisions made on farm align with the family goals. As part of the family farm plan, the role of each family member, targets for work/life balance, annual family drawings, other expenses (e.g. education/travel) and key areas for improvement to help the farm achieve target performance should all be included. **The benefit of a shared family farm plan is to create a united focus whereby the goals of the family and the farm can be compatible and consistent with enjoyable, healthy, low stress and profitable farming. The plan should be updated annually to ensure that it remains central to decision making on the farm.**

2. Creating time for management

Time is increasingly the most limiting and valuable resource on dairy farms. Like any other business in transition, the increasing complexity of farming and the corresponding increase in operational and managerial demands requires farmers to have a much broader range of operational and business skills. Recently, a large body of research has highlighted the important contribution of well-designed farm systems that use high Economic Breeding Index (EBI) dairy cattle, compact spring calving and the efficient production and utilisation of grass to build business resilience. Irish farmers have invested heavily to develop these technologies within their farms.

Unfortunately, the challenges of developing more resilient businesses stretch way beyond operational considerations. Many growing businesses fail for non-operational reasons, such as growing too quickly and running out of cash, or because the owner is unable to delegate effectively. It is recognised that as dairy farms move from owner-operator to team-based, farm systems need to be redesigned with an increased focus on simplicity, subcontracting non-essential tasks and staff recruitment, development and retention. Figure 3 illustrates how the role (and limited time) of the dairy farmer must evolve within a resilient business. **In the future, dairy farmers will have to reduce the time spent on operational jobs and instead spend more time managing people and physical and financial resources.** This will be really challenging for farmers who typically enjoy the day to day operational work. However, the financial return from time invested in managing the business greatly exceeds that realised from operational work. **To achieve this, hired help will be required to meet the operational workload and additional contractors and professional business support services will also be needed.**

3. Developing the farm management capabilities for resilient systems

The optimal growth of any dairy farm business is based on efficiently using the available resources (such as high EBI dairy stock, high productivity grazing swards and farm infrastructure) to maximise profitability while minimising capital and financing costs. Farm management is the continuous process of planning, implementation and control of those resources, and is the principal factor explaining higher farm profitability. The resource-based view of business growth first proposed by the economist Edith Penrose (The Theory of the Growth of the Firm) contends that management is the most important resource within the farm business. Many dairy farmers focus on the physical resources of the farm (cows, grass, money, infrastructure), but when considering expansion, few farmers question if the necessary management capability is available to manage the expansion successfully. For those farms considering expansion, investing in additional training and skills development for both the farm owner and staff must be an essential consideration to get the best return from the expanding business. The successful farm business of the future will require additional skills particularly in people, financial and general business management.

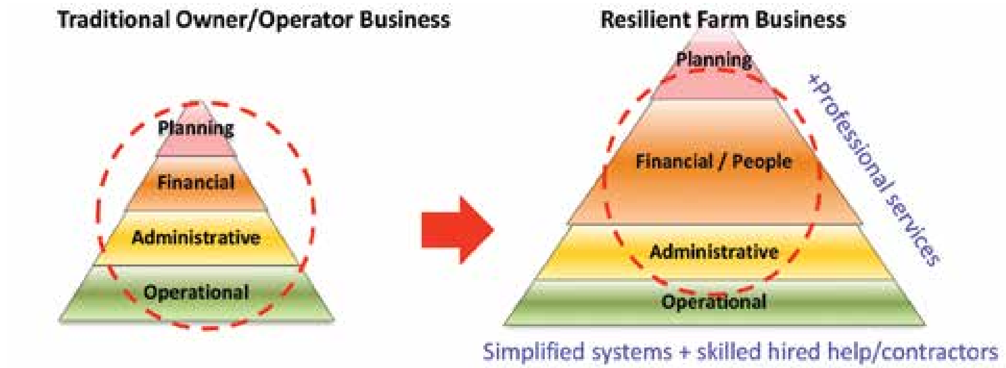

Figure 3. *The changing managerial requirements of resilient farming businesses (Owner role represented by the dashed red line)*

Regardless of the current technical efficiency of the farm, every farm business periodically needs a sounding board for new ideas. Consequently, part of the increased management capability of the farm must be provided by trusted external support networks. These include an active and trusted discussion group, which can also provide advice and experience to positively influence the future direction of the business. **Every dairy farm family should participate in a discussion group to bring a much larger pool of experience and skills to bear on the analysis of the farm business. They must also put together an excellent support network of professionals (adviser, accountant, vet, etc.), which will contribute to the farm family achieving their long-term goals.**

4. Successfully developing other people within the farm business

Becoming an employer and working with short-term and long-term hired (non-family) labour is among the main immediate challenges facing many farmers. The culture of employment on farm must be modernised to reflect the requirements of employees within modern labour markets. Farmers must develop additional skills to manage hired labour and get the best outcomes for the farm business. In addition to the legislative requirements, the immediate cultural considerations required are outlined below.

- *Communication:* The ability to explain your expectations for the work to be undertaken and to provide the necessary on-the-job training and feedback is essential. Employees succeed only if they know how to do what they are hired to do. Farmers must also remember that effective communication is a 2-way process and listening carefully is equally important.
- *Team leader, mentor and member:* There must be an overall vision and plan for the farm business that incorporates the role of employed labour. As a mentor, the farmer must invest time in building the new persons skills and experience, and also having patience while the employee adapts to the workplace or new practices. Sharing sensitive farm information, involving the employee in decision making and completely delegating important tasks builds commitment and confidence in the team.
- *Simple profitable farm system design:* The simplicity of the farm system will be a key consideration for employed staff in future, as it has a significant influence on workload and the ability to maintain a healthy work/life balance.
- *Opportunity for personal development:* Viable businesses need high caliber young people with positive outlooks, open minds and knowledge. The continued personal development of farm employees is as important as financial remuneration. There needs to be an annual budget within the business for training and development of everyone working on the farm.

Milk production from pasture: achieving 12 tonnes of grass utilised per hectare

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Summary

- In 2014, increasing grass utilisation by 1tonne DM/ha increased net profit/ha by €267
- Higher stocking rates will require substantial increases in both grass production and utilisation
- Only 10% of dairy farms have optimal soil pH, P and K status; this is a major constraint to grass production
- Grazing management factors that have greatest influence on grass production and utilisation are spring grazing management and correct mid-season pre-grazing herbage mass and post-grazing sward height
- National grass production data shows that high grass DM production can be achieved on dairy farms irrespective of location, provided soil fertility and grazing management are optimum
- Weekly farm grass cover measurements combined with grazing management decisions arising from these measurements need to be adopted on all farms

Introduction

The Food Harvest 2020 report set increased production targets for Irish dairy production systems. There are major improvements needed in the areas of grass production and utilisation. While every farm situation is unique with varying soil types, local climatic conditions, stocking rates and farmer management capabilities, grass production is limiting on most farms. If the level of expansion predicted is to be produced profitably at farm level then it needs to be produced from grazed grass. Currently only 7.5 tonnes of grazed grass is utilized per hectare nationally. Data from the best commercial grassland farms and research farms indicate that this can be increased significantly. Therefore, large increases in grass production can be achieved. This paper will outline how more grass can be utilised on farms. Dairy farmers need to up-skill their grazing management practices. This means regularly measuring pasture cover, using specialized grassland software to analyse grass production data, and making decisive grazing management decisions. These are key drivers to increasing the grass growth capacity on the farm.

Increasing grass utilisation

An analysis of farms completing both grassland measurements in PastureBase Ireland and a Teagasc Profit Monitor in 2014 were used to estimate the effect of increasing grass utilisation on profit/ha. These farms were on average stocked at 2.35 cows/ha, producing 404 kg MS/cow and 950 kg MS/ha and were utilising 9.6 t DM/ha. The analysis included an allowance for the farmers own land and labour. Increasing grass utilisation by 1 tonne/ha increased net profit by €267/ha.

Soil fertility management

Soil fertility is critically important for grass growth. Approximately 90% of the soils sampled in Ireland are limiting in one of the three major factors that affect soil fertility (pH, P and K). Soil pH affects the availability and crop uptake of both macro and trace elements. The ideal pH for grass growth is 6.3; this maximises the availability of nitrogen (N), phosphorus (P) and potassium (K). A higher soil pH stimulates the release of N from soil organic matter and may also increase N supply by increasing white clover growth.

Applying lime to increase the soil pH, will increase nutrient uptake and DM yield and improve the long-term persistency of perennial ryegrass and clover in the sward. Recent research illustrates that 5 t/ha of lime applied to a soil with low pH (5.3) increased grass production by approximately 1.5 t DM/ha in the following two year period. Previous research on a soil with very low soil pH (5.3) and old permanent pasture indicated that the application of 7.5 t of lime/ha increased the stock carrying capacity by 20% by the end of the first year and by 100% in the fourth year. The impact on grass DM yield was attributed to the effect of lime on soil organic matter breakdown. Liming was estimated to be equivalent in benefit to using approximately 60 units/ac (72 kg/ha) of N fertiliser per year. Only approximately 30% of soils are in the agronomically optimum Index 3 range for P and K. Current trends in soil P and K status indicates a movement from higher and more productive Index 3 and 4 down to low fertility Index 1 and 2. The target for both P and K needs to be Index 3 (targeting high values within Index 3).

Upgrading soils with poor fertility status is essential to prevent an overall reduction in soil fertility below that required to grow productive grass swards. Increasing soil fertility of Index 1 and 2 soils up to Index 3 is vital to maintain high DM production across the farm. Recent research has shown that soils with P Index 3 will grow approximately 1.5 t DM/ha per year more grass than soils with P Index 1. A longer term study on the effect of P fertiliser on grass yield on two sites with low soil P showed that low inputs of P (15 kg/ha per year) resulted in total annual DM yield benefits of close to 1 t DM/ha per year. Most of the DM yield response in these experiments took place in spring and early summer. Sulphur (S) is also a key nutrient that needs to be applied in fertilizer, especially on lighter more free draining soils. Deficiency of S in swards will reduce DM yield by up to 14%, and also reduces the response to N fertilizer. The fertiliser value of slurry translates to approximately five and 30 units of P and K per 1,000 gallons (very close to one bag of 0/7/30) respectively. Slurry alone will not be adequate to maintain P and K in silage paddocks, and hence these two nutrients must also be applied in the form of chemical fertilizer.

Grass DM production performance on dairy farms

High grass dry matter production can be achieved on dairy farms with good grazing and soil fertility management irrespective of location. This is one of the key early findings already emerging from PastureBase Ireland (Figure 1). It is obvious that there is huge variation in grass DM production on farms. There are many reasons for this, including differences in stocking rate, soil fertility and grazing management practices. But if soil fertility and grazing management can be improved, clearly many farms are capable of increasing DM production. There are many farms in Ireland that have extremely high grassland production and can consistently produce high yields of grass.

Figure 1 shows the annual DM production data from farms across the country. Each of these farms have >30 weekly farm grass cover estimations completed, so individual paddock DM production can be calculated and validated. In 2013, these farms produced an average of 12.2 t DM/ha. This increased to 13.8 t DM/ha in 2014, highlighting the large year effect on grass output. The variation between farms is very high; the difference between the lowest and highest producing farms was 9.4 t DM/ha. The highest producing farms are growing >16.0t DM/ha, with little variation between paddocks. The lower producing farms have much greater variation between individual paddocks. The reasons why are discussed in the PastureBase Ireland paper in this booklet.

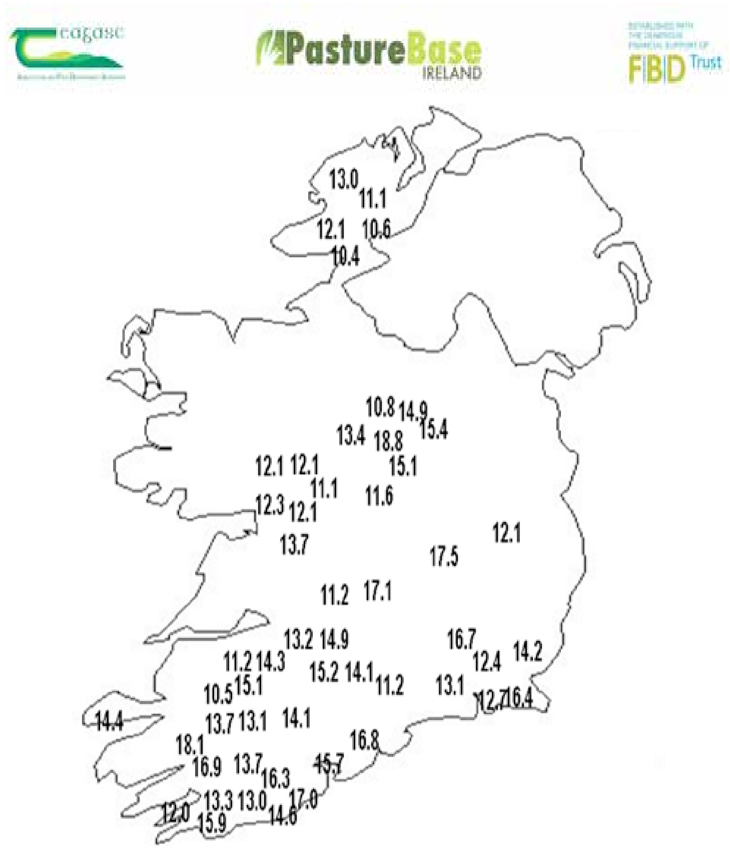

Figure 1. *Grass Dry matter production in 2014 across the PastureBase Ireland farms*

Achieving high grass utilisation

Stocking the farm at the appropriate level has a major effect on the level of grass utilisation achievable. The most recent research data generated from Curtin's farm (2014) has shown that increasing stocking rate will increase grass utilisation. Grass utilisation was 10.9, 11.1 and 11.8 t DM/ha at 2.5, 2.9 and 3.3 cows/ha, respectively. A recent investigation of PastureBase Ireland farm data indicated that for every one unit increase in stocking rate, grass utilization increased by 3.8 t grass DM. There was a strong correlation between stocking rate and grass utilisation (r = 0.85). Therefore, stocking the farm appropriately will ensure high grass utilisation.

Increasing the number of grazings and targetting early turnout in spring are key aspects of increasing grass utilisation. Targeting early turnout and high grass utilisation in March/April can increase the growth capacity of the farm substantially. This stimulates spring grass production, and increases the number of grazings achieved. In an analysis of the 2014 grazing performance from PastureBase, the greater the number of grazing achieved the greater the grazing grass DM production (r^2 = 0.73; Figure 2). Every extra grazing achieved increased grass DM production by 1,386 kg DM/ha. Therefore, maximising the number of grazings achieved on each paddock is a very effective method of increasing grass utilisation on the farm. There are many reasons why the number of grazings is low on farms; on many farms spring turnout takes place too late and grazing rotations are delayed too long in mid-season.

Sward species

The use of the Pasture Profit Index is crucial for farmers to identify appropriate varieties for their grassland systems. This allows a farmer to focus on the key traits in a cultivar that will be most complimentary to the purpose of the reseeded paddock(s) (see paper on Pasture Profit Index). Replacement of old permanent pastures with new perennial ryegrass swards by annually reseeding a proportion of the farm is important to maximize grass growth. Sward perennial ryegrass content has a major impact on pasture productivity. Paddocks with low levels of perennial ryegrass grow less grass, have a poor response to fertilizer N (hence highly N inefficient) and have reduced stock carrying capacity.

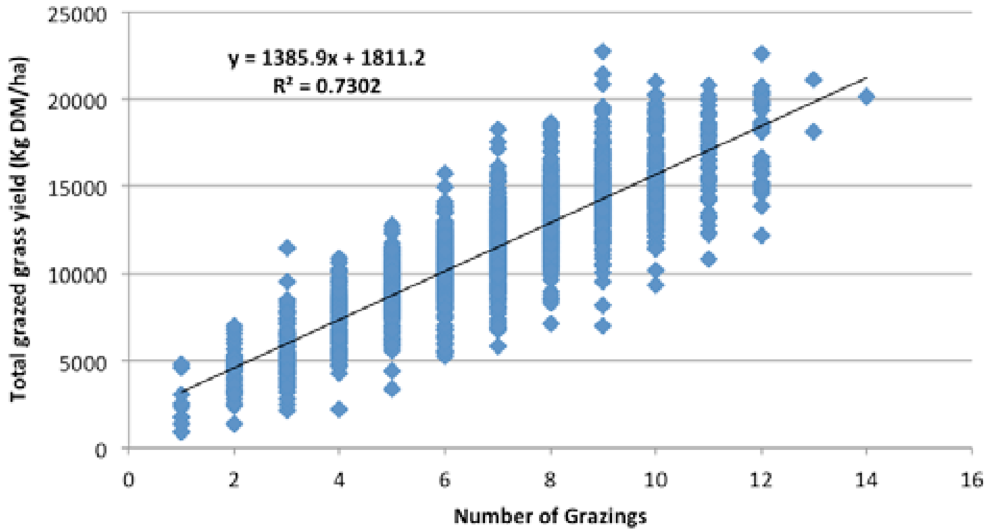

Figure 2. *Relationship between number of grazing and DM production of grazed grass*

Two clover grazing experiments are currently being undertaken at Moorepark and Clonakilty. Where high levels of clover (>25%) are included in perennial ryegrass swards, large annual DM production responses are evident, and this supports higher animal performance. In the Clonakilty experiment in 2013, the perennial ryegrass/white clover swards yielded 15 t DM/ha compared to 14.3 t DM/ha for the grass only swards. In 2014, DM production was 17.2% greater on the perennial ryegrass/white clover (17 t DM/ha) compared with the perennial ryegrass only swards (14.5t DM/ha). The research focus will now move to clover management in the swards, and ensuring the clover persists for the long term.

Conclusion

It is possible to grow and utilise more grass by focussing on increasing farm soil fertility, improving grazing management, reseeding swards with low perennial ryegrass content, incorporating clover and developing better grazing infrastructure. This will deliver higher profits in the short, medium and long term.

Reducing replacement cost on Irish dairy farms

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Summary

- Cow fertility and longevity are critical components of herd profitability. While there has been improvement, average performance on Irish dairy farms continues to be substantially below optimum
- The target longevity is, on average, 5.5 lactations per cow culled, or a herd average lactation number of 4.5 for non-expanding herds; this equates to a replacement rate of 18%
- The evidence is overwhelming that both the exploitation of genetic improvement and application of best reproductive management practices will result in reproductive targets being readily achieved

Introduction

Cow fertility and longevity are critical components of herd profitability. While reproductive performance has improved in recent years, average performance on Irish dairy farms continues to be substantially below optimum, negatively impacting dairy farm profits. Recent data from the ICBF database illustrates that median calving date on Irish spring calving herds is March 9, mean 21-day submission rate is 60% and mean six week calving rate is 52%; these are well below the target of February 20 for median calving date, 90% for 21-day submission rate and 90% for six week calving rate. A long productive life is necessary to generate a return on the investment made during heifer rearing. The full cost of rearing a replacement has been estimated to be €1,545.

It is well established that the optimum average parity in a stable herd is 4.5 lactations, which equates to an annual replacement rate of 18%. Both statistics are available from the ICBF HerdPlus. Cows being culled should, on average, be one year older than the cows that remain in the herd. Hence, the average parity of cows that are culled should be 5.5. On average, however, cows culled from Irish milk recorded herds achieved just four lactations in 2014 (Figure 1a). Only 5% of milk recorded herds achieved the target of, on average, 5.5 lactations per cow. This difference in longevity represents a difference in replacement costs in excess of €100 per cow annually or approximately 1.5c/l, the vast majority of which is due to replacement costs. The cost to the system should not be underestimated. Sub-optimal fertility/longevity is the number one cost on Irish dairy farms.

Expanding herds

Herds that are expanding through the introduction of a large number of heifers will have a lower herd average lactation profile than the recommended 4.5. This complicates comparisons between herds using the current 'replacement rate' metric. It is suggested, therefore, given the high proportion of herds in expansion mode, that the average number of lactations achieved by the cull cows is a more appropriate metric.

National statistics

As stated, the full cost of rearing a replacement is approximately €1,545. This implies that a cow needs to complete 1.63 lactations to reimburse her rearing investment as a heifer (Figure 2). In fact, 16.5% of Irish cows do not survive beyond the mid-point of their second lactation meaning that they have not fully paid off their rearing costs. Each additional lactation that a cow achieves beyond mid-way in the second lactation contributes to profit (Figure 2). Although dependent on many factors external to the farm gate such as milk price and cull cow price, assuming an average profit per lactation of €1,000, a herd achieving, on average, 5.5 lactations per cow will yield approximately €3,870 profit per cow over the rearing cost.

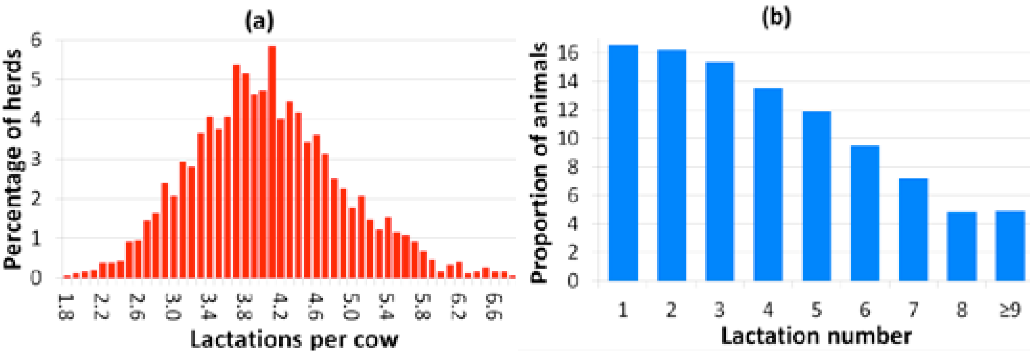


Figure 1. *(a) Herd average number of lactations achieved per cow before culling in milk recorded herds in 2014 and (b) proportion of culled cows (including deaths) in each lactation*

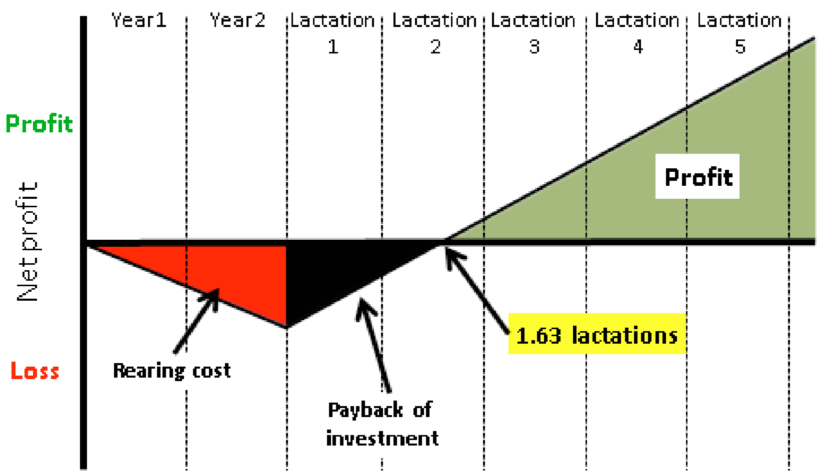


Figure 2. *The economic importance of achieving a high number of lactations per cow to ensure full return on investment made in heifer rearing and maximise farm profitability*

Is it possible to consistently achieve the fertility and longevity targets?

Achieving optimal performance, demands significant time investment in developing the appropriate herd breeding program and the necessary management skill. Fertility is complex and is affected by many factors including genetics and management as well as the interaction between them. Excellent genetics can never fully compensate for poor management, and likewise the best management cannot compensate for poor genetics. Both must be addressed in tandem. The following is a brief summary of the research and innovation activities at Teagasc Moorepark aimed at identifying: i) genotypes that will deliver greatest profit potential under grass-based systems and ii) the opportunities to improve herd reproductive management practices.

THE POWER OF GENETICS

Dairy breeding programmes across the globe were traditionally based almost solely on aggressive selection for milk production potential. While intense selection for production has resulted in huge progress in yield of milk, fat and protein, it has also had unfavourable effects on traits such as fertility and longevity. This is because of an unfavourable genetic relationship between yield and fertility traits; higher producing cows, in general, have poorer fertility and subsequently less chance of survival. Selecting for greater milk yield also resulted in a taller, more angular dairy cow. These cows tend to enter greater negative energy balance during early lactation resulting in mobilisation of excessive levels of body reserves, body condition loss and a greater risk of metabolic disorders and infertility. To address these problems, the Economic Breeding Index (EBI) was launched in 2001. The aim of the index is to provide farmers with a tool to help them maximise their farm profit by exploiting genetic variation that exists for key drivers of profitability. The main traits in the EBI are milk, fat, and protein yield (milk sub-index) and calving interval and survival (fertility sub-index).

Both national statistics and research conducted at Teagasc Moorepark demonstrate that the introduction of the EBI has been effective. The advent of genomic selection has accelerated the rate of genetic progress and reproductive performance on-farm is improving. The average EBI of dairy females born in 2014 was €158 which is over double the EBI of females born when the EBI was introduced in 2001 (€68 using the same economic values in the EBI as those used today). The average milk sub index and fertility sub index of females born in 2014 was €49 and €84, respectively. Calving interval on Irish dairy herds has shortened by almost one week in the last five years, some of which is undoubtedly due to improved genetic merit of the herd.

At Teagasc Moorepark, three research studies that clearly demonstrate the power of genetic selection to improve dairy cow fertility are: i) the 'High' versus 'Low' fertility study, ii) the *Next Generation Herd* study, and iii) a number of studies evaluating the merits of crossbreeding in the dairy herd.

'High' versus 'Low' fertility cows

While cows with high genetic merit for milk production have generally been reported to have poorer fertility than cows with average genetic merit for milk production it is unlikely that high milk production *per se* is directly responsible for poor fertility. Indeed, a number of studies have indicated similar or even superior fertility in high yielding cows compared to lower yielding cows. To investigate this issue, a lactating cow model was set up by sourcing 50 cows with similar genetic merit for milk production, but with either good (Fert+) or poor (Fert-) genetic merit for fertility traits. Both groups of cows had similar proportions of Holstein genetics as well as similar body weight, milk yield and milk composition, but their Fertility sub-indexes differed by €100. Fertility performance was markedly better in the Fert+ cows compared with the Fert- cows. For example, pregnancy rate to first service, six week in-calf rate and 12 week in-calf rate were +22, +31 and +19 percentage units higher for the Fert+ cows, who met all fertility targets. A summary of the main features that distinguish the Fert+ cows from the Fert- cows is in Table 1.

Next Generation Herd

The *Next Generation Herd* was established as a strategic resource to validate that genetic selection using the EBI will deliver improved performance and profitability under intensive grass based systems. Cows representing National Average genetics (EBI of €133; NA) and cows representing the very best (top 1% nationally) genetics (EBI of €249; ELITE) are being evaluated across three intensive grass-based systems. After two production seasons, clear trends in both production characteristics and fertility/longevity are emerging. Based on [an artificially managed] common lactation length, the ELITE cows produced more milk solids yield per cow per lactation (+7kg) compared to the NA cows. More notably, pregnancy rate to first service, six week in-calf rate and 12 week in-calf rate were +13, +14 and +14 percentage units greater for the ELITE cows, who met all fertility targets.

Table 1. Summary of the physiological mechanisms responsible for greater fertility in Fert+ cows compared with Fert- cows

Early post-calving (Weeks 1 to 7)	At breeding (Weeks 8-16 post-calving)
Greater dry matter intake	Stronger oestrus expression
Greater body condition score	Fewer silent heats
Earlier resumption of cyclicity	Less ovulation failure after oestrus
Superior uterine health	Greater luteal-phase circulating P4
More favourable metabolic status (glucose, IGF1)	More favourable uterine environment
	More favourable metabolic status (IGF1)

IGF1, insulin-like growth factor 1; P4, progesterone

Crossbreeding

There is now an increasing body of research verifying that crossbreeding with high EBI sires can offer substantial animal performance benefits with consequent improvements in profit. This research has been conducted on Moorepark research farms as well as using data from commercial farms. Jersey×Holstein-Friesian cows tend to produce less milk volume compared with Holstein-Friesian cows but have significantly higher milk composition and consequently greater milk solids (fat plus protein) yield and milk value. Production characteristics of Norwegian crossbreds are similar to that of the Holstein-Friesian cows. Contrary to common perception, crossbred cows can further increase herd productivity. This is due to longer lactations and a more mature herd structure because of improved fertility/survival. Both Jersey×Holstein-Friesian and Norwegian Red×Holstein-Friesian cows display other favourable traits such as the ability to maintain better body condition, a moderate body size, and a substantial improvement in reproductive efficiency. Udder health is also better with the Norwegian Red crossbreds compared to the Holstein-Friesians. Our most recent research findings, presented in more detail later in this book, provides heterosis estimates for first cross Jersey crossbred cows amounting to +25 kg of milk solids (fat + protein kg), -7.5 days in calving interval, and +3.5% survival. These substantial performance gains equate to almost €200 per cow per lactation more profit in addition to performance expected based on EBI alone.

The EBI - is it still relevant post-quota?

The recent abolition of milk quotas has resulted in questions being asked about the suitability of the EBI for a non-quota environment. The abolition of quota has been pre-empted within the EBI since 2007. Since then, land has been assumed to be the limiting factor, reflective of the current situation on most Irish dairy farms in a non-quota environment.

It is sometimes said that the weighting on milk production in the EBI is not sufficiently high. In fact, the economic values on the milk production traits in the EBI are similar to most international breeding goals (Table 2). The exception is the Net Merit Index (NMI) in the USA, which has a positive weighting on milk volume owing to its large domestic liquid milk market. In an index with just milk production and fertility, 32% emphasis would need to be placed on fertility to simply halt any deterioration. A greater emphasis needs to be placed on fertility to achieve improvements. Therefore, the weighting on the different traits in the EBI is appropriate. Milk solids yield per cow is a function of:

Genetic merit for milk solids yield

There is now overwhelming evidence from the analysis of national database both in Ireland and internationally as well as two decades of research studies in Moorepark that selection for increased genetic merit for milk solids yield will result in increased milk solids yield per lactation. Although the EBI has a negative weighting on milk yield, the positive weighting on both fat and protein yield is expected to increase genetic gain for milk solids yield.

Table 2. Economic values (converted to Euros) for the NMI (USA), NVI (the Netherlands), PLI (UK), APR (Australia), EBI (Ireland) and BW (New Zealand)						
Trait	NMI	NVI	PLI	APR	EBI	BW
Milk	0.002	-0.03	-0.032	-0.064	-0.09	-0.05
Fat	4.72	2.2	0.94	1.1	1.01	1.06
Protein	5.57	5	2.01	5.44	6.26	5.26

Lactation length

In seasonal calving herds, it is common to have all cows dried off on a set calendar date. As a result, calving date has a major influence on lactation length and thus total lactation yield. The median lactation length in Irish milk recorded herds is 279 days. Relative to a 305-day lactation, a cow milking for only 279 days yields 4% less; this equates to 20 kg milk solids for a cow yielding 500 kg milk solids. Equally, assuming a dry off date of December 20th, a March 1st calving cow will yield 6% more than an April 1st calving cow. In a seasonal production system, achieving optimal lactation length can be best achieved with superior genetic merit for fertility. A one day shorter calving interval equates to a one day longer lactation length.

Cow longevity

Based on the national database of milk recorded cows, second lactation cows yield, on average, 14% more milk solids than first parity cows and mature (third to sixth lactation cows) cows yield, on average, 21% more milk solids than first lactation cows. The average reappearance rate of cows calving in 2013 with a predicted transmitting ability for survival of <1 unit was 69% but was 82% for cows with a predicted transmitting ability for survival of >2 units.

BEST PRACTICE REPRODUCTIVE MANAGEMENT

Heifer rearing

Heifers should be reared with the goal of reaching puberty by 10 to 12 months of age, and cycling regularly by 13 to 15 months of age. The specific weight targets vary depending on the breed, strain and cross (Table 3). Achieving target weights at 13 to 15 months of age will improve fertility at first breeding, and achieving target weights at first calving, will increase conception rates as first lactation cows, improve performance as lactating cows, and result in increased longevity and overall profitability. Heifers need to be weighed regularly, and light heifers should be given preferential feeding to ensure that the target weights outlined in Table 3 are met.

Table 3. Bodyweight (BW) targets for maiden heifers at breeding and for heifers pre-calving by breed/crossbreed							
	HF	NZ	HF*NZ	NR	HF*NR	J	HF*J
Maiden heifer BW (kg)	330	315	330	315	330	240	295
Pre-calving BW (kg)	550	525	550	525	550	405	490

HF = Holstein-Friesian, NZ = New Zealand HF, NR = Norwegian Red, J = Jersey

There may be advantages in starting to breed the heifers seven to 10 days before the lactating cows:

- Initial heat detection and AI efforts can be focused on the heifers before the breeding period begins for the lactating herd

- If all heifers are cycling, those that did not get bred in the first six days will respond to a single injection of prostaglandin, resulting in the majority of heifers being bred by day 10 of the breeding season
- After calving, first lactation cows take about 10 days longer to start cycling. By calving earlier in their first lactation, extra time is allowed to increase the likelihood that they will have resumed cycling and hence achieve high submission rates at the start of the breeding season as first lactation cows. This will increase the likelihood that they will again calve early the following year, hence lengthening their productive lifespan in the herd.

It is critical that easy calving bulls are used for breeding heifers (both AI and natural service). Dystocia (calving difficulty) will result in increased incidence of retained placenta, metritis, and delayed resumption of cyclicity after calving. Collectively, these problems are associated with reduced submission and conception rates during the breeding period. When identifying AI sires for use on heifers, choose bulls with direct calving difficulty values less than 2%.

Lactating cows

Good fertility and compact calving are essential to maximise grass utilisation, and hence farm profit. The target is to have 90% of the herd calved within 42 days from the planned start of calving, and all cows calved by mating start date (MSD). For a 100 cow herd, increasing the six week calving rate (heifers and cows) from 70% to 90% is worth €16,500 per annum. The major management factors under direct farmer control that affect fertility of dairy cows are:

- » Duration calved at mating start date
- » Body Condition Score (BCS) at mating start date (MSD) and BCS loss from calving to MSD
- » Nutritional management
- » Reproductive management
- » Genetic merit for fertility traits

Duration calved at mating start date (MSD)

The single biggest factor that influences a cow's reproductive performance during the breeding season is how long she calved at MSD. Cows that calve early will have resumed cyclicity, be regularly displaying strong behavioural oestrus, have completed uterine recovery, have passed peak milk production and finished losing BCS by the time the breeding season commences. As a result, early calving cows are likely to be submitted for AI during the first three weeks of the breeding season and have a high likelihood of successful pregnancy establishment. One research study demonstrated that cows calved 9-12 weeks versus 3-6 weeks at MSD had six week in-calf rates of 71% versus 51%. *This underlines the importance of ensuring that heifers calve down at the start of the calving period, and using replacement heifers every year to achieve improvements in calving pattern.*

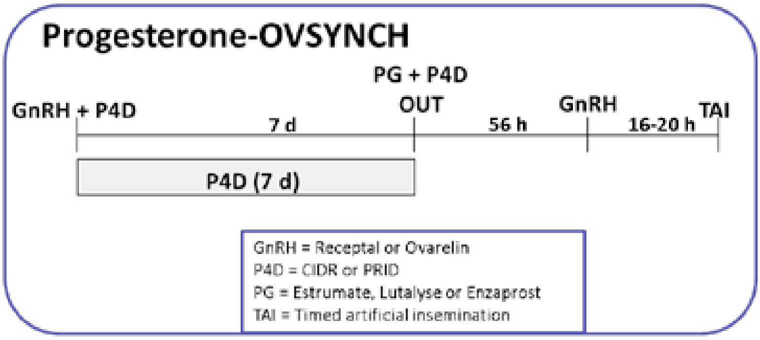
BCS management

After parturition, dairy cows experience a rapid increase in milk yield and a slow rise in dry matter intake (DMI). This results in a deficit in energy intake (more energy required for maintenance plus milk production than energy supplied from the diet) that is generally referred to as Negative Energy Balance (NEB). The cow responds to NEB by mobilising energy from fat reserves to fill the energy deficit. While it is normal for dairy cows to mobilise fat in early lactation, it becomes a problem when cows mobilise excessive amounts or when the duration of fat mobilisation is prolonged. Cows should calve at a BCS of 3.25 and lose no more than 0.5 of a unit of BCS after calving. Cows with low BCS at calving will have lower milk yield with reduced fat content and are more likely to have retained foetal membranes (RFM), a longer postpartum anoestrus period, increased likelihood of weak or silent heats and poor response to synchronization. Achieving the appropriate herd average and range in target BCS requires monitoring of BCS at distinct times throughout the year, not just during the breeding period. Thin cows need to be identified in advance of dry-off, allowing longer dry periods and preferential feeding to achieve target BCS at calving. More details on BCS management is presented elsewhere in this booklet.

Reproductive management

Attention to detail in relation to reproductive management will be rewarded with better herd reproductive performance. Key issues are:

1. Maintain a list of all cows that had dystocia, retained placenta, metritis and metabolic problems in early lactation such as milk fever, ketosis, or displaced abomasum. These cows should be examined in advance of the breeding season as they are at risk of having endometritis and delayed resumption of normal oestrous cyclicity. These cows should be treated as appropriate. Cows calved >14 days and diagnosed with endometritis should be administered an intrauterine infusion of cephapirin (Metricure). Cows calved >30 days and diagnosed as non-cycling (and free of endometritis) should be treated with the Progesterone-Ovsynch synchronisation protocol.



2. Commence pre-breeding heat detection around four weeks before MSD (~April 1st). Implement a simple form of heat monitoring (e.g., tail paint with twice weekly checks) to identify non-cycling cows. Use a Progesterone-Ovsynch synchronisation protocol for cows calved >30 days that are still anoestrus at MSD. For animals with BCS ≥2.75, conception rates >50% have been achieved with this protocol
3. Ensure farm staff are fully trained to pick up signs of heat. During the period of AI use, combine heat detection aids with at least three periods of observation in the field.
4. If using DIY AI, take a refresher course every two to three years.
5. Monitor daily submission rates. By day 10, 43% of the herd should be submitted for breeding. If the submission rate is markedly lower than this, consider implementing synchrony to increase submission rate.
6. Sexed semen is most suited to high fertility herds, and within these herds should be targeted towards the highest fertility animals. Sexed semen use should be targeted primarily towards heifers, and if using sexed semen on lactating cows, target the younger cows (lactations one and two) that are calved more than nine weeks and have BCS ≥3.00.
7. Ensure adequate bull power during the period of natural service (1 bull per 20 cows not in-calf). Bulls should be rotated every three to four days.
8. Pregnancy diagnosis for the whole herd should be carried out ~5 weeks after the end of the breeding season. Confirm pregnancy status for cows in calf to AI, and determine the stage of pregnancy for cows in calf to natural service. Compile expected calving dates, and use these dates to determine dry off strategy and dry cow nutritional management.

A milk pregnancy test is also now available, and can be used to detect a pregnancy from four weeks after conception. If using the milk pregnancy test, be aware that this only provides a pregnant or not-pregnant diagnosis; it does not indicate a stage of pregnancy for cows diagnosed as pregnant. Hence, it may be necessary to conduct a milk pregnancy test at approximately 10 weeks after MSD to identify all cows that established pregnancy during the first six weeks of the breeding period. This coincides with the normal period of AI use, and hence date of conception can be identified. A second milk pregnancy test will be needed at some point more than four weeks after mating end date. The purpose of the second pregnancy test is to verify the pregnancy status of the cows that conceived during the first six weeks of the breeding period, and also to identify both the cows that conceived to natural service and the non-pregnant cows.

Nutritional management

1. Intervene quickly to treat any metabolic disorders that occur around calving and minimise the duration that cows have reduced intake.
2. Ensure that the dry cow diet is properly balanced for energy, protein and minerals, and that the amount allocated is correct for the BCS target at calving.
3. Supplement the grazing diet with the necessary minerals to prevent deficiencies or imbalances. The main mineral deficiencies prevalent in Ireland are phosphorus, copper, selenium, iodine and zinc. Analyse the mineral composition of grass available for grazing every two to three years. Cows should be supplemented with minerals at the appropriate rate to complement the minerals supplied in the grazed grass. Collect blood samples from a subset of cows before the breeding season to ensure that herd mineral status is satisfactory.
4. Feed concentrates in early lactation to minimise the deficit in energy intake.

Conclusions

Achieving optimal performance requires significant expertise and effort. Fertility performance is complex and influenced by a multitude of factors. The evidence from Teagasc research is overwhelming that both the exploitation of genetic improvement (EBI +/- crossbreeding) and application of best practice fertility management will result in herd fertility targets being achieved.

Healthy herd: healthy profits

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Summary

- Infectious diseases result in a variety of clinical signs many of which are detrimental to the profitability of a dairy enterprise
- Depending on the herd somatic cell count, mastitis is the most costly infection on Irish dairy farms
- The presence of *Salmonella*, however, is also very costly. Carriers in a herd can result in losses of over €11,000 in an unvaccinated 100-cow spring-calving dairy herd
- A combination of biosecurity, diagnostic testing, and vaccination will reduce the risk of disease introduction and spread, thereby minimising losses due to infectious disease

Introduction

The World Organisation for Animal Health (OIE) estimates that approximately 20% of animal production is lost due to unhealthy animals. While this is important at a global level in terms of ensuring food security for an increasing human population, it also highlights the potential production losses that can be experienced at farm level due to disease. Disease reduces farm profitability, and as importantly, reduces the well-being of domestic livestock. It is critical therefore to control infectious diseases efficiently and effectively as dairying enters an era of price volatility and increased consumer expectations.

Ill-health in animals can be caused by infectious agents (e.g. *Salmonella* species), or by sub-optimal management that can result in diseases such as mastitis and lameness. In any herd farmers and veterinary practitioners (PVPs) must be mindful of both infectious and production diseases, prominent examples of which are outlined in Table 1.

Table 1. Prominent production and infectious diseases on Irish dairy farms

Production diseases	Infectious diseases
Mastitis	BVD
Lameness	Johne's disease
Milk fever	IBR
Displaced abomasum	Parasitic disease
Ketosis	Salmonellosis
Calf scour and pneumonia	Lameness (infectious)

This paper will concentrate on infectious diseases and associated, losses but many of the preventative tools outlined will also prove useful in preventing the introduction and spread of many 'so-called' production diseases such as mastitis and infectious causes of lameness. **It is important to note, however, that ensuring the availability of adequate resources, including infrastructure, labour, and time, is often the most critical element in the control of production diseases.**

Costly diseases

Infectious diseases result in a variety of clinical signs many of which are detrimental to the profitability of a dairy enterprise. Clinical and sub-clinical manifestations of infection can include reductions in milk yield, increased somatic cell count, increased levels of mortality (both youngstock and adults), poor conception rates, increased calving intervals, higher culling rates, increased rate of abortion, and sub-optimal body condition.

Table 2 summarises a selection of the clinical signs that have been associated with various infectious diseases.

Table 2. Clinical and sub-clinical manifestations of a number of infectious diseases present on Irish dairy herds

Disease	↓ Milk Yield	↑ SCC	Infertility	Abortion	↑ Calf Mortality	↓ BCS
BVD	✓	✓	✓	✓	✓	
IBR	✓		✓	✓		
Johne's disease	✓	✓	✓			✓
Leptospirosis	✓		✓	✓		
Mastitis	✓	✓				
Neosporosis				✓		
Parasitic disease	✓		✓		✓	✓
Salmonellosis	✓			✓	✓	

Individual disease losses

To quantify these losses in greater detail, Teagasc has undertaken a number of research projects involving determination of the prevalence of these diseases in Irish dairy herds and subsequent investigation of losses experienced in herds harbouring carriers of each disease.

BVD

Investigation of a herd BVD outbreak highlighted potential losses of up to €30,000 in a single year due to culling of BVD persistently infected calves, increased calf treatment costs, and most importantly, sub-optimal fertility, including an increased rate of empty heifers and poor conception rates to first service. With more herds now naïve to BVD virus, the potential for outbreaks exists on a higher proportion of farms. This stresses the importance of culling the remaining BVD persistently infected animals to close out BVD virus eradication.

Bovine herpesvirus-1 (BHV-1)

BHV-1 is a viral agent of cattle that causes the highly infectious bovine rhinotracheitis (IBR). In 2009, over 80% of dairy herds studied had evidence of exposure to BHV-1 and the national prevalence across all herds is estimated at greater than 70%. Many herds antibody positive for BHV-1 experience minimal clinical signs of disease but preliminary studies from Teagasc indicate that milk yield losses can occur sub-clinically and a reduction in milk yield of up to 250kg per cow per year in bulk milk positive herds is possible. Further investigations are continuing in this regard. The awareness of this disease has increased greatly over the past number of years. In 2009, only 12% of dairy herds included in a Teagasc prevalence study vaccinated against BHV-1. Based on updated data, over 60% of the same population of dairy farmers now vaccinate, an extremely positive step in IBR control.

Johne's disease

Johne's disease, a mycobacterial infection of ruminants, has been the subject of much public debate over the years. It is a global phenomenon amongst dairy herds and a postulated link to Crohn's disease has pushed it to the top of the public health agenda. The most recent prevalence study in Ireland (2005) recorded a prevalence of approximately 20% in the cattle population. Clinical cases of disease, however, are relatively rare compared to international data. Two major studies are underway in Ireland currently; (i) ICONMAP - a DAFM funded project, and (ii) an Irish dairy-levy funded project co-ordinated by Teagasc. Teagasc has just completed an economic analysis of over 20 commercial dairy farms based on ELISA testing of individual animals. No economic losses between ELISA positive and negative individual was evident, but Johne's control remains of vital importance for international markets.

Leptospirosis

Leptospirosis is widespread on Irish dairy farms. An economic analysis highlighted that exposure of a dairy herd to *Leptospira hardjo* resulted in a reduction in annual farm profits of €13.83, €13.78, and €13.72 per cow at milk prices of 24.5, 29.5, and 34.5 cents per litre. It should be noted, however, that herds vaccinated for *L. hardjo* generated almost €10 more profit per cow than unvaccinated exposed herds. Also, leptospira species are zoonotic (i.e., humans coming in contact with infectious cows can also become infected). A vaccination programme should therefore be implemented on all farms.

Mastitis

Teagasc and Animal Health Ireland (AHI) have conducted an extensive study on the cost of mastitis to Irish dairy farms. Costs included in the analysis were milk losses, culling, diagnostic testing, treatments, veterinary consultations, waste milk, and penalties. Farms were grouped based on bulk milk somatic cell count and those farms recording less than 100,000cells/ml used as the baseline for comparative purposes. For a 40 hectare, 94 cow farm it was found that net farm profit decreased from €31,252 to €11,748 as BMSCC increased from 100,000cells/ml to greater than 400,000 cells/ml. The mastitis CostCheck calculator[1] can be used to calculate the economic losses on your farm.

Neosporosis

Exposure to *N. caninum* has been shown to result in a reduction in annual farm profit of approximately €12 per cow. Control of *N. caninum* is difficult, in that dogs and additional canine species such as foxes transmit the disease to cattle. As yet, no vaccine is licensed in Europe for *N. caninum* and control centres on feed and grazing-area hygiene (i.e. reducing access of canines to cattle feed and pasture). Calving hygiene is critical (removal of calving membranes) thereby preventing further infection of farm dogs or foxes.

Parasitic disease (Liver fluke, Lungworm, Gut-worm)

The major economic losses from parasitic infections in Irish livestock stem from liver fluke (*Fasciola hepatica*), lungworm (*Dictyocaulus viviparous*) and gutworm (*Ostertagi ostertagi*). Interest in parasitic diseases and their control has greatly increased recently with the detection of anthelmintic resistance and the need for alternative and sustainable strategies for effective parasite control. Recent data (2009) from Teagasc has recorded prevalence of 75%, 98%, and 60% for liver fluke, gutworm and lungworm, respectively, in Irish dairy herds. Exposure to these parasites was found to be associated with reduced milk production parameters.

Salmonellosis

Salmonella species are a group of bacteria that cause disease in a number of species. Bulk milk analysis of a nationally representative group of dairy herds in 2009 highlighted that approximately half of Irish dairy herds have evidence of *Salmonella*, the majority of infected herds located in the dairy dense Munster region. An economic analysis of the impact of *Salmonella* in dairy herds has highlighted that the presence of *Salmonella* carriers in a herd can result in losses of over €11,000 in an unvaccinated 100-cow spring-calving dairy herd. Vaccination has a significant role to play in recouping these losses highlighting the importance of vaccination with regard to farm profitability.

Control

Control of the pathogens listed above is of critical importance to dairy farmers. Biosecurity is the single most important contributor to the prevention of infectious diseases and subsequent losses on a farm. Biosecurity in its simplest form means the implementation

[1] *www.teagasc.ie; www.animalhealthireland.ie*

of measures to prevent the introduction and spread of infectious diseases. Implementation of a strict closed herd policy is a critical component of disease control. A closed herd policy (i.e. no cattle movement onto the farm, including bulls) combined with additional on-farm biosecurity measures will maximise protection against the introduction of infectious diseases onto a farm. It is important to note, however, that not all individuals infected with these pathogens will show any symptoms, and it is these sub-clinical carriers that can silently damage dairy production. This highlights the importance of including diagnostic testing into a disease control programme - test results allow informed decisions to be made with regard to effectively controlling disease at farm level and informing strategic vaccination programmes.

Vaccines play a hugely important role in the control of many infectious diseases including Salmonellosis, Leptospirosis and IBR. Their use, however, without the implementation of a biosecurity plan and the supporting knowledge provided by diagnostic testing, could potentially undermine their effectiveness in a disease control programme. The most important components of a vaccination programme are correct administration of the particular product according to manufacturer's instructions which must include accurate administration of the correct dose, correct site of administration, and correct dosing schedule. Teagasc has compiled a vaccination booklet in 2015 for dairy farmers. This is available on request from your dairy advisor.

Expansion

Keeping your herd free of disease is challenging at the best of times. During an expansion phase, however, the risk to the health of a herd increases dramatically. This is particularly true where expanding herds purchase new stock, increase farm fragmentation (including contract heifer rearing) and introduce new management systems, including a new labour structure, to the farm. If purchasing livestock, follow the 10-point plan outlined below to minimising risk of disease introduction.

1. Establish your current disease status with your PVP before introducing cattle.
2. Buy all cattle from a single source if possible.
3. Talk to the seller and request test results, previous health history and vaccinations.
4. Quarantine all newly purchased cattle.
5. Ensure that all housing for new purchases is adequately cleaned and disinfected.
6. Vaccinate all new purchases over six months of age for leptospirosis and salmonellosis.
7. At a minimum, test all purchases for BVD virus, IBR antibody and purchase from a herd with a high confidence of being free from Johne's disease.
8. Test all purchased females for BVD virus and IBR antibody. If economically feasible Leptospirosis, Salmonella, and Neospora should also be investigated with your PVP.

NOTE: In buying a pregnant heifer or cow, you are essentially buying two animals (dam and calf), both of whom need to be investigated in terms of their health status. A healthy in-calf heifer or cow may be harbouring a BVD persistently infected calf.

9. Dose all purchased animals for parasites (gut-worm, lungworm and liver fluke).
10. Footbath new cattle on arrival to prevent introduction of infectious causes of lameness.

ACHIEVING MORE MILK SOLIDS FROM PASTURE

Grazing practices for the new production environment: increasing stocking rate and grass utilisation

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Summary
- Dairy farmers must adapt grazing practices to increase grass production and utilisation within higher intensity grass-based dairy systems
- Increased stocking rates (SR) in combination with increased grazing severity results in higher productivity swards characterised by increased grass DM production, improved sward quality and increased grass utilisation

Introduction

There is an increasing international awareness of the multifunctional benefits of grassland farming due to its capability for high productivity and profitability but equally for the environmental and animal welfare benefits it confers. In comparison with mechanically harvested or purchased feeds, grazed grass provides a relatively inexpensive and uniquely nutritious feed source for milk production and consequently, the profitability of milk production on Irish farms is closely related to the amount of grass consumed (t DM/ha) each year. Notwithstanding the improvements in grazing practices within the industry in recent times, research studies continue to highlight the further potential for productivity gain that remains where best practice grazing management is implemented (Table 1). On that basis, Irish dairy farms must continue to further develop their grazing management skills to attain higher animal performance from grazed grass and realise the potential from their farms over the coming years.

Table 1. Key components of high productivity grazing systems

	Current Average	Current Top 10%	Target
Stocking rate (cows/ha)	1.9	2.1	2.5 - 2.9
Grass growth (t DM/ha)	6 - 14	10 - 16	14 - 20
Grass utilisation (t DM/ha)	4 - 9	10 - 12	11 - 16
Six week herd calving rate (%)	59	70	90
Milk solids yield (kg/cow)	370	394	450
(kg/ha)	700	830	1,300

How should my grazing practices now change?

Grazing management for high animal productivity is based on a common sense approach to continuously present sufficient high quality grass to the dairy herd while ensuring that the sward is properly conditioned for future grazing events. The following basic management guidelines have the potential to dramatically increase animal performance at grazing.

Stocking rate

Foremost among the factors influencing the productive efficiency of grazing systems, SR, defined as the number of animals per unit area of land used during a specified defined period of time (cows/ha) is widely acknowledged as the main driver of productivity. In Table 2, the optimum SR for farms that produce different quantities of grass and feed different amounts of supplement are defined. For example, if a farm can grow 10 t DM/ha of grass on average and the system involves feeding 0.5 t concentrate DM/cow, the stocking rate should be 1.8 cows/ha. In comparison, a farm capable of growing 16 t DM/ha and feeding 0.5 t concentrate DM/cow should be stocked at 3.0 cows/ha.

Table 2. Stocking rate (cows/ha) that optimises profit on farms growing different quantities of grass and feeding different quantities of supplement/cow

	Grass grown, t DM/ha			
t supplement DM/cow	10	12	14	16
0.00	1.5	2.0	2.3	2.6
0.50	1.8	2.2	2.5	3.0
1.00	2.0	2.4	2.9	3.2

Grazing severity

Increasing SR is usually associated with an increase in grazing severity and many studies have attributed the increased productivity of higher SR systems to an improvement in grass utilisation and increased grass production and quality. Although pre-grazing herbage mass tends to increase within laxly grazed swards, grass production is actually reduced, as increased quantities of residual stem and decaying material are contained within the regrown material. Accelerated grass regrowth following more severe defoliation results from an increase in leaf content (above and below the grazing horizon) and an increased number of developed vegetative tillers within the severely defoliated high SR swards resulting in increased photosynthesis capacity during favourable climatic conditions. In addition to the beneficial effects on grass regrowth, the potential for more severe grazing at higher SR in spring and summer to efficiently harvest early reproductive tillers arrests the decline in grass quality observed during midseason, and therefore negates the necessity for mechanical intervention (topping and pre-mowing) to correct sward quality during the midseason.

Feed budgeting

Higher SR will place added pressure on available feed resources on farms in future and therefore, the development of disciplined feed budgeting during autumn and spring will be among the greatest opportunities for Irish dairy farmers to expand their businesses profitably while continuing to harness the benefits of a predominantly grass-based diet.

Conclusion

Increased milk production in Ireland post quota must be driven by increased grass DM production and utilisation of grazed grass. In comparison with current on-farm practices, this will require an increase in both SR and grazing severity at farm level in addition to more disciplined feed budgeting.

The benefits of white clover

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Summary

- Sward white clover content varies across the year; it is lowest in spring, increases to a peak in late summer, and then begins to decline during autumn
- Annual milk solids (MS) production can be increased by up to 33 kg MS/cow when average annual sward white clover content is 25%
- Frequent tight grazing (4 to 4.5 cm above ground level) of grass clover swards will encourage clover persistence in grazed swards

Introduction

Grass-based milk production systems in Ireland rely on nitrogen (N) fertiliser to ensure they can grow enough grass to feed dairy cows for most of lactation. Nitrogen fertiliser use on farm is limited under the Nitrates Directive. On farms with high stocking rates and therefore large demand for grass, there can be a requirement for extra N for grass growth. White clover (clover) fixes atmospheric N and makes it available for herbage growth. Previous research has shown that including clover in grass swards can increase milk production and herbage production. Sward clover content is greatest in late summer and autumn, a time when grass quality can be reduced. At this time of year clover can increase the overall quality (i.e. nutritive value) of the sward compared to a grass-only sward. Despite the benefits described above, clover is not widely used on Irish dairy farms.

Incorporating clover into fertilised grass swards

One of the main reasons why farmers are reluctant to incorporate clover into fertilised swards is persistency and spring grass supply. In fertilised swards, good grazing management (18 to 21 day rotations mid-season; 4 to 4.5 cm post-grazing sward height) is crucial to ensuring that white clover persists. Grazing swards out to 3.5 cm in the first and last rotations will benefit clover persistency. It is important that light penetrates to the base of the sward for clover stolon production. Stolon production is the means by which the clover will be maintained in the sward.

Grazing experiment

At Teagasc Moorepark a farm systems experiment is comparing herbage and milk production from a grass sward receiving 250 kg N/ha per year (Grass250), and a grass clover sward receiving 250 or 150 kg N/ha per year (Clover250 and Clover150, respectively). Each treatment is stocked at 2.74 LU/ha. All swards receive similar N fertiliser until May. From then onwards N fertiliser application is reduced on the Clover150 treatment. The three treatments have similar rotation lengths, target pre-grazing herbage mass in mid-season is 1,300 to 1,500 kg DM/ha and target post-grazing sward height is 4 cm.

Results are available for the two year period 2013 to 2014. Herbage production was similar across the three treatments - 14.3 t DM/ha per year. Annual average sward clover content was 27% on Clover150 and 24% on Clover250. Milk solids production was greater on the clover treatments (485 kg MS/cow and 489 kg MS/cow on the Clover150 and Clover250 treatments, respectively) compared with the Grass250 treatment (454 kg MS/cow) (Figure 1). The clover treatments produced an additional 85 to 96 kg MS/ha compared with the Grass250 treatment.

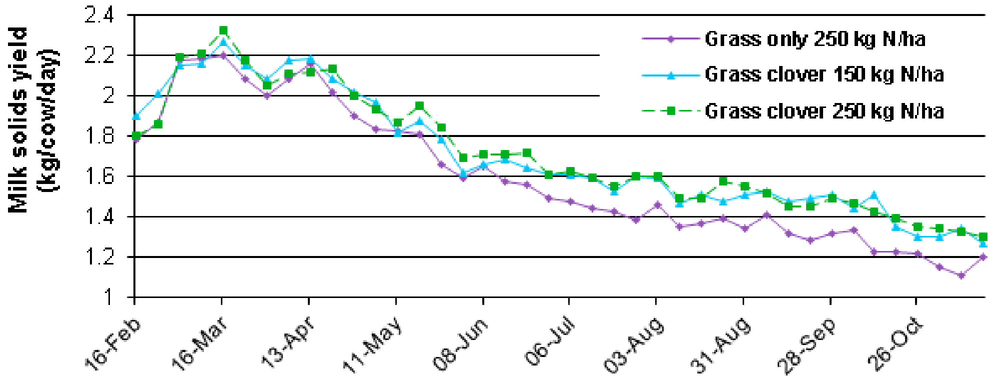

Figure 1. *Daily milk solids production (kg MS/cow per day) from grass-only swards receiving 250 kg N/ha per year, and grass clover swards receiving 250 or 150 kg N/ha per year*

Plot experiment

Plot experiments are also being undertaken at Teagasc Moorepark. One experiment examined the effect of N fertiliser application rate on herbage production and sward clover content from grass-only and grass clover swards. A series of grazing plots were established in May 2009. Treatments consisted of two swards (grass-only and grass clover) and five N fertiliser application rates (0, 60, 120, 196 and 240 kg N/ha per year). Measurements were undertaken from 2010 to 2013 inclusive.

Across the four years of this experiment, regardless of N fertiliser application rate, the quantity of herbage removed by grazing animals from the swards increased by 2,930 kg DM/ha when clover was included in the sward (Table 1). As N fertiliser application rate increased, average annual sward clover content declined from 33.3% when 0 kg N/ha was applied to 19.6% when 240 kg N/ha was applied.

Table 1. Average annual herbage removed (kg DM/ha) and average sward clover content (%) from grass-only and grass clover swards receiving 0, 60, 120, 196 and 240 kg N/ha per year between 2010 and 2013

Herbage removed (kg DM/ha per year)	N application rate (kg N/ha per year)				
	0	60	120	196	240
Grass-only	9,080	9,200	10,980	11,310	12,630
Grass clover	13,310	13,050	13,100	13,760	14,420
Sward clover content (% of DM)	33.3	30.6	27.0	21.7	19.6

Conclusions

Incorporating clover into N fertilised grass swards can increase herbage production and milk yield and MS production per cow and per ha. There may be potential to reduce N fertiliser application in summer when clover is included in swards.

Clonakilty update: clover incorporation into tetraploid and diploid swards

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Summary

- Results from year one of the study show that there is potential to increase the performance of grass-based production systems by incorporating white clover into the sward
- White clover increased milk solids (MS) production by 55 kg/cow
- White clover increased total annual herbage production by 2.5 t DM/ha
- Results are from year one of a five year study; further research is required to see the effect of white clover over a number of grazing seasons.

Introduction

Irish dairy farmers, for the first time in 30 years, have the potential to increase milk production free from the constraints of milk quota. In order to do this profitably, Ireland must maximise its competitive advantage which is the ability to grow and utilise large amounts of grazed grass because grass is the cheapest feed for animal production. This grass must be high quality (highly digestible) in order to be converted efficiently into MS. Recent research in Teagasc Moorepark has indicated that grass cultivars effect milk production, as animals that grazed tetraploid monocultures produced more milk than animals that grazed diploid monocultures. Recent research conducted using short term and plot experiments has also shown potential benefits of white clover (clover) over perennial ryegrass only swards for milk and herbage DM production. Cow genotype also has an effect on milk production and overall farm profitability. Therefore, the objective of this study was to evaluate the effect of tetraploid and diploid cultivars sown with and without clover, and cow genotype, on the productivity of spring calving milk production systems.

The study

The study was established in Teagasc Clonakilty Agricultural College, Co. Cork in 2012. Forty four ha of the dairy unit were assigned to the study with 75% of the experimental area reseeded in 2012 and 25% reseeded in 2013. Four separate grazing treatments were sown on the experimental area, a tetraploid only sward (TO), a diploid only sward (DO), a tetraploid with clover sward (TC) and a diploid with clover sward (DC). In the clover paddocks a 50:50 mix of Chieftain and Crusader clover was sown, at a rate of 5 kg/ha. Three distinct cow genotypes (Holstein-Friesian (HF), Jersey x HF (JEX) and Norwegian Red x JEX (3WAY)) were used on the study. Thirty cows (10 of each genotype) were assigned to each treatment group. All grazing treatments were stocked at 2.75 cows/ha, received 250 kg of nitrogen fertiliser per ha and target concentrate supplementation was 300 kg/cow.

Animal and herbage production performance

The effect of treatment on milk and herbage production during the 2014 grazing season is presented in Table 1. Although there was no difference between the tetraploid and diploid grass in terms of milk production, the TO treatment produced 11 kg more MS per cow than the DO treatment. The presence of clover in the sward affected milk and MS yield/cow and per ha, which were greater for cows on the grass clover treatments (TC and DC) compared to the grass only treatments (TO and DO). Cows on the grass clover treatments produced 647 kg more milk and 55 kg more MS than cows on the grass-only treatments which equated to an extra 1,781 kg milk and an extra 151 kg MS per ha. There was also no difference between the tetraploid and diploid grass in terms of herbage DM production, herbage utilisation or winter feed production. Clover, however, did have a significant effect. Total herbage DM production was 2.5 t DM/ha greater on the grass clover swards compared with the grass-only swards. As a consequence, herbage utilisation (+ 2.2 t DM/ha) and winter feed production (+ 0.44 t DM/cow) were greater on the grass clover swards than on the grass-only swards.

Table 1. The effect of grass ploidy, and the incorporation of clover into grazing swards, on milk and herbage production in 2014

	Tetraploid only	Diploid only	Tetraploid + clover	Diploid + clover
Milk yield (kg/cow)	4,895	4,848	5,532	5,506
Fat (%)	4.74	4.70	4.65	4.68
Protein (%)	3.73	3.65	3.75	3.75
Lactose (%)	4.76	4.74	4.79	4.82
MS yield (kg/cow)	414	403	464	463
Milk yield (kg/ha)	13,473	13,366	15,284	15,118
MS (kg/ha)	1,140	1,109	1,279	1,273
Total herbage production (t DM/ha)	14.9	14.8	17.5	17.2
Herbage utilised (t DM/ha)	13.9	14.2	16.2	16.4
Winter feed produced (t DM/cow)	1.18	1.27	1.70	1.63

Cow genotype had a significant effect on milk production with the exception of MS yield. Although not significant, the JEX (444 kg/cow) produced 12 kg more MS/cow than the HF and 3WAY (both produced 432 kg/cow). Milk yield per cow was greater for the HF (5,402 kg/cow) compared with the JEX (5,160 kg/cow) and 3WAY (5,023 kg/cow). Reproductive efficiency was superior for the JEX cows compared with the HF and 3WAY, as six week in-calf rate was 92%, 82% and 73% for the JEX, HF and 3WAY, respectively.

Conclusions

Cow genotype effected milk production and reproductive performance, however further data from multiple years is required before any definite conclusions can be drawn. Perennial ryegrass ploidy did not significantly affect animal performance. Initial results suggest that the inclusion of white clover in grass swards can be an effective strategy to increase milk and herbage DM production in grass-based milk production systems. This is however only year one of a five year experiment and further research is required to see if these results are repeatable and dependable.

Early lactation challenge - feeding the dairy cow

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Summary

- Grass growth in spring is extremely variable
- Higher stocking rates may necessitate lower pasture allowances in early spring
- Reducing pasture allowance for six weeks will lead to reduced total lactation milk yield

Introduction

There is little grass growth over winter and during early spring in Ireland which may result in limited feed supply during early spring in intensive grazing systems. In the post-quota era, increased herd sizes and stocking rates on farms may further deplete the availability of grass in spring. Furthermore, in a low milk price year the quantity of supplement offered to cows in early lactation may be reduced to lower feed costs which currently account for 60 to 80% of total variable costs on Irish dairy farms.

Grass allowance in early spring

Many previous studies carried out at Teagasc Moorepark have shown the benefit of early spring grazing on mid-season sward quality, both in terms of higher milk solids yield (MSY) and grass growth and production.

With increasing stocking rates and the resulting higher demand for grass in early spring farmers must investigate ways of maintaining a high proportion of grass in the cow diet. For early calving farmers with a high stocking rate one option is to graze lower or deeper into the sward. By lowering post-grazing height more grass can be made available to the grazing herd. However, caution is required as grazing too low will lead to reduced dairy cow production.

A series of experiments have been undertaken at Teagasc Moorepark during the last two years to investigate if different pasture allowances, offered above 3.5 cm, for varying time durations to grazing dairy cows during early lactation influenced dairy cow production and welfare. Cows were offered one of four pasture allowances (60%, 80%, 100% or 120% of intake capacity) for either two or six weeks in very early lactation. Once the 2- and 6-week time durations had elapsed, the cows in all treatments were offered 100% of their intake capacity. Intake capacity was calculated using an equation based on age, parity, days in milk, bodyweight, body condition score and potential milk yield.

The mean pasture allowances for the 60, 80, 100 and 120% treatments were 8.4, 11.2, 13.9 and 16.8 kg DM/cow per day, respectively; this resulted in post-grazing heights of 2.7, 3.2, 3.8 and 4.3 cm, respectively. Dry matter intake (DMI) measured during the second week of the experiment showed that the cows offered 100% and 120% allowances had a similar DMI (13.7 kg DM/cow) but the cows offered an allowance of 120% had higher MSY than the cows offered an allowance of 100% (1.76 and 1.91 kg/day, respectively). Offering 60% and 80% allowances, even for just two weeks, significantly reduced DMI (10.5 and 11.5 kg DM/cow, respectively). Consequently, MSY was also reduced for the 60% (1.60 kg/day) and 80% (1.68 kg/day) treatments.

During week six, when DMI was measured again, cows assigned to the 2-week treatment had been offered a 100% allowance for the previous four weeks. All of the '2-week' cows had a DMI (13.9 kg DM/cow) similar to cows offered 100% for the full six weeks. As a result MSY was similar for all '2-week' treatments and the 100% allowance for six weeks. Within the six-week group however, offering 120% allowance increased DMI by 1.3 kg/cow per day compared to cows offered 100%; conversely, offering cows 60% resulted in a DMI 2.6 kg/cow per day lower than cows offered 100%. Thus, MSY of the cows offered 60% and 80% for six weeks were similar to each other but lower than the 100% treatment which, in turn, was lower than the 120% for six weeks treatment.

Total annual production

Variations in pasture allowance offered for a two-week period in very early lactation, did not affect MSY production over the entire lactation. This suggests that in periods of feed deficit cows can be restricted for a short (i.e. two weeks) period of time. However, altering early lactation pasture allowance for a 6-week period significantly affects total lactation MSY (Table 1). Cows offered a 60% allowance for six weeks produced 15% less MSY than the cows offered 120% and 9% less MSY than cows offered 100%. The 80% treatment had a similar cumulative lactation MSY to the 60% allowance group; however the 80% group had a MSY 11% lower than the 120% treatment.

Table 1. Effect of early lactation pasture allowance on milk solids yield during the first ten weeks of the experiment and on total cumulative milk solids yield

	60% of intake capacity for six weeks	80% of intake capacity for six weeks	100% of intake capacity for six weeks	120% of intake capacity for six weeks
Milk solids yield during 1st 10 weeks (kg)	101	107	118	129
Cumulative milk solids yield (kg)	299	315	328	353

**Data for two week cows not presented as no differences between treatments were observed*

Effects on bodyweight and body condition score

Pasture allowance had an effect on bodyweight; cows offered a low pasture allowance (60 and 80%) lost more weight than those offered 100% or 120%. However, any differences between treatments had disappeared four weeks after cows were offered 100% of their intake capacity. There were no differences in body condition score.

Conclusions

The results of this study suggest that cows recover immediately after short term (i.e. two-week) changes in pasture allowance however imposing varying pasture allowances for a six-week period can affect total lactation production. Other variables such as cow fertility, health and welfare will be considered in order to obtain a complete picture of the residual effects of altering pasture allowance in early lactation. This experiment forms the basis of a large research programme on supplementary feeding and response to concentrate.

Grass as a feed for dairy cows

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Summary

- Grass quality influences dairy cow intake and production performance
- Grass quality is indicated by grass digestibility
- High digestibility grass has a high intake potential and a high energy content
- High digestibility grass is characterised by
  - » high leaf content, low true stem content
  - » high protein concentration, medium fibre concentration
  - » short to medium regrowth interval, with a low to medium pre-grazing herbage mass (PGHM)
- Grass digestibility is highest in spring
- In autumn grass digestibility decreases rapidly as PGHM increases

Introduction

Grass-based dairy cow production is based on the efficient production and utilisation of high quality grazed grass. Cows must ingest high quantities of high quality grass. The quality of the grass impacts not only the quantity of grass which the cow eats, but also her milk yield, milk composition and milk solids yield (MSY).

What is grass quality?

The quality of grass is indicated by its digestibility. Digestibility is a measure of the amount of nutrients which the cow can extract from the feed. The more nutrients the cow extracts from the feed, the less of the feed which is excreted as waste. Highly digestible grass is characterised by its chemical composition - high protein concentration and medium fibre concentration. Highly digestible grass is also characterised by its physical structure - high leaf and pseudostem content and low true stem and dead content. Grass digestibility is heavily influenced by grazing management. Highly digestible grass comes from implementing a short to medium regrowth interval and cows grazing grass with a low to medium PGHM.

Importance of grass quality

Low digestibility grass has a higher fibre concentration than high digestibility grass. This means that low digestibility grass is bulkier and the cow can eat less of it, compared to high digestibility grass. This low intake potential is undesirable in a grass-based milk production system which relies on cows consuming large quantities of high energy grass. Additionally, low digestibility grass has a lower energy content than high digestibility grass. This is due in part to the high fibre concentration, because fibre does not give much energy. This low energy content is also undesirable in a grass-based milk production system which relies on cows consuming large quantities of high energy grass. Thus, cows suffer on two fronts when they consume low digestibility grass. In summer, grazing a high PGHM sward (2,500 kg DM/ha) rather than the recommended PGHM (1,300-1,600 kg DM/ha) could result in a reduction in energy intake of approximately 1 UFL. This could equate to a loss of approximately 2 kg milk with 3.4% protein and 3.8% fat, which equates to ~150 g MSY. A survey conducted by Teagasc Moorepark in 2005, on mid-season milk protein concentration, indicated that grass quality was significantly associated with milk protein concentration. As grass digestibility increased so too did milk protein concentration. More recently (August 2014), a detailed nutrition experiment was undertaken. For 12 days four lactating dairy cows were offered medium PGHM grass (1,700 kg DM/ha) and four were offered high PGHM grass (4,000 kg DM/ha). The cows then swopped treatments for a further 12 days. The cows were mature animals (parity four to six) with a mean calving date of 26th March 2014. The cows consumed more of the medium PGHM grass (17.3 kg DM/cow per day) than the high PGHM (14.5 kg DM/cow per day). This was reflected in higher milk yield (19.4 kg/cow per day and 14.6 kg/cow per day for the medium and high PGHM, respectively) and MSY (1.53 kg/cow per day and 1.13 kg/cow per day for the medium and high PGHM, respectively). The dry matter digestibility was 73.9% for the medium PGHM and 69.7% for the high PGHM. These data clearly show a strong negative effect of increasing PGHM on grass quality.

Using PGHM to control grass quality

Grass digestibility is clearly hugely important and, as the grassland manager, you can control grass digestibility by controlling PGHM. A series of detailed experiments were conducted from 2012 to 2014, from February to October. Grass swards differing in PGHM were established. Detailed grass digestibility measurements were undertaken. There was a clear relationship between PGHM and grass digestibility. As PGHM increased grass digestibility decreased. There was, however, a clear seasonal effect. The rate at which grass digestibility decreased as PGHM increased differed by season. The rate of decrease in grass digestibility as PGHM increased was similar in spring and summer. In autumn, however, the rate of decrease in grass digestibility was faster than in spring and summer. This indicates that, in autumn, grazing higher than recommended PGHM could lead to a more pronounced decrease in grass quality, grass intake and animal production performance.

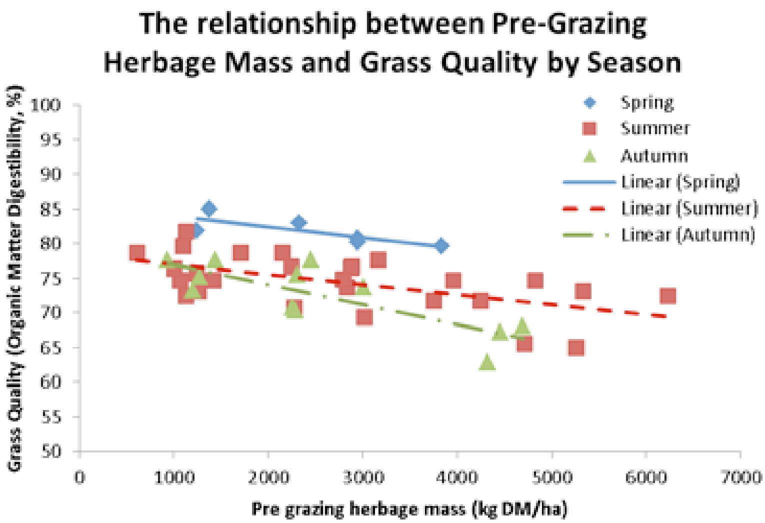

Figure 1. *The relationship between pre-grazing herbage mass and grass quality by season*

Conclusions

Grass quality, measured by grass digestibility, has important implications for dairy cow intake and milk production performance. Grass quality should therefore be maximised by following recommendations on target PGHM.

Grass growth and dry matter intake modelling to predict the impact of management decisions on farm performance

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Summary

- Modelling allows us to predict the impact of farm management decisions on short and long term farm performance
- Grass growth modelling allows us to predict the impact of grazing management on grass growth and environmental impact (in terms of nitrogen (N))
- Modelling the grazing paddock and its interaction with the animal allows us to predict the impact of management on animal and farm performance
- Combining different models allows us to answer specific questions, for example, the effect of grazing severity on farm profitability. In this study a stocking rate of 2.5 cow/ha was more profitable than a stocking rate of 1.9 or 2.2 cows/ha

Introduction

In temperate climates where high grass growth can be achieved over a prolonged period of the year, low cost grass-based systems are best placed to deal with fluctuations in milk price and input costs. This is achieved by lower costs of production allowing a break-even scenario at a low milk price. With the removal of milk quotas, dairy farmers will question what the optimum system is. They will require continuing extensive advice and support to ensure they remain viable and profitable through the transition from a quota to a no-quota scenario, and further into the future. This support can be offered by using models which predict the short- and long-term impact of changes in on-farm management. These models need to be developed specifically for Irish grazing systems in order to predict the impact of changes in on-farm management on grass growth and animal performance.

The Moorepark grass growth model (MGGM)

The MGGM was developed in Teagasc Moorepark, specifically for Irish grazing systems and meteorological conditions. The model predicts daily grass growth depending on weather conditions and grazing management. Farmer decisions which can impact grass growth within the model are N fertilisation as well as the presence of animals in the paddock and the post-grazing height or the cutting height. The model has also been developed with the aim of recreating the N flow in the soil and the plant. The mineral and organic N content of the soil are predicted for each day of the year. In conjunction with information on soil moisture content, this will allow the total N leached during the year to be predicted, as well as N emissions in the form of N gas, nitrous oxide or ammonia. These are impacted in the model by different weather conditions and management practices. Consequently, this model will also be used to predict the environmental impact of different farm management decisions.

The PastureBased herd dairy milk model (PBHDM)

The PBHDM model has been developed to model the Irish grazing system and to predict the impact of different farm management practices. Within the model, every animal and paddock on a farm are described individually. The model can take into account the impact of pre- and post- grazing height, stocking rate, grass quality, quantity and quality of supplement, as well as the animal characteristics on the daily dry matter intake of the animal at grazing. Daily milk production of the animal is also predicted and is based on daily energy intake and the partitioning of this energy between milk production and body condition score gain or loss. Within the model, grassland management decision rules are included to ensure realistic simulations. Animals move from one paddock to another based on a fixed residency time in the paddock or based on a post-grazing height which can be either fixed or dependent on the pre-grazing height. The farm cover is evaluated daily and is compared to the requirement of the animals. In situations where there is grass surplus on the farm, paddocks can be allocated for silage conservation. In the case of a grass deficit, according to the management rules defined by the user, forage or concentrate supplementation can be fed.

Examples of use

The MGGM and PBHDM models can be used together in conjunction with the Moorepark Dairy Systems Model to predict the most profitable scenario at farm level. Three scenarios were simulated within the three models:

- 1.9 cows/ha (76 cows), post-grazing height of 5.2 cm and 160 kg N/ha (low grazing severity, LGS)
- 2.2 cows/ha (88 cows), post-grazing height of 4.5 cm and 200 kg N/ha (medium grazing severity, MGS)
- 2.5 cows/ha (100 cows), post-grazing height of 3.8 cm and 250 kg N/ha (high grazing severity, HGS)

In each scenario concentrate supplementation was 0.5 t/cow. For each simulation the farm size was fixed at 40 ha divided into 18 paddocks. The results are presented in Table 1 at a milk price of 29.5 c/l and a concentrate price of €250/t. The results show that at a milk price of 29.5 c/l and concentrate price of €250/t, the HGS system is the most profitable of the three investigated. The model predicts a higher grass growth (due to the increased N fertiliser usage), a decrease in milk yield per cow and average BCS, but an increase in milk yield per ha and farm profit for the HGS system compared to the other two.

Table 1. Results of the simulation on the impact of grazing severity on farm performance

	Low grazing severity	Medium grazing severity	High grazing severity
Stocking rate (cows/ha)	1.9	2.2	2.5
Total grass growth (kg DM/ha/year)	12,682	13,341	13,503
Grass harvested for silage (kg DM/ha/year)	5,625	5,668	5,411
Milk per lactation (kg/cow)	5,827	5,716	5,590
Milk per hectare (kg/ha)	11,072	12,576	13,974
Average BCS	3.2	3.2	3.1
Total farm profit (€/year)	18,010	21,339	23,279

Conclusions

Models can be used to predict the impact of changes in farm management practices on the performance of the farm as well as the environmental impact. Within the scenario studied, an increase in grazing severity (from SR 1.9 to 2.5 cows/ha) led to an increase in farm profitability.

Automated grass measurement and animal control on dairy farms

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Summary

- Accurate and efficient grassland management is critical for optimal milk production
- An automated grass height measurement device ('Grasshopper') has been developed that will assist accurate and precise grass measurement and allocation
- Current research is focused on (i) an automated objective method of predicting grass DM yield and (ii) adapting virtual fence technology for use in intensive grazing systems

Introduction

Dairy farmers that rely on grass as their primary source of feed require accurate real-time measurement of grass DM yield (kg DM/ha) to optimise cow nutrition and grazing management. The development of technology for precision feeding of animals in a grass-based system is critical. It is also important to assist farmers in making decisions on grass budgeting, for example during different weather conditions. Grass budgeting and informed decisions based on accurate estimation of grass DM yield promote better grass utilisation on the farm.

Technologies to assist farmers to measure grass DM yield are available but not widely used. Reasons include lack of confidence in their accuracy, high labour demand, difficulty in operation and cost. Specifically, these technologies include manual clipping and weighing of grass within a representative quadrant of a field ('cutting and weighing method') or using a rising plate meter, which measures grass height and indirectly estimates grass DM yield. The rising plate meter is an upright stick with a horizontal disc that moves along the stick, depending on the height and density of the grass underneath it. Usually the farmer will walk across the field and take 30 to 50 measures to achieve an average grass height. Once the grass DM yield is known, the farmer calculates the area of the field that will supply the cow herd with the correct amount of grass, and manually sets up the fences. This method of data capture is extremely laborious. Additionally, if the farmer wishes to use the grass measurement data for grass budgeting on a whole farm basis (e.g. PastureBase Ireland), they must manually enter the results into a computer.

ICT tool to capture data automatically from a 'rising plate meter'

Current research at Teagasc Moorepark is focused on the development of an ICT tool to capture data automatically from a rising plate meter which is equipped with global positioning system (GPS) technology and mapping capabilities, i.e. a reliable, precise, consistent and easy to use tool to estimate grass DM yield. The device which has been developed is known as the '*GrassHopper*'. It has a micro-sonic sensor to accurately and precisely measure compressed grass height, with recorded GPS coordinates, integrated with the capacity to transfer generated data automatically to a SMART device and then to the internet cloud (thus allowing integration with e.g. PastureBase Ireland). The micro-sonic sensor is placed on the shaft of the plate meter and measures the height of the grass by recording the time for the sonic transmission from the unit on the shaft and its reflective return from the plate. This work is being conducted at Teagasc Moorepark as part of the EU project 'ICTGRAZINGTOOLS', with the aim of optimising the competitiveness of grass-based milk production systems. There are four partners involved in the project: three research organisations (Teagasc, Ireland; Institute de l'Elevage, France; Agroscope, Switzerland) and one small, medium enterprise (TrueNorth Technologies, Co. Clare, Ireland).

This *GrassHopper* is now developed and calibrated for measurement of grass height against the 'Jenquip' New Zealand plate meter, which was considered to be the scientific gold standard for grass height measurement. A Pearson correlation test indicated R values of 0.9998, 0.9995, 0.9998 for the relationship between the Grasshopper and Jenquip for three different operators, respectively. The precision of the Grasshopper in measurement of absolute height was considered marginally better than that of the Jenquip. The next stage of this work focuses on the prediction of grass DM yield in a paddock using the grass height measurement. This work is currently in progress and aims to develop an equation to predict grass DM yield for any given set of conditions across the parameters of season, grass variety and grass DM content. This is being conducted by using the gold standard measure of grass DM yield from the 'cutting and weighing' method and developing an equation using the associated grass height data.

Paddock mapping and precise allocation of grass

A package to survey paddocks and display paddock maps with real-world coordinates in real time has also been developed, whereby a specific paddock map may be displayed on the SMART phone. The grass height and/or yield data of that paddock may then interact with data such as grass DM, number of cows and grass DM to be allocated/cow. Results from an integration of these data will indicate, on the phone screen, the fence line position which would provide the intended grass allocation for the cow herd. Thus, it has the potential to inform the operator of where to place the fencing wire within the paddock, in order to achieve an accurate and precise grazing allocation.

Virtual fence technology

This technology provides the advantage of removing physical fencing components normally required to contain animals in a specific area. In place of fencing, GPS localisation, wireless networking and motion planning are combined to create an invisible fence line. The system uses GPS to automate the generation of stimuli designed to alert the animal (and stop them progressing towards the boundary), at a defined distance from the boundary. Thus, movement of the animal is controlled by auditory stimuli delivered by a device worn around the neck. With virtual fencing technology it is therefore possible to position virtual fences and allocate the required grass supply from a computer. This technology involves detailed research on equipment hardware and animal awareness and training and is currently in progress.

Conclusion

It is envisioned that use of the *GrassHopper* will improve the accuracy and precision of estimating grass DM yield while simultaneously reducing labour by automating data capture, analysis and recording to the internet cloud. The recorded data can then be used to automatically define the area for grass allocation, possibly using virtual fence technology. In an ideal precision operated farm, the technology should be low cost, reliable, robust, flexible, easy to maintain and update, and provide information that can be immediately converted into a management action. This is the goal with regard to ICT within grassland management and the research being conducted in this area.

Making good quality grass silage on dairy farms

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Summary
- Grass silage is the main winter feed on most dairy farms. Producing sufficient good quality silage will increase in importance with increasing milk output per farm
- Good digestibility and preservation, as well as the absence of heating or mould, are the key silage quality targets. An adequate yield of grass is also necessary
- Implement each step of a comprehensive plan to achieve the key quality targets
- Guidelines for achieving these targets are best considered as long-, medium- and short-term investments

Grass silage quality
Grass silage quality can range from being as good as grazed grass to being insufficient to meet the cow's maintenance requirements. Digestibility and preservation, and the absence of heating/mould, are the main determinants of this quality. Highly digestible silages support much better cow performance (Table 1) than silages of low digestibility. Silage digestibility depends mainly on how much leaf and how little stem, seed-heads and dead vegetation were in the harvested grass. Properly preserved silage will retain the feed value of the grass from which it was made. Preservation depends on storing grass under fully air-free conditions through to feedout, and on lactic acid fermentation in the pit or bale. Heating at silo filling or at feedout, and the presence of mould at feedout, indicate the loss of the most digestible part of silage, and must be prevented by minimising the duration of access of the ensiled grass to air.

Table 1. Silage digestibility and concentrate input effects on milk output (kg ECM/d*)

Silage digestibility	Concentrate input (kg/cow/day)				
(DMD%)	0	4	8	12	16
79.4	23.4	29.1	32.8	31.0	-
75.8	-	27.1	29.3	28.8	-
69.0	-	24.9	27.3	30.1	28.7

**kg ECM/d = kg energy-corrected milk/day* *Source: Randby et al. (2012)*

Long-term guidelines
A deficiency of lime, phosphorus (P) or potassium (K) in soil is the main constraint to reliably producing adequate yields of good quality silage on many farms. Thus, manage lime, slurry and inorganic fertiliser application based on regular soil analysis to ensure the appropriate pH, P and K status is maintained. Where water-logging of soils is a direct or indirect constraint to producing sufficient good quality silage then an effective land drainage system may be required. Ryegrass dominant swards are best suited to producing high digestibility silage. Their higher sugar content makes them easier to preserve as silage than other grasses.

Medium-term guidelines
Digestibility
Manage livestock so they tightly graze (uniformly < 5 cm) silage fields in autumn or spring, to avoid the accumulation of low quality dead or very stemmy grass at the base of the sward. Such grass reduces overall digestibility by 5 to 6 % units in May. If grazing silage

fields in spring, remove the cows by late March so as to permit high yields be achieved when the grass is at the target growth stage for silage making. If rolling silage fields in spring, complete this before grass stems start to elongate. Avoid excess nitrogen (**N**) input, from inorganic fertiliser (urea/CAN) and slurry, as this can predispose heavy yields of grass to lodging in wet/windy weather. The digestibility of lodged grass can decline two to three times faster than unlodged grass. Weeds should also be controlled, as some weeds, such as docks, have quite a low digestibility.

Preservation

Reduce inorganic fertiliser N input to allow for (i) 20 to 25% carryover of N applied for spring grazing and (ii) N provided by applied slurry, so as not to exceed 125 kg N/ha for first-cut silage. Applying more N than required reduces grass sugar concentration and increases its buffering capacity, making it harder to preserve as silage. Similarly, late or uneven application of slurry risks the grass being contaminated at harvest time, which makes it difficult to preserve the silage properly.

Short-term guidelines

Digestibility

Frequently monitor the grass, with an emphasis on noting the development of its growth stage, the accumulation of dead herbage or lodging. If a silage digestibility of 75% is required then aim to harvest intermediate heading-date ryegrasses as seed-heads start to emerge and late heading-date ryegrasses a few days before seed-heads emerge. Grass digestibility can be expected to decrease by 2 to 3% units per week from early May onwards. Some flexibility may be needed with the contractor if the grass is to be harvested at the target growth stage.

Preservation

Successful wilting will greatly assist silage preservation and reduce effluent output. It requires at least a half day and not more than 1.5 days of good drying conditions. The best wilting occurs where the grass is mown after the morning dew has evaporated and is then tedded or at least placed in separate wide windrows. Attempting to wilt in merged windrows or in damp/wet weather is likely to have negative effects on both silage digestibility and preservation. Some grass does not require an additive to be applied at harvesting, especially if it is well wilted or has adequate sugar content. If an additive is being applied to leafy, wet grass of low sugar content, know the grass ensilability (measure its sugar content with a refractometer), its yield (t DM/ha) or harvest rate (t/hour), and the rate of additive that should be applied. Additives such as beet pulp or citrus pulp, molasses or acid-based products, when evenly applied at appropriate rates, are most effective under 'low sugar' conditions. If there is adequate sugar in the grass then some bacterial inoculants can improve milk production. For a walled pit or clamp, fill it quickly, rolling throughout filling, and then rapidly seal the grass from air. This is necessary for good preservation and to prevent mould growth. Thus (i) place a plastic sheet at the sides and fold it onto the grass (walled pit only), (ii) seal the grass beneath two 0.125 mm thick plastic sheets, (iii) cover the plastic sheets completely with tyres, etc., placed edge-to-edge, (iv) seal the edges of the plastic sheets with a continuous row of sandbags, silt, etc., (v) as the grass sinks in the silo, keep the plastic sheets stretched to prevent any ingress of air, and (vi) inspect the plastic sheets frequently and repair any damage. For baled silage, dense cylinder-shaped bales of wilted grass wrapped in at least four layers of plastic stretch-film, and where no damage occurs to the plastic, provide the required air-free conditions. Channel effluent quickly from pits or clamps and landspread or feed the effluent.

Conclusions

Some farmers consistently make good quality silage. Their repeated success reflects the plan they follow rather than 'good fortune'. Implementing each step of a plan that delivers on the above guidelines is essential for reliably producing good quality silage.

Soil fertility costing dairy farmers dearly

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Summary

- Lime and fertiliser phosphorus (P) and potassium (K) use on Irish farms has declined steadily over the past two decades
- Currently >60% of soils have below target soil pH and lime applications to land are less than half mid 1980's level
- Soil test results indicate that 90% of soils have suboptimal fertility to maximise grass growth (target soil pH = 6.3, target soil P & K Index = 3)
- Low soil fertility (e.g. soil P Index 1) equates to a loss of in excess of 1.5 t grass DM/ha per year, which is worth €300/ha per year
- Higher yielding swards require higher nutrient application rates to replace nutrients removed during grazing and silage cutting
- Soil testing and fertiliser planning are key requirements for any successful farm
- Slurry is valuable resource and should be targeted at soils with highest requirement for P & K to help offset expensive fertiliser costs

Introduction

Soil fertility levels have declined on dairy farms coinciding with a reduction in fertiliser usage in recent years. Of the dairy farm soil samples analysed by Teagasc in 2014 only 10% had optimal soil fertility levels as indicated by soil pH, P and K. Over 60% of soils sampled on dairy farms have soil pH that is sub-optimal (<pH 6.3) (Figure 1).

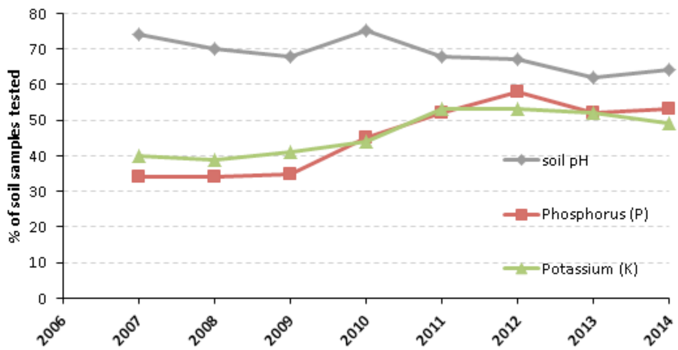

Figure 1. *The % of soil samples from dairy farms, analysed by Teagasc, with low soil pH, P and K from 2007 to 2014*

With up to 90% of soils currently deficient in at least one of these critical elements, poor soil fertility poses a significant threat to achieving increased productivity and profitability on dairy farms.

Nutrient requirements for grass swards

Grass requires a continuous and balanced nutrient supply from the soil to achieve its production potential. Some well managed and fertile farms are capable of growing in excess of 16 t grass DM/ha annually. This level of grass production requires large quantities of nutrients, such as the major nutrients nitrogen (N), P, K, and sulphur (S) (Table 1). However, only a fraction of these quantities of nutrients are required as fertiliser inputs due to the continuous recycling of nutrients that occurs within the soil. These high rates of nutrient uptake by high yielding grass swards shows the importance of having soils in optimum condition to deliver the quantities of nutrients required over the growing season.

Table 1. Typical concentrations of N, P, K and S in a tonne of grass DM, and the total uptake of each nutrient required in a full year by swards growing 16 t grass DM/ha

Nutrient	Typical concentration in grass (kg/t DM)	Total uptake required for 16 t grass DM (kg)
N	34.9	558
P	4.1	67
K	29.7	475
S	2.9	46

Lime & Fertiliser advice

The starting point when building soil fertility is to apply lime according to the soil test recommendations. The nutrient application advice for P and K for dairy grassland is shown in Tables 2 and 3. The guidelines given below for P and K applications include P and K from both chemical fertiliser and slurry sources. In addition, the P application rates should also be adjusted to account for the P coming onto the farm in concentrate feeds.

Table 2. Simplified P requirements (kg/ha) of grazed and cut swards for dairy farms (These total P requirements should be adjusted for concentrate feeds or organic manures applied)

Soil P Index	Grazed Swards				Silage Swards	
	Farm Stocking Rate (LU/ha)				Cut Once	Cut Twice
	<1.5	1.5-2.0	2.0-2.5	>2.5		
1	30	34	39	43	+20	+30
2	20	24	29	33	+20	+30
3	10	14	19	23	+20	+30
4	0	0	0	0	0	0

Table 3. Simplified K requirements (kg/ha) of grazed and cut swards for dairy farms (These total K requirements should be adjusted for organic manures applied)

Soil P Index	Grazed Swards				Silage Swards	
	Farm Stocking Rate (LU/ha)				Cut Once	Cut Twice
	<1.5	1.5-2.0	2.0-2.5	>2.5		
1	85	90	95	100	+120	+155
2	55	60	65	70	+120	+155
3	25	30	35	40	+120	+155
4	0	0	0	0	0	0

Conclusion

Trying to plan fertiliser application strategies without information on soil fertility levels is impossible. Therefore, soil test results for the whole farm are essential. Although it costs money to increase fertility levels on low fertility soils, the returns in terms of grass production can be considerable, which can increase livestock carrying capacity, provision of winter feed (silage), animal health and ultimately profitability.

Developments in the Pasture Profit Index (PPI)

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Summary

- The PPI is a total economic merit index which ranks grass varieties on the economic value to a grassland farm
- The PPI will assist grassland farmers in identifying the most appropriate variety(s) for their farm
- A PPI range exists between the highest (€208) and lowest (€54) PPI varieties
- Farmers can use the PPI sub-indices to choose varieties for a specific purpose
- The PPI will be refined over time; further agronomic data will be used in the index as will commercial farm data from PastureBase Ireland

Introduction

Food Harvest 2020 set clear production targets for Irish ruminant production systems. In the pursuit of these targets it is vital that Ireland maintains its grass-based focus. Thus, improvements must be made in grass production and utilisation on dairy enterprises. Current levels of perennial ryegrass proportions within swards are low and farm reseeding levels are low. Total merit indices have been used to successfully rank animals based on their expected profitability (e.g. the Economic Breeding Index). A number of studies were reviewed to identify the most valuable grass traits affecting grass-based production systems. The traits identified were those which have the largest effect on the economic performance of a grass-based system. It was considered critically important that the traits selected could be easily measured in grass evaluations (undertaken by DAFM) and that improvements in each trait could be achieved through plant breeding.

Approach used

The PPI is comprised of six sub-indices: spring, mid-season and autumn grass DM production; grass quality (April to July, inclusive); 1st and 2nd cut silage DM production and persistency. The performance of a variety for a trait was calculated by determining the difference between the performance of each variety and the base value for that trait. This was multiplied by the economic value for the trait which was calculated using the Moorepark Dairy Systems Model. The economic value of 1 extra kg grass DM in spring and autumn was higher than mid-season because it supported an extended grazing season. The relative emphasis on each trait in the index is grass DM production (31%), grass quality (20%), silage production (15%) and sward persistency (34%). The sub-indices present an opportunity to select varieties for specific purposes. If selecting a cultivar for intensive grazing, the emphasis is on seasonal DM production. If selecting a variety specifically for silage production, then greater emphasis would be placed on the performance of that cultivar in the silage sub-index. The performance values included in the PPI are based on data collected from the DAFM grass evaluation trials. Varieties are evaluated over a minimum of two sowings. Each sowing is harvested for two consecutive years after the sowing year. The two harvest years include a six-cut system (one spring grazing cut, followed by two silage cuts and then three grazing cuts) and an 8 - 10 cut system (corresponds to normal commercial rotational grazing). The PPI index values range from €208 to €54/ha per year for the 31 cultivars the data were assigned to. It is likely that new traits will gain importance in the future, and will be incorporated into the PPI.

Teagasc Pasture Profit Index (PPI) 2015

Grass Variety Details			Pasture Profit Index Sub-indices (€ per ha per year)						Total €/ha/year
			Dry Matter Production			Quality	Silage	Persistency	
Variety	Ploidy	Heading date	Spring	Summer	Autumn				
Abergain	T	June 5	42	50	43	58	26	-11	208
Dunluce	T	May 30	43	45	58	35	24	-11	194
Aberchoice	D	June 10	24	52	47	57	9	-5	184
Abermagic	D	May 30	47	53	78	21	13	-28	184
Kintyre	T	June 8	29	40	58	25	14	0	166
Rosetta (*)	D	May 24	97	40	39	-2	19	-28	165
Astonenergy	T	June 2	10	41	43	54	12	0	160
Seagoe (*)	T	May 29	30	45	43	13	38	-11	158
Aberplentiful (*)	T	June 8	15	44	48	30	15	0	152
Magican	T	May 22	59	37	42	-5	28	-11	150
Giant	T	May 20	39	50	39	-2	22	0	148
Trend	T	May 24	25	41	30	3	38	0	137
Navan	T	June 6	14	41	50	21	10	0	136
Aspect (*)	T	June 5	26	45	29	30	10	-5	135
Carraig	T	May 24	42	40	38	-19	31	0	132
Solomon	D	May 23	66	32	35	-30	22	0	125
Drumbo	D	June 7	27	35	35	36	-4	-11	118
Delphin	T	June 2	13	42	27	10	21	0	113
Abercraigs	T	June 4	14	38	21	17	18	0	108
Glenroyal (*)	D	June 5	25	41	46	-2	6	-11	105
Majestic (*)	D	June 2	43	38	43	-23	0	0	101
Boyne (*)	D	May 22	42	39	33	-56	41	0	99
Glenveagh (*)	D	June 3	37	39	34	-22	7	0	96
Twymax (*)	T	June 7	-11	48	20	27	17	-5	95
Stefani (*)	D	June 1	25	34	27	-9	9	0	86
Piccadilly (*)	D	June 3	31	38	22	-30	16	0	77
Tyrella	D	June 4	41	23	19	-1	0	-11	71
Mezquita	D	June 6	22	30	18	-22	6	0	54
Solas	T	June 10							
Rodrigo	D	May 27							
Clanrye	D	June 6							

Guide to reading the table:

Grass variety details
Variety, Ploidy (T = tetraploid; D = diploid), Heading date

PPI details (Total €/ha per year)
Indicates relative profitability difference when compared to the Base Values

PPI sub-indices
DM production (spring, summer and autumn), Quality (April, May, June and July), Silage (1st and 2nd cut), Persistency. This indicates the economic merit of each variety within each trait, summed together this provides the overall Pasture Profit Index figure.

Varieties with no PPI values
Varieties listed with no PPI values do not have enough agronomic data available for the PPI value calculation at present. These varieties should also be considered for variety selection given that they are present on the Recommended List. Data for all varieties will be available within the next two years. Actual performance data of each variety is presented in the DAFM Grass and Clover Recommended List Varieties for Ireland 2015.

PastureBase Ireland (PBI) - National grassland database

Micheál O'Leary, Anne Geoghegan, Liam Hanrahan, Michael O'Donovan and Laurence Shalloo

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Summary

- PastureBase Ireland (PBI) gives farmers the opportunity to plan towards greater efficiency through growing and utilising more grass
- Grass DM production on PBI dairy farms increased from 12.2 t DM/ha in 2013 to 13.8 t DM/ha in 2014. Large variation between farms and paddocks within a farm was evident
- Higher grass producing dairy farms are focused on implementing a spring rotation planner, targeting early nitrogen (N) and achieving >8 grazings per paddock per year
- Farmers measuring grass should ensure regular measurements and investigate the relative differences between paddocks on their farms

Introduction

PastureBase Ireland is a web-based grassland management tool. It has a dual function. It is a grassland management decision support tool, but it also collates and stores a vast quantity of grassland data from grassland farmers in Ireland in a central national database. This provides an opportunity to increase the understanding around all aspects of grassland production and utilisation. Data recorded on PBI spans all enterprises - dairy, beef and sheep. Key parameters which PBI calculates are seasonal and annual grass DM production (this can be further divided into grazing and silage DM production). PastureBase Ireland data can be used to measure the factors that affect grass production across different enterprises, and to measure the effects of grassland management practices, region, and soil type and fertility across a large range of farms on annual and seasonal grass production. PastureBase Ireland now has in excess of 1,000 users (including farmers, industry personnel and researchers) while there are 779 farms nationally imputing data weekly. In total 15 research farms and 764 commercial farms (567 dairy, 183 beef and 14 sheep) are using PBI. PastureBase Ireland can stimulate the increase in grass DM production and utilisation required to fulfil Food Harvest 2020 targets, but farmers must use grass measurement more and make use of grassland management data benchmarks.

Results to-date - what do we know

At the end of the grazing season, farms with >30 weekly farm cover measurements recorded are compiled and analysed for seasonal and annual grass DM production. It is not possible to calculate an annual grass DM production figure without regular grassland measurement. Figure 1 shows data for dairy farms in 2013 and 2014. There is a large year effect which is expected, with grass DM production increasing by 1.6 t DM/ha between years (13.9 t DM/ha in 2014 versus 12.3 t DM/ha in 2013). The grass apportioned to grazing increased by 1.2 t DM/ha in 2014. This increase was reflected in an increased number of grazings per paddock. The top producing dairy farms produced 16.5 t DM/ha in 2014, an increase of 2.6 t DM/ha compared with 2013. The key principles which the higher producing dairy farms are implementing include: adherence to the spring rotation planner, ensuring the application of sufficient N in March and April, proactive management (reacting quickly and decisively to a surplus or deficit of grass supply and changeable weather conditions), managing soil fertility (achieving soil indexes of 3 for P and K) and targeting a high number of grazings per paddock.

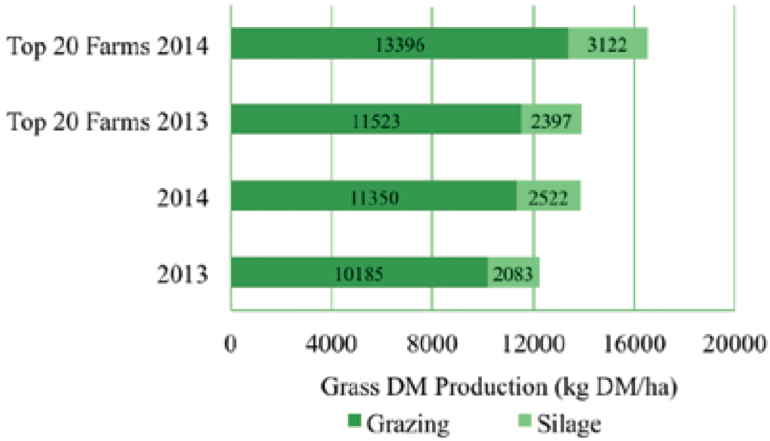

Figure 1. *Grass dry matter production on PastureBase Ireland dairy farms in 2013 and 2014*

Spring grass DM production is low on dairy farms. In 2014, PBI highlighted that spring grass DM production was 8% of annual production while summer and autumn accounted for 56% and 36%, respectively. From a feed budget perspective it is more advantageous to increase grass DM production in the shoulders of the grazing season than in the summer. This is because extra grass grown in the shoulders of the grazing season displaces expensive supplementary feeds. There was also considerable variation in spring grass DM production between farms. Poorly producing grassland farms only grew 0.6 t DM/ha in spring (1st January 2014 to 10th April 2014), while the top producing grassland farms grew 1.8 t DM/ha during this period. Early N application and on-off grazing should be the top two priorities for all farmers in 2016 to ensure high spring grass DM production. There is a strong correlation between spring grass DM production and annual grass DM production.

Future plans

Over time PBI will be able to provide information on the variation in annual grass DM production which will ultimately contribute to the development of more precise mechanistic grass growth models, parameterised regionally with farm specific data. PastureBase Ireland is designed to be functional at the paddock level, which will allow the evaluation of paddock performance, to increase the knowledge on the relationship between soil fertility and grass variety in relation to grass DM production. PastureBase Ireland has the potential to refocus grassland research in Ireland, while contributing to significant increases in both productivity and profitability on grass-based farms.

Reseeding to increase pasture production

Philip Creighton[1] and Michael O'Donovan[2]
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Summary
- Reseeding is one of the most cost effective on-farm investments
- There is little difference between reseeding methods in terms of grass DM production, sward establishment, and sward persistence
- With spring reseeding there is no loss in grass DM production in the establishment year compared to permanent pasture
- Management after reseeding is just as important as decisions made at sowing

Introduction

Many farms in Ireland have swards that cannot grow enough grass during the year especially in spring and autumn. This is mainly due to the absence of productive perennial ryegrass in swards. Economically, pastures with a low proportion of perennial ryegrass are costing farmers up to €300/ha per year due to a loss of grass DM production and reduced nitrogen use efficiency during the growing season. If the cost of reseeding is estimated at approximately €700/ha, the increased profitability of the reseeded pasture would cover the reseeding cost in just over two years. This means reseeding is one of the most cost effective on-farm investments.

Reseeding methods

Paddock preparation for reseeding is dependent on soil type, amount of underlying stone and machine/contractor availability. There are essentially two methods of preparing the seedbed. The most common method is ploughing. In many areas however this is not possible because the ground is too stony, soil is too shallow or topography is too steep. Recent technological advances, such as minimal cultivation techniques, enable reseeding to be carried out without ploughing. Studies undertaken at Teagasc Moorepark in recent years have investigated the effect of reseeding method on grass DM production. Four methods of reseeding were compared, namely 1) direct drilling, 2) discing followed by onepass, 3) onepass with powerharrow and 4) ploughing (conventional). One of the main aims of the studies was to evaluate alternative grassland reseeding methods in terms of their effect on grass DM production, sward establishment, and sward persistence. Each of the sward renewal methods evaluated performed satisfactorily because all were equally as effective as the conventional method of grassland reseeding. The length of the study (2.5 years) may be too short to fully evaluate the lifetime performance of the swards, but 24 months after establishment, it appears that prevailing grazing management is more likely to influence grass DM production than the reseeding method.

Timing of reseeding

Most reseeding in Ireland is completed in the autumn. This may make sense from a feed budget perspective but it does have some negative consequences. Conditions deteriorate as autumn progresses - lower soil temperatures can decrease seed germination and variable weather conditions reduce the chance of grazing the new sward. The opportunity to apply a post-emergence spray for weed control is also reduced as ground conditions are often unsuitable for machinery to travel. With this in mind, if planning to reseed, the spring period should be considered for at least a proportion of the area, with all reseeding completed as early as possible in the autumn. The effect of timing of reseeding was investigated over a two year period. Swards were established in both autumn and spring. The autumn sown reseed in its first year of production out yielded an old permanent pasture control sward by 958 kg DM/ha (11,326 versus 10,368 kg DM/ha). In Year 2, this difference increased to 2,410 kg DM/ha (12,749 versus 10,339 kg DM/ha). For the spring sown reseed there was virtually no difference in grass DM production in the establishment year (both swards yielded 9,700 kg DM/ha), while in Year two this difference increased to 2,033 kg DM/ha in favour of the reseeded swards. A key finding from this study was that there was no loss of grass DM production in the establishment year when reseeding in the spring period This was due to the new sward being back in production during the main grass growing season allowing four grazings to take place post-reseeding in the establishment year. The autumn reseed provided one grazing post-reseeding in the establishment year. These studies indicate that irrespective of timing of reseeding, swards require time to recover after the reseeding process, and to allow perennial ryegrass hierarchy establish. Then the advantage of reseeding becomes apparent.

Management of reseeds

It is vitally important that soil fertility is at recommended levels to ensure high performance from reseeded swards. Soil samples should be taken from the freshly cultivated soil for analysis to gauge the level of nutrients required. Prior to reseeding the old sward should be killed off using glyphosate. When reseeding, ensure that grass varieties from either of the Irish (Republic or Northern) recommended lists are used. These varieties have been tested under Irish conditions. The new Teagasc Pasture Profit Index is also a valuable tool to select the most suitable grass varieties for your farm. Teagasc recommendations are to sow 14 kg seed/acre (35 kg/ha) to ensure good establishment of the sward. It is also advised to sow a minimum of 3 kg of each variety within a mixture. The best time to control docks and all other weeds is after reseeding. By using a post-emergence spray, seedling weeds can be destroyed before they develop and establish root stocks. The post-emergence spray should be applied approximately six weeks after establishment just before the first grazing takes place. Care needs to be taken when grazing newly reseeded swards. The sward should be grazed as soon as the new grass plants roots are strong enough to withstand grazing (root stays anchored in the ground when pulled). Early grazing is important to allow light to the base of the plant to encourage tillering. Light grazing by animals such as calves, weanlings or sheep is preferred as ground conditions may still be somewhat fragile, depending on the seedbed preparation method used. The first grazing of a new reseed can be completed at a pre-grazing yield of 600 to 1,000 kg DM/ha. Frequent grazing of the reseeds at light pre-grazing yields (<1,400 kg DM/ha or less than 10 cm) during the first year post-establishment will have a beneficial effect on the sward. The aim is to produce a uniform, well tillered, dense sward. If possible reseeded swards should not be closed for silage in their first year of production as the shading effect of heavy covers of grass will inhibit tillering of the grass plant resulting in an open sward which is liable to weed ingress.

Conclusion

The timing of reseeding will be influenced by feed budgets and weather conditions. There is little difference between reseeding methods once a firm seed bed is established and good seed-soil contact is achieved. Many management factors affect the success of reseeded swards. Good management after sowing is just as important as decisions around timing and methods of reseeding.

Teagasc grass and clover breeding programme

Patrick Conaghan

Teagasc, Animal & Grassland Research and Innovation Centre, Oak Park, Carlow

Summary

- Our goal is to breed varieties of perennial ryegrass and white clover that offer high yields of quality forage over a long grazing season
- Twenty-five perennial ryegrass and 10 white clover varieties have been commercialised to date
- Teagasc has entered into a new partnership with Goldcrop Ltd. to support the programme and commercialise all new varieties that emerge from the programme

Introduction

Grassland is Ireland's greatest renewable feed resource and provides the main feed for ruminant livestock. The genetic improvement of forage grass and clover offers a cost effective mechanism to increase the profitability and reduce the environmental cost of animal production from grassland. Forage grass and clover have been subjected to very little formal breeding. Genetic variation within and among populations is still extremely high, and shows no signs of decreasing. Harnessing the power of modern technologies such as genomic selection may accelerate genetic improvement. The potential of forage breeding is limited only by human imagination, ingenuity and available funding.

History

The Teagasc forage breeding programme was initiated in the early 1960s at the Oak Park Research Centre, Carlow. To date, the programme has bred and commercialised 25 perennial ryegrass varieties and 10 white clover varieties. The programme is supported by Goldcrop Ltd., an Irish seed company with headquarters in Carrigtwohill, Co. Cork and DLF-Trifolium, a plant breeding and seed production company with headquarters in Denmark. Goldcrop have exclusive world-wide rights to commercialise and market all new varieties that emerge from the programme.

Breeding goals

Our emphasis is on breeding improved varieties of perennial ryegrass and white clover for Irish farmers. The main plant traits for genetic improvement are: (i) spring and autumn growth, (ii) quality, particularly at mid-season, (iii) sward persistency and density, and (iv) disease resistance. The perfect variety would provide sufficient yield to match the animal feed demand curve over the entire grazing season and also provide additional yield during the mid-season that could be conserved for use during the winter when grazing is not possible. We want a grass variety that heads only once in a compact period of time for seed production. For the rest of the year we want a leafy, highly digestible sward. We want a variety that produces a dense sward with no bare ground and that will persist indefinitely. Finally, we want a variety resistant to rust. Rust is not a major disease problem in Ireland at present but it is predicted to get worse.

Breeding methods

The release of a new variety is the culmination of a 15 to 20 year process consisting of three main stages: (i) forage breeding, (ii) independent variety evaluation and (iii) commercial seed production. The breeding process consists of a multistep and cyclic process, known as recurrent selection, where the best plants (genotypes) are evaluated, selected and intercrossed to produce a new variety. The generalized method consists of: (i) development of a source population from which to begin selection, (ii) evaluation of individual plants from the source population and (iii) selection and intercrossing of superior plants to form a new population. The source population consists of varieties, elite families and introductions from genebanks. Selection is based on phenotypic and genotypic recurrent selection. Phenotypic recurrent selection is selection based on visual observation or physical measurement of the trait. Genotypic recurrent selection is selection based on progeny performance. The Teagasc breeding programme uses mainly full-sib progeny test selection. The superior plants identified through one cycle of recurrent selection may become the starting point for the next cycle of recurrent selection or may be used to construct new synthetic varieties. A synthetic variety is defined as a population produced by crossing in all possible combinations a number of selected plants and which is thereafter maintained by random mating in isolation. The new variety is submitted to the Department of Agriculture, Food and the Marine for independent testing under cutting and grazing. The variety is added to the Irish Recommended List if it is found to offer improved agronomic performance and its botanical characteristics are distinct from other varieties, uniform and stable (DUS). Commercial seed of Teagasc bred varieties are produced and sold under license by Goldcrop Ltd. or DLF-Trifolium.

Varieties

In 2015, farmers may choose among 10 perennial ryegrass and four white clover varieties bred by Teagasc for reseeding. All varieties are included on the Grass and Clover Recommended List Varieties for Ireland 2015.

Perennial ryegrass varieties:

- Early diploid: *GENESIS*
- Intermediate diploid: *SOLOMON*
- Intermediate tetraploid: *CARRAIG, GIANT and MAGICIAN*
- Late diploid: *GLENROYAL, GLENVEAGH* and *MAJESTIC*
- Late tetraploid: *KINTYRE* and *SOLAS*

White clover varieties:

- Medium leaf size: *AVOCA, BUDDY, CHIEFTAIN* and *IONA*

- New in 2015 are *GLENROYAL* and *SOLAS* perennial ryegrass varieties, and *BUDDY* white clover. *GLENROYAL* (late diploid) and *SOLAS* (late tetraploid) offer excellent yields and high density swards. Although a medium leaf size white clover variety, *BUDDY* offers exceptional persistency and ground cover under tight grazing comparable to a small leaf size variety. Forthcoming Teagasc varieties, currently undergoing seed increase and with predicted release dates of 2016-2017, include *KERRY* (late diploid perennial ryegrass) and *COOLFIN* (small leaf white clover).

Conclusions

The Teagasc forage breeding programme continues to develop improved varieties of grass and clover for Irish farmers. Farmers may currently choose among 10 perennial ryegrass and four white clover varieties bred by Teagasc for reseeding. A number of other new varieties are currently undergoing seed increase for future release.

Milk from grass in Ballyhaise College

Donal Patton

Teagasc, Ballyhaise Agricultural College, Ballyhaise, Co.Cavan

Summary

- Highly productive grass-based milk production systems are achievable in the BMW region
- Grass production at Ballyhaise averaged 13.8 t DM/ha over the last four years; however grass production can drop to as low as 11 t DM/ha during very wet years due to the heavy soil type
- Utilising the grass grown is challenging, especially at the shoulders of the year. Good grazing infrastructure, flexible grazing management practices and a compact calving pattern are all essential components which help to overcome the challenge of operating on heavy soil types
- A reasonable target for farmers in the BMW region is 1,250 kg milk solids (MS)/ha with production costs of less than €2.50/kg MS

Introduction

Profitable and resilient systems of milk production will be driven by high output of MS/ha at low cost. From its beginnings in 2005 the project in Ballyhaise has focused on improving the profitability of milk production systems for farmers in the region through a number of avenues: increasing grass growth and utilisation, improving MS production per ha, improving herd fertility performance and reducing feed costs. The purpose of this paper is to outline how improvements in these areas have increased productivity and profitability of the Ballyhaise system.

Grass production

Land type has a significant impact on grass production and utilisation. Recent studies at Ballyhaise have reported high grass growth and utilisation at the site in normal growing seasons. Over the last four seasons, average grass production was 13.8 t DM/ha, ranging from 11 t DM/ha in 2012 to 15.5 t DM/ha in 2014 (Figure 1). Wet years have a significant impact on grass growth potential due to the heavy nature of the soil, for this reason it is important to have 1.4 t DM of winter feed available per cow each year. Soil fertility is another key factor which impacts grass production. In terms of soil fertility, Ballyhaise is not typical of dairy farms in the region, with high levels of both P and K in soils. Only 5% of the soils are below index 3 for P and 14% are below index 3 for K. However, soil pH is still an issue with 35% of soils below optimum; this has been tackled in recent years with an extensive liming programme.

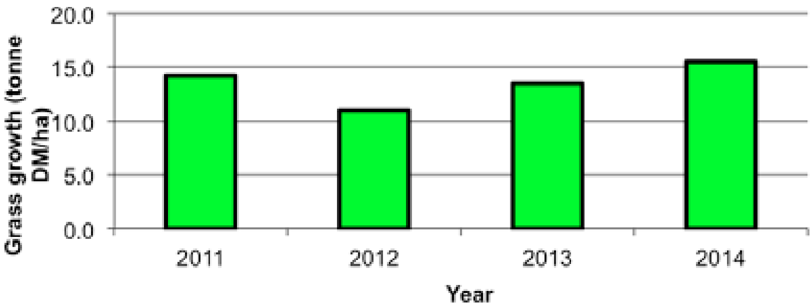

Figure 1. *Annual grass production (t DM/ha) in Ballyhaise from 2011 to 2014*

Achieving high grass utilisation on heavy soils

In order to utilise a high level of grass per ha for milk production, days at grass must be maximised. Over the last 10 years investments in good grazing infrastructure have had a major impact on the length of the grazing season which now extends from 10th February to 15th November. In addition the adoption of techniques such as on-off grazing and block grazing has helped to minimise pasture damage during wet conditions. While a target pre-grazing yield of 1,300 to 1,600 kg DM/ha is exactly the same as for dry farms, on heavy soils grazing decisions are often more tactical and are based on ground conditions in an individual paddock as well as pre-grazing yield. Measurement and budgeting of grass is critical to achieve a long grazing season. One of the key differences for most farmers in the BMW region is that they must start closing off paddocks from 25th September to 1st October to ensure an opening cover in spring of above 800 kg DM/ha. At Ballyhaise the average over winter growth over the past five years has been 1.5 kg DM/ha per day, therefore closing cover in autumn must be in excess of 650 kg DM/ha to ensure sufficient grass for the following spring. The two key targets for those operating on heavy soils are that in the autumn 70% of the farm is closed by 1st November and that in spring 30% of the area is grazed by 7th March.

Animal performance

A compact calving pattern is an essential part of grazing systems, especially on heavy soils where grass growth tends to be low in early spring but accelerates quickly in April and May. Poor fertility performance in the early years of the project led to a spread out calving pattern and a very high replacement rate. Using high EBI AI sires increased the fertility sub-index from €13 in 2006 to €100 in 2014. Over this period six week in-calf rate increased from 36% to 68% and empty rate after 12 weeks breeding decreased from 35% to 11%. These improvements in fertility have had a direct impact on the output of MS/ha which increased from 1,030 kg MS/ha in 2006 to 1,250 kg MS/ha in 2014 (Figure 2).

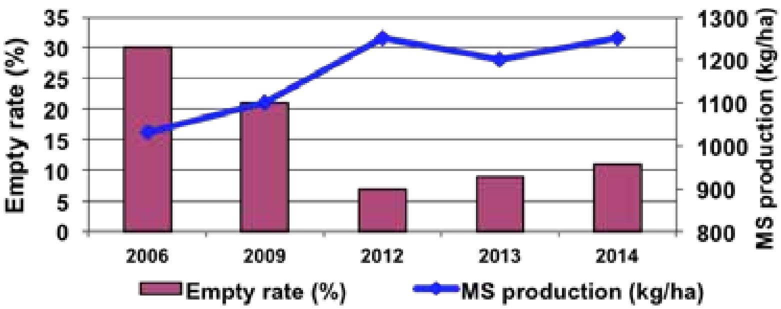

Figure 2. *Herd empty rate (%) and MS production (kg/ha) in Ballyhaise from 2006 to 2014*

Conclusions

In a quota free environment farmers must strive to increase output per ha at low cost to improve profitability. For those constrained by heavy soils some of the grazing management practices and targets may need to be altered to achieve this but the basic principal of maximising grass production and utilisation is universal regardless of land type or location.

Making the best use of grazed grass for winter milk herds

Joe Patton and Aidan Lawless

Teagasc, Animal & Grassland Research and Innovation Centre, Johnstown Castle, Wexford

Summary

- Converting more grass to milk per ha farmed is central to controlling costs and improving margins for winter milk herds
- Much of the difference in annual feed cost between high and lower cost winter milk farms arises during spring and early autumn. Grass budgeting can be employed at these key times to deliver more milk from forage
- Start of grazing should not be delayed due to high demand in spring. Instead follow a spring rotation plan, offering grass daily and balancing feed demand with high quality silage plus concentrate until grass supply is adequate
- High quality mid-season grass can support a daily milk output of 25 to 26 kg (1.90 kg milk solids) under normal grazing conditions. Autumn calving cows have a persistent lactation curve and are capable of high milk solids yield into late summer on grass-only diets
- A peak average farm cover of 850 to 900 kg DM/ha in late September is suitable for herds with a high proportion calving in autumn. It strikes a balance between extending grazing, feeding freshly-calved cows well and ensuring correct post-grazing heights

Introduction

It is well established that purchased feed, along with labour and machinery, is the main source of increased cost for winter milk herds compared to their spring-calving counterparts. Nonetheless a large range in feed cost (± 3.2 c/l relative to average) is evident when comparing farms within the winter milk sector, indicating factors other than the defined 'system' impact upon costs.

Feeding the freshly-calved group during winter is commonly cited as the main reason for additional purchased feed in autumn-calving herds. This largely holds true relative to spring calving systems. However, much of the difference in supplement input between high and lower cost winter milk herds actually occurs during spring/early summer and autumn (Figure 1). For the average winter milk herd, up to 75% of annual milk is delivered from February to October, so there is good scope to increase margins by implementing grazing management protocols.

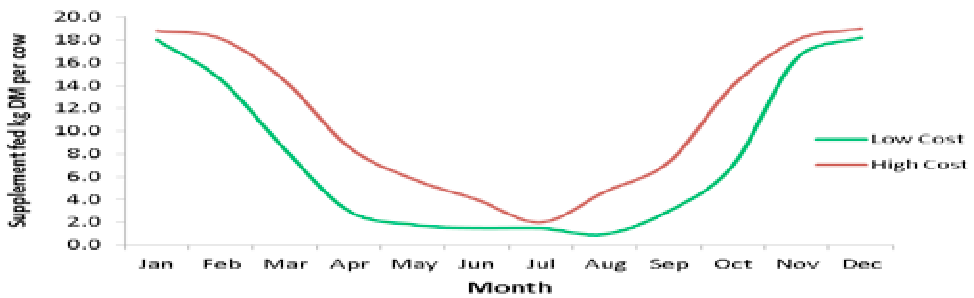

Figure 1. *Supplement use (forage plus concentrate) on high- and low-cost winter milk farms*

A framework for grazing management in winter milk systems

The Teagasc Johnstown Castle herd comprises 120 Holstein Friesian cows (€178 EBI), with >60% calving in autumn and the remainder from February to April. Annual milk production is 7,104 kg milk at 4.02% fat and 3.58% protein from a concentrate input of 1,210 kg DM/cow. Grazing stocking rate in the current system is 3.05 LU/ha. An important objective for this programme is to develop practical grazing management guidelines for herds operating similar systems, to maximise the proportion of grass utilised for milk production.

Spring rotation

In early spring the main challenge is managing high daily feed demand. A long first rotation promotes adequate high quality grass supply in April, so grazing commences in early February with a target of 35% total area grazed by 1st March. Grass is allocated by day. Cows are housed by night and fed high quality silage. Minimum grass allowance per bout is 5 kg DM/cow. Indoor feed allowance is reduced on grazing days to encourage grazing to 4 cm. The full indoor ration is offered on non-grazing days. Supplements are reduced further as grass availability increases.

Mid-season grazing

Autumn-calving cows have a persistent milk production curve, with milk yields up to 90% of peak possible at >200 days in milk. The mid-season objective is to feed cows well with 100% grazed grass where possible. Grass at 1,300-1,600 kg DM/ha, grazed at the 3-leaf stage, provides an excellent diet. The grass wedge is used to monitor farm cover (target 170 kg DM/cow) and identify emerging surpluses and deficits. Target post-grazing height is 4.0-4.5 cm. Concentrates balance feed deficits up to 5 kg DM/day, above which extra forage is needed.

Autumn budgets

Building autumn grass covers to >1,100 kg DM/ha presents problems in an autumn calving herd. Firstly, heavy pre-grazing yields will not be well utilised by freshly calved cows. Autumn grass is high in nitrogen but has relatively low energy content so supplements will be required reducing the value of 'banked' grass. Based on results from the Johnstown herd and on-farm experience, a peak cover of 850 to 900 kg DM/ha is suggested (Figure 2) for herds with >40% autumn calving. Grass surpluses are removed until mid-August. Lower peak covers in September result in grazing being complete by early November, but this is offset by earlier turnout in spring. Herds with a lower proportion of autumn calving can delay start of calving until mid-October and build autumn grass as standard.

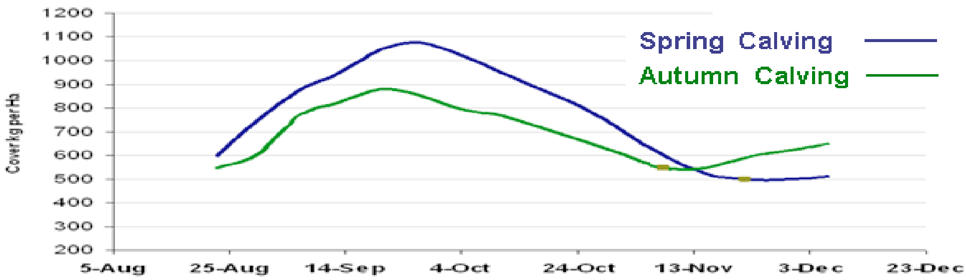

Figure 2. *Autumn grass cover guidelines for spring and autumn calving herds*

Conclusions

Feeding the milking herd indoors is a significant structural cost for winter milk systems, however significant benefits can be gained by implementing correct grazing management at key times of the year. Balancing early spring demand and reducing peak autumn covers are important adjustments to grazing protocols for autumn calving herds.

NEXT GENERATION BREEDING AND REPRODUCTION

Teagasc's Next Generation dairy herd - proofing the EBI

Frank Buckley, Sinead McParland and Morgan O'Sullivan

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Summary

- The establishment of a *Next Generation Herd* represents a futuristic national herd, and is a strategically important resource providing a "forward view" of the performance implications of high EBI herds under varying grazing strategies
- The *Next Generation Herd* will allow the impact of selection for EBI on traits not currently included in the EBI to be quantified
- Early results are extremely promising. Performance differences are in line with expectation based on EBI. Thus, the EBI is delivering more profitable dairy genetics

Introduction

The goal of the EBI Is to identify animals whose progeny will be most profitable under future Irish production systems. Analysis of commercial farm data indicated that each €1 increase in herd EBI results in a €2 increase in profit per cow per lactation. The incorporation of Genomic Selection into the national breeding programme since 2009 increased the theoretical rate of increase in EBI to €38 per cow per year. The *Next Generation Herd* was established as a strategic resource to validate that genetic selection using the EBI will deliver under intensive grass based systems. It will also enhance the future development of the EBI, and provide a potential nucleus herd to supply young bulls into the national breeding programme.

The study

The *Next Generation Herd* was assembled during 2012. Maiden heifers, in-calf heifers, and heifer calves were sourced from commercial dairy herds and from within Teagasc dairy herds. Before purchase, all animals were subjected to genomic testing and rigorous health screening. The first animals (all parity 1) calved in the spring of 2013, and an additional 33% parity 1 cows were introduced in 2014. There are two distinct EBI groups; 90 ELITE (extremely high EBI; €249) and 45 national average (NA) EBI (NA; €133 EBI) females. The herd is exclusively Holstein-Friesian and genetic diversity (sire lines) has been maximised. Of the 90 ELITE heifers assembled in 2012, 40 sires, 83 paternal grandsires and 27 maternal-grandsires are represented. The ELITE females are firmly inside the top 1% in the country based on EBI.

Table 1. Summary statistics of the Next Generation Herd

	EBI	Sub-Indices (€)						
		Milk	Fertility	Calving	Beef	Maintenance	Health	Management
ELITE	249	69	142	35	12	12	0	3
NA	133	49	65	25	9	2	0	1

	Milk kg	Fat kg	Protein kg	Calving interval days	Survival %
ELITE	+98	+12.5	+9.8	-7.8	+3.7
NA	+166	+9.3	+8.2	-4.0	+1.2

The two EBI groups are being evaluated across three seasonal pasture-based systems. The three systems are: 1) intensive grazing; CONTROL, 2) high stocking rate with tighter grazing residuals; LGA, and 3) intensive grazing with additional concentrate feed (+4 kg daily) offered throughout lactation; HC.

Preliminary results

The NA cows had a greater milk volume yield compared with the ELITE, whereas the ELITE cows had significantly greater milk fat and protein concentrations and yield of milk solids (fat + protein yield). Somatic cell count was not different. To date, neither response to concentrate supplementation nor response to restricted grazing differed between the two EBI groups. On average, the NA cows were numerically heavier (+7 kg) but had lower body condition score (-0.17) compared to the ELITE cows (Table 2). The difference in condition score was consistent throughout lactation (Figure 1). Large differences in fertility performance were observed. The three week submission rate, pregnancy rate to first service, six week in-calf rate and final in-calf rate averaged 95%, 60%, 71% and 90% for the ELITE, and 89%, 47%, 55% and 76% for the NA cows, respectively.

Table 2. EBI group effect on lactation performance

	ELITE	NA
Milk yield (kg/cow)	4,852	5,029
Fat (g/kg)	45.1	42.3
Fat (kg)	218	212
Protein (g/kg)	36.9	35.2
Protein (kg)	179	178
Solids corrected milk yield (kg/cow)	4,984	4,958
Somatic cell count (‘000 cells/ml)	132	147
Milk receipts (30 c/l)	1,665	1,631
Average body condition score (1-5)	2.94	2.77
Average weight (kg)	486	493

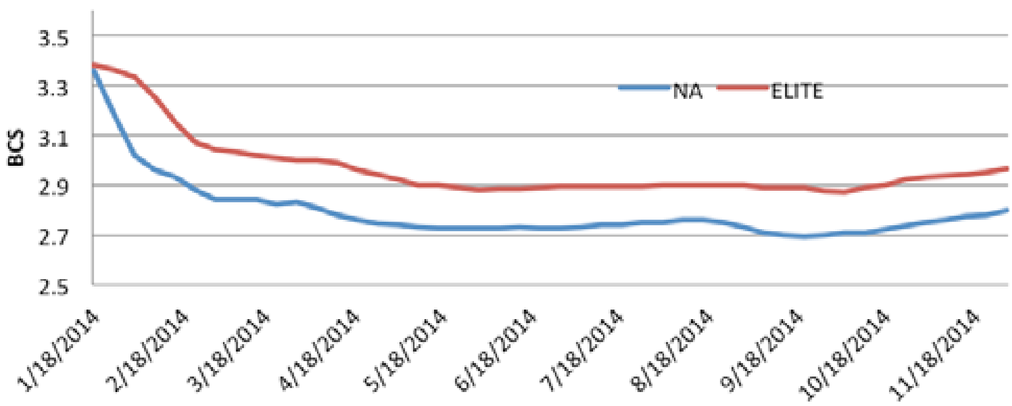

Figure 1. *Body condition score profile for ELITE and National Average EBI cows*

NEXTGEN GS sires

A secondary objective of the *Next Generation Herd* is to make the very highest EBI bull calves born available to the Irish AI industry. So far, seven young GS bull calves (two in 2014 and five in 2015) have been recruited by Irish AI companies. 'NEXTGEN Brigade' (AI code FR2007), with an EBI of €375, is one of the top GS sires available in 2015.

Conclusions to-date

The preliminary results indicate that the EBI is working to identify more profitable dairy genetics, and demonstrate performance differences in line with expectation based on EBI. Hence, the EBI is equally relevant now in the post-quota era as before. Irish dairy farmers must now continue the genetic progress that has been made to date. A herd fertility sub-index of €140 should be the targeted to achieve the necessary herd fertility and longevity targets.

Crossbreeding to increase profit

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Summary

- Our most recent research conducted at Curtin's Research Farm and using commercial farm data have reaffirmed the considerable performance and profit advantage highlighted by the earlier research on Jersey and Norwegian Red crossbreds
- Jersey crossbred cows yielded 78 kg more milk solids per ha per lactation compared to Holstein-Friesian cows, where both breed groups were stocked at a similar live weight/ha
- Heterosis estimates for first cross Jersey crossbred cows were +25 kg of milk solids (fat + protein kg), -7.5 days in calving interval, and +3.5% survival, equating to almost €200 per cow per lactation more profit above the performance expected based on EBI alone
- Heterosis estimates must be considered when making sire selection decisions. Heterosis alone, however, will not guarantee success in a crossbreeding programme. The key must be to utilise the best available genetics (high EBI) to maximise the benefit and ensure genetic improvement

Fundamentals of crossbreeding

The two primary reasons to crossbreed are: 1) introduce favourable gene variants from another breed selected more strongly for traits of interest, and 2) to capitalise on what is known as heterosis or hybrid vigour. The first point relates to additive genetic differences between breeds (e.g., breed differences in milk yield, milk composition, size, beef merit, fertility, mastitis resistance, intake capacity and feed efficiency). Heterosis refers to the phenomenon that occurs when an animal is heterozygous (different) at a particular locus (gene), resulting in synergies that allow crossbred animals to perform better for certain traits than that expected based on the average of their parents. Additive genetic differences must be considered, however, and becomes particularly relevant after the first cross. A major portion of the ultimate success of crossbreeding will come from additive genetic merit for different traits that bulls and cows transmit to their offspring (long term genetic gain). Heterosis alone will not guarantee success in a crossbreeding programme.

Estimates of heterosis vary in magnitude depending on the trait being examined, and the genetic distance between the breeds being crossed. Heterosis for production traits such as milk yield or liveweight/growth rate is usually in the range 0 to 5%, whereas heterosis for traits related to fertility is usually in the range 5 to 25%. Milk composition is generally not influenced by heterosis, and therefore improvements in solids yield is due to the influence on milk volume. Heterosis will generally be higher in traits related to fitness and health i.e. traits that have lower heritabilities. In New Zealand, crossbred cows (Jersey × Friesian) survive 227 days longer (almost one lactation more) compared to the average of the parent breeds. This equates to almost 20% hybrid vigour.

Summary of most recent research results from Moorepark

The performance data generated at Ballydague (Jersey) and on the large on-farm study (Norwegian Red) demonstrated that crossbred dairy cows were capable of production levels per cow that were at least similar to their Holstein-Friesian contemporaries on low cost systems. Fertility, survival and profit, however, were considerably improved for crossbred cows. Since 2013, Jersey crossbred cows have been incorporated into the intensive grass based systems study alongside high EBI Holstein-Friesian cows at Curtin's Research Farm. Within three stocking rate treatments, both the Holstein-Friesian and Jersey crossbred cows are stocked at equivalent live weight per ha. Averaged across the first two years, 2013 and 2014, the crossbred cows have produced 78 kg (6%) higher milk solids yield per ha compared to their high EBI Holstein-Friesian contemporaries.

Recent research using performance data from 40 commercial dairy herds engaged in long-term crossbreeding found that F1 Jersey × Holstein-Friesian cows produced +25 kg of milk solids (fat + protein kg), had -7.5 days shorter calving intervals, and had 3.5% higher survival rates compared with the mean of the 'purebred' Jersey and Holstein-Friesian cows. This corresponds to a considerable profit increase of (economic heterosis) €200 per lactation.

Sire selection decisions

When selecting non-Holstein-Friesian sires, the first and most important thing to remember is that you continue to use high EBI sires. Based on the research findings, using a Jersey AI sire with an EBI of €250 will result in progeny with an increased profit per lactation of €450 (i.e., €250 from the direct genetic effect, plus another €200 from heterosis. Hence, to be comparable in terms of profit a Holstein-Friesian sire needs to have an EBI of €450 to be considered superior to a Jersey sire with an EBI value of €250. Conversely, using a Jersey sire with an EBI of €100 will only return an additional profit of €300 when mated to Holstein-Friesian cows, which is less than many of the top Holstein-Frisian sires available. Hence, the importance of additive genetic gain must be borne in mind. Otherwise, the benefits of cross-breeding will be negated by the use of inferior sires. First crosses tend to tick all the boxes: they display full hybrid vigour, good production, excellent fertility and tend to be uniform in appearance (colour, size etc). For traits displaying a lot of heterosis (e.g., fertility and longevity), performance in subsequent generation may decline. This depends on the additive genetic contribution of the follow-on sires selected. A common question among dairy farmers considering crossbreeding is "where to after the first cross?" The three most common breeding strategies are as follows:

- Two-way crossbreeding. This entails mating the F1 cow to a high EBI sire of one of the parent breeds used initially. In the short term heterosis will be reduced but over time settles down at 66.6%.
- Three way crossing. Uses high EBI sires of a third breed. When the F1 cow is mated to a sire of a third breed heterosis is maintained at 100%. However, with the reintroduction of sires from the same three breeds again in subsequent generations, the heterosis levels out at 85.7%.
- Synthetic crossing. This involves the use of high EBI crossbred bulls. In the long term a new (synthetic) breed is produced. Heterosis in this strategy is reduced to 50% initially and is reduced gradually with time.

Conclusions

Crossbreeding must make an even greater contribution on Irish dairy farms in the future than it currently does. This is especially important in light of current drive by the industry to maximise output and profit per ha and reduce costs. While crossbreeding is not for everyone, it is very clear from the research at Moorepark that crossbreeding in the dairy herd can very quickly improve traits such as fertility and productivity, and thus has favourable effect on profit generating ability.

Futuristic traits for inclusion in the EBI

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Summary

- A breeding profit index such as the EBI should include all heritable traits that will affect profit in the future
- Product quality and feed efficiency are currently not explicitly included in the EBI; animal health and disease resistance is poorly represented in the EBI
- Genetic variation is known to exist for all these traits, and data are now being routinely generated for these traits

Introduction

The EBI of an animal is the average expected profit per lactation of its daughters. The daughters of a bull with an EBI of €400 are therefore expected to, on average, be €100 more profitable per lactation than the daughters of a bull with an EBI of €300. The assumptions underpinning the EBI were changed in 2007 to account for the impending abolition of milk quotas in 2015. Any breeding index must 1) include all traits affecting farm profit; and 2) be futuristic in identifying the traits of importance. The three suites of traits either not explicitly considered or poorly represented in the EBI are: 1) milk quality; 2) feed efficiency; and 3) health and disease.

Milk quality

Ireland exports the vast majority of its dairy products, and hence supplying consistently high quality dairy products is vital to ensure sustainable market growth. Because breeding is cumulative and permanent, breeding programs are a logical approach to ensure a consistent high-quality product. The EBI favours animals with greater milk fat and protein concentrations. However, no consideration is given to the individual fatty acids or groups of fatty acids in milk, nor is consideration given to the milk casein and whey fractions or even the individual proteins. Milk technological properties such as rennet coagulation time, curd firming time, curd firmness, heat coagulating time, pH and casein micelle size are important determinants of cheese yield. Research at Moorepark has clearly shown the ability to predict some of these milk characteristics using infrared spectroscopy. Infrared spectroscopy is currently used to predict milk fat, protein and lactose concentrations in milk. Therefore prediction equations using the infrared spectrum can be developed for other milk quality measures, and can be immediately exploited at negligible cost. Considerable genetic variation has also been demonstrated for these traits with average heritability estimates across many studies varying from 0.20 to 0.36. A survey of Irish stakeholders representing farmers, milk processors, advisors, and researchers indicated positive attitudes to including these milk quality traits in future iterations of the EBI. In fact, stakeholders interviewed as part of the survey, cited a preferred relative emphasis on milk quality traits within the EBI as high as 6%.

Feed efficiency

Land, or quantity of feed grown, is the limiting factor on most dairy farms. Furthermore, feed constitutes the majority of the total costs on most Irish dairy farms. Thus, improving milk value output per unit feed intake without any repercussions on other animal characteristics is of growing interest. Feed efficiency is already largely accounted for within the EBI through the simultaneous inclusion of both milk solids output and cow live-weight as a proxy for cow maintenance requirements. Calving interval and survival are also major components of feed efficiency. Previous research has shown that considerable differences in feed intake exist among cows even at the same yield and live-weight. Approximately

11% of this variability is due to genetic differences. Figure 1 illustrates the mean net energy intake of daughters of Holstein-Friesian sires, and the variability in energy intake of daughters of sires after accounting for differences in the live-weight and milk energy yield of the daughters; therefore it may be assumed that all cows weighed the same and yielded the same amount of milk energy. The extent of the variability that exists can be illustrated from the daughters of two sires (10 and 13 daughter records each) from the Moorepark feed intake database. The mean live-weight (516 kg v 521 kg) and body condition score (2.9 v 3.0 units) of the progeny groups was similar, but the daughter of the most efficient sire consumed less (13.1 UFL/day) than the daughters of the less efficient sire (17.1 UFL/day). Both daughter groups produced similar milk energy yield albeit the daughters of the most efficient sire produced slightly more energy in the milk. Comparison of the extreme 10% of sires on efficiency reveals a difference of 3.0 UFL/day. Assuming a cost of 7.8 cents/UFL, this equates to €469.76 saving over 5.5 lactations or €85 million annually per million cows.

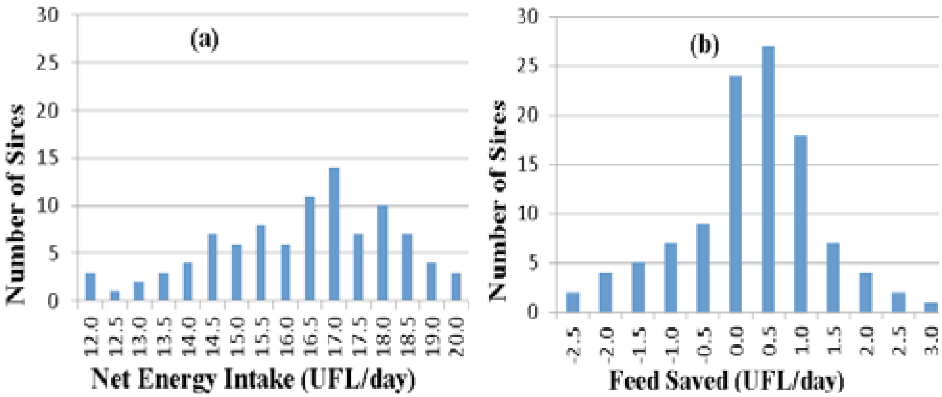

Figure 1. *(a) The mean net energy intake of paternal half-sib daughters and (b) the mean net energy intake of these daughters at the same live-weight, body condition score, live-weight change and milk energy production*

Animal health and disease

Selection on EBI is improving fertility and evidence from the *Next Generation Herd* clearly shows that optimal reproductive performance is achievable once the fertility sub-index is approximately €140. Although the national herd is several years off achieving this target, it is likely that animal health will be "the next fertility" and will hinder cows achieving their full genetic potential for milk solids production. Considerable genetic variation exists in a range of different health and disease traits. Udder health and lameness are both currently included in the EBI although the lack of data from farmers preclude achieving high accuracy of selection for these traits. Careful examination of current high EBI sire lines suggests that future genetic trends in both lameness and mastitis may be unfavourable thereby substantiating the necessity to generate accurate estimates of genetic merit for a range of health traits and immediately include them in the EBI to halt any unfavourable trends.

Conclusions

The EBI reflects future profit, and therefore will evolve both in terms of traits that are included in the EBI as well as the relative emphasis placed on each trait to reflect future market dynamics.

Mid-infrared red technology to routinely predict milk quality and animal characteristics

Sinead McParland[1], Audrey McDermott[1,2], Giulio Visentin[1,2], Massimo de Marchi[2] and Donagh Berry[1]

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Summary

- Mid-infrared spectroscopy (MIR) analysis of milk is the method used by milk recording companies to quantify milk fat, protein and lactose concentrations
- Algorithms have been developed to predict detailed milk quality attributes and animal characteristics from this MIR
- Considerable exploitable variability in these characteristics (of which some is genetic) exists among Irish dairy cows

Introduction

Mid-infrared spectroscopy (MIR) analysis of milk is the study of the interaction between matter and radiated energy in the infra-red region of the electromagnetic spectrum. Mid-infrared spectroscopic analysis of milk samples is the method chosen internationally for the quantification of milk composition, especially fat, protein and lactose concentrations. A total of 565,077 Irish cows were milk recorded on several occasions in 2014. The milk samples of all these cows were subjected to MIR analysis. If MIR could be used to quantify other useful milk quality characteristics, then these measures of milk quality could be routinely generated on a large population of Irish dairy cows. Moreover, because the milk characteristics in a sample could reflect the physiological state of the cow, it is plausible that milk MIR analysis could also be used to predict cow characteristics such as energy balance or feed intake.

Milk quality

Milk quality measures currently evaluated on all milk recorded cows include milk fat, protein and lactose concentrations; some also record milk casein fraction. Ireland's reliance on export markets, as well as its reputation for high quality and safe products, places an even greater importance on milk quality characteristics. For example, the average milk fat of a dairy cow contains 70% saturated fatty acids, 25% mono-unsaturated fatty acids and 5% polyunsaturated fatty acids. Currently dairy products provide 15 to 25% of the fat consumption in the average human diet, but this represents 25 to 35% of the saturated fat intake. A recent international research project with Moorepark involvement has documented the ability of MIR analysis of milk to predict milk fatty acid content. Considerable variability among cows exists in fatty acid composition. For example, the saturated fatty acid concentration in milk from animals in the Moorepark *Next Generation Herd* varied from 58% to 72%. The heritability of the saturated fatty acid content of milk is 0.24, implying that 24% of the variability among cows in milk saturated fatty acid content is genetically determined. Figure 1 illustrates the MIR-predicted milk saturated fatty acid content of the elite EBI and national average EBI animals in the Moorepark *Next Generation Herd*. The milk saturated fatty acid concentration of the elite EBI cows was greater.

Recent Moorepark research has also highlighted the ability of the milk MIR to predict other milk characteristics related to the milk nutrient content and milk processing characteristics. Such attributes include detailed protein fractions, heat stability, and coagulation properties.

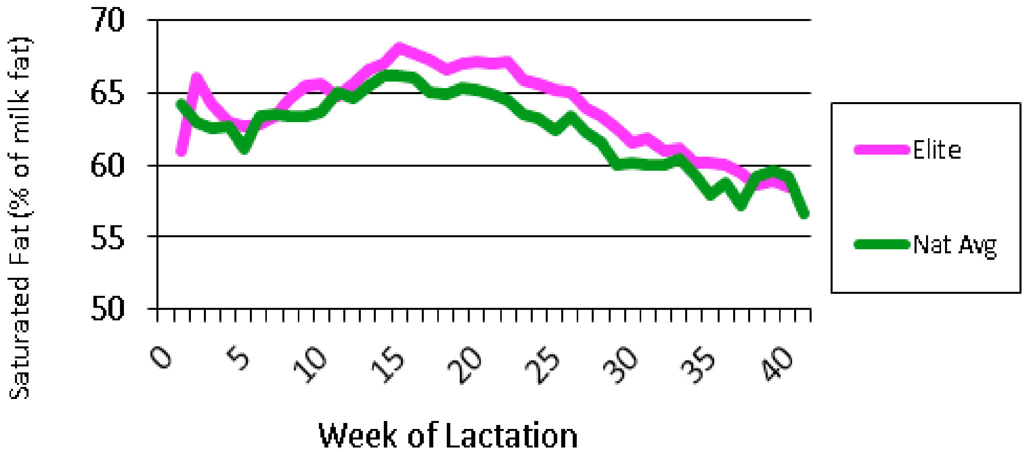

Figure 1. *Saturated fat lactation profile of elite and national average cows in the Next Generation Herd research trial predicted using MIR*

Animal characteristics

Milk composition is related to the physiological state of a cow. Fat to protein ratio is often cited as an indicator of energy balance status of a cow, although research from Moorepark has failed to support such a relationship. Nonetheless, both milk fat and protein concentration are predicted from milk MIR. Similarly, milk fatty acid content and milk acetone concentration have both been proposed as indicators of cow energy status. Both milk acetone and milk fatty acid concentration can be predicted by milk MIR. Recent research at Moorepark proposed predicting energy intake and energy balance directly from the MIR. The accuracy of predicting energy intake and energy balance was up to 0.80 and 0.69, respectively. Preliminary research in INRA in France has also confirmed the ability of milk MIR to predict energy balance.

The heritability of true energy balance and MIR-predicted energy balance was 0.16 and 0.10, respectively. The heritability of true and predicted feed intake was 0.35 and 0.20, respectively. Therefore, exploitable genetic variation in both energy balance and feed intake does exist. Because the predictions are based on milk MIR, measures of cow energy balance could be made available at negligible additional cost for all milk recorded cows. Such information could be useful for day-to-day herd management, but could also be used in the national breeding program to identify cows that maintain more favourable energy balance status. As a test of the efficacy of MIR for use in genetic evaluations, a recent cohort of Moorepark cows were stratified as divergent in genetic merit for feed intake from their MIR data. The cows genetically predisposed to greater feed intake had 5% greater dry matter intake than the cows of average genetic merit for feed intake.

Conclusions

Milk MIR data is available on over 0.5 million milk recorded cows annually in Ireland. Currently, the milk MIR is used to predict milk fat, protein and lactose concentrations, but the tools now exist to predict other milk quality attributes and animal characteristics from the MIR. Because the necessary MIR data is already generated, these new traits could be generated nationally for all milk recorded cows at negligible additional cost.

Breeding healthier cows

Tara Carthy[1], Eoghan O'Brien[1], Noel Byrne[1], Riona Sayers[1], Mary Cooke[2], Brian Kirkpatrick[2] and Donagh Berry[1]

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Summary

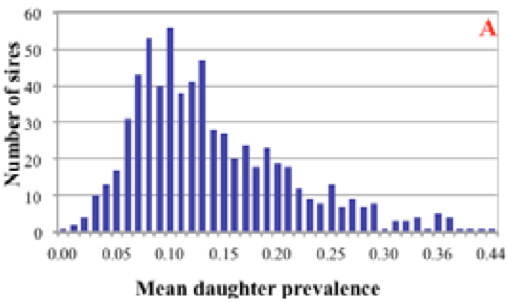
- Considerable exploitable variability exists among sire progeny groups in a range of different health and disease traits
- Genetic evaluations for health traits are being developed in Ireland to identify sires whose daughters are less predisposed to health issues
- Incorporation of health traits in the EBI will facilitate the breeding of healthier, more profitable animals

Introduction

Significant advancements in herd health status have been achieved through a combination of management practices, biosecurity awareness and national control programs. Genetic improvement is both cumulative and permanent and is well known to have contributed to gains in milk production and reproductive performance. As reproductive performance improves with selection on the EBI, the next limiting factor to achieving the genetic potential for milk production is likely to be animal health. Breeding for improved animal health, however, requires genetic variability in animal health.

Genetic variability exists in a range of health traits

Exploitable genetic variability exists for common health traits. Several studies have documented large differences in the prevalence of disease among sire families; some sires' daughters have little or no prevalence of disease while other sires have a high proportion of their daughters exhibiting disease symptoms. This means that some sires are more likely to produce daughters that have a greater incidence of health problems, thereby increasing veterinary costs and reducing milk production, culminating in reduced profits. Based on sires that had >50 daughters in >20 herds, the percentage of daughters that experienced mastitis ranged between 0 and 44% while the percentage of daughters that experienced lameness ranged from 0 and 40% (Figure 1).



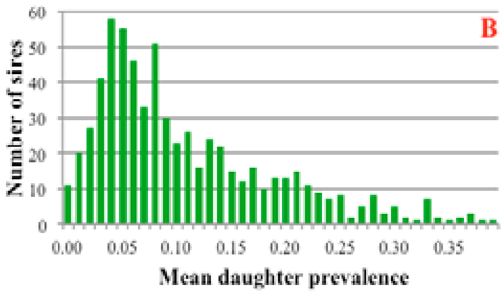


Figure 1. *Mean daughter prevalence of mastitis (A) and lameness (B) per sire family*

Furthermore, sires with the greatest prevalence of mastitis and lameness had the worst (i.e., higher) corresponding genetic merit as estimated by the ICBF (Figure 2). Therefore, potential exists to breed superior genetics or avoid the inclusion of inferior genetic merit sires in the national breeding program.

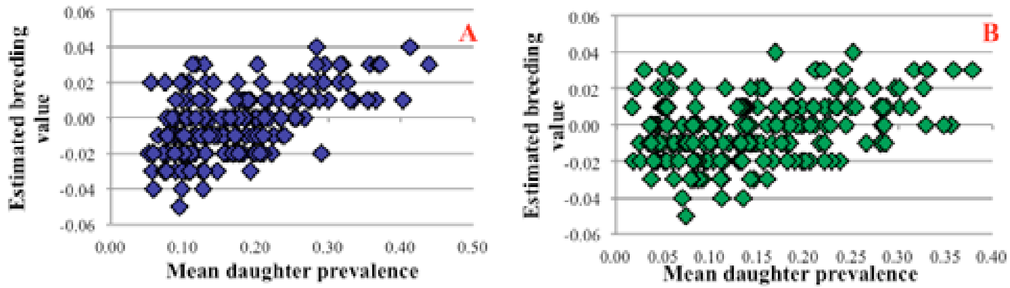


Figure 2. *Sire estimated breeding value and the corresponding mean daughter prevalence of mastitis (A) and lameness (B)*

HealthyGenes

As part of the Research Stimulus Project "HealthyGenes", common health and disease traits are being recorded on over 10,000 cows. This project will provide a better understanding of national incidences as well as provide information to generate genetic evaluations for these health traits. Information on traits such as mastitis, lameness, liver-fluke, uterine health status, body condition score (BCS) and a range of different infectious diseases are currently being compiled. Results to date revealed that 12.9% of cows had a BCS ≤ 2.50, below the minimum recommended BCS of 2.75 at breeding. A total of 3.4% of cows had a locomotion score ≥ 2 (i.e., obvious signs of lameness), but considerable prevalence differences existed among sires. For example, none of the 81 daughters of one sire in several herds showed any signs of lameness, whereas 22% of the 23 daughters of another sire also in several herds had obvious signs of lameness. Ultrasound examination of the reproductive tract revealed that 12.7% of the calved cows were not cycling at the time of ultrasound examination at the start of the breeding season, 2.5% had ovarian cysts, and 13.2% had evidence of uterine infection. These statistics also varied greatly among sires. None of the 65 daughter of one sire in several herds were identified with ovarian cysts while 14% of the 21 daughters of another sire also in several herds had ovarian cysts.

Experience from the US

Currently the only health trait incorporated in the US net merit index (EBI equivalent) is somatic cell score. Measurement of this trait is part of the voluntary dairy data recording system in the US, and consequently the availability of millions of records makes its inclusion feasible. Efforts are underway to expand the recording and collection of health data so that other health traits could be included in the calculation of net merit. Recognising that some health traits will be more difficult to evaluate using field data, national research funding has been directed towards evaluation of genetics of susceptibility to disease in more intensive studies with the objective of identifying specific genetic variants. Two such projects relevant to the US dairy cattle population target bovine respiratory disease and Johne's disease or paratuberculosis. The intent is to incorporate genetic marker information resulting from these studies directly into the net merit calculation, supplementing information from the dairy data recording system.

Conclusion

The EBI is continuously evolving to ensure it reflects the most relevant issues to the Irish dairy industry. Possible expansion of the current health index to include other health and disease traits has the potential to complement management practices and national control/eradication programs to produce healthier more robust cows.

Genomic selection is delivering genetic gain in profit

Michelle Judge[1], Noirin McHugh[1], Sinead McParland[1], Francis Kearney[2] and Donagh Berry[1]
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Summary
- Almost 60% of dairy semen used in 2014 was from genomically tested sires
- Retrospective analysis of the performance of genomic bulls since their sale in 2009 reveals that the incorporation of genomic (i.e. DNA) information into the genetic evaluations improved accuracy by up to 54%
- Genomic selection in Ireland does not, on average, over-estimate EBI

Introduction
Genomic selection is the incorporation of DNA information into national genetic evaluations to more accurately identify the genetically superior candidate parents of the next generation. Genomic selection is now the method of choice in most national dairy cow genetic evaluations. As yet, however, genomic evaluations are not official in New Zealand.

Genomic selection in Ireland
Genomic selection was launched in Ireland in February 2009. The number of animals in the training population to estimate the optimal DNA profile for Ireland was less than 1,000 in the year 2009 but is now over five times greater (Figure 1); the end result is greater reliability of genetic evaluations. The proportion of dairy semen originating from genomically tested sires is increasing year-on-year; 59% of dairy AI semen sold in Ireland in 2014 was from genomically tested sires (Figure 1). This statistic is relatively consistent with trends in most countries (e.g., US, France, Netherlands) although usage in Ireland is greater than in both New Zealand (~25%) and the UK (~30%) but lower than in Nordic countries (~80%).

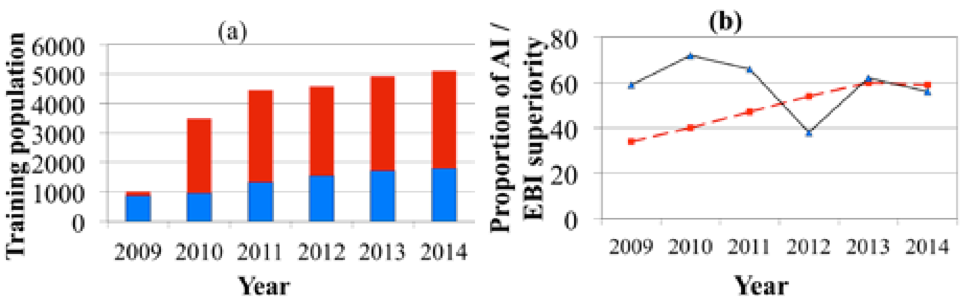

Figure 1. *(a) Number of animals in the training population generated in Ireland (blue bars) or from bilateral sharing (red bars) and (b) proportion of semen sales from genomically tested sires (broken line) and genetic superiority (€) of used genomically tested sires relative to used proven bulls (continuous line)*

Sufficient data now exists to evaluate how accurately historical genomic predictions reflect the current genetic evaluations of bulls based on daughter proofs. Genomics did not, on average, over-estimate the EBI of bulls (Table 1) as is often documented in other populations (e.g., New Zealand). Moreover, genomics was up to 54% more accurate in ranking bulls compared to the traditional method of genetic evaluation based on pedigree index (Table 1). Additionally, the fluctuations in individual bulls from their original genomic evaluation as young bulls was generally small with most varying by ≤€15 for the milk subindex and ≤€15 for the fertility subindex. The reliability of genomcially tested sires is still not 100%, and thus risk should be minimised by always using a team of at least four to five genomically tested bulls. Bulls without a calving proof from actual calving events should not be used on heifers.

Table 1. Mean (reliability) daughter-based PTAs from the most recent genetic evaluation as well as past parental average (PA) or genomic-based PTAs; also included is the correlation with the most recent daughter PTA for both PA and genomic PTAs

Trait	Mean			Correlations	
	PA	Genomic	Daughter	PA	Genomic
Milk (kg)	168 (41)	108 (61)	116 (90)	0.71	0.79
Fat (kg)	11.9	10.2	10.4	0.55	0.7
Protein (kg)	9.6	7.7	7.8	0.63	0.75
Calving interval (days)	-3.1 (30)	-3.7 (46)	-4.5 (71)	0.6	0.63
Survival (%)	1.52	1.7	2.01	0.41	0.63

Other uses of DNA-based technologies in dairy cattle breeding

1. *Major genes:* Genetic mutations that can result in conception failure, embryo/foetal death or periparturient mortality include CVM, BLAD, DUMPS and Brachyspina; the frequency of carriers of these lethal mutations in the Irish Holstein-Friesian population is 2.28%, 0.00%, 0.53% and 1.75%, respectively. All AI bulls are screened for these mutations and carriers do not enter AI. Although low frequency, carriers in the commercial population do exist and are contributing to reduced reproductive performance. There is a 25% chance that a mating of two carriers will result in pregnancy failure. Interest is also increasing in the A1-A2 beta casein genotype. Of the Irish Holstein-Friesian cattle genotyped, the frequency of animals with the A1A1, A1A2 and A2A2 variants of beta-casein were 14%, 45% and 41%, respectively.
2. *Parentage:* Accurate pedigree is vital to increasing genetic gain and reducing inbreeding. Parentage errors in Ireland are approximately 8.5%. Where incorrect parentage exists, the DNA can be used to assign the true parents.
3. *Breed composition:* The breed composition of an individual from at least one crossbred parent cannot be known with certainly other than through examination of the DNA. Knowledge of breed composition might be of interest in crossbreeding strategies to maximise the benefit of heterosis by availing of information on the actual breed composition of the cow.
4. *Precision mating:* Selecting a sire with a complimentary DNA profile to that of a dam could result in a more genetically elite individual while minimising inbreeding. More precise sire mating advice can therefore be generated if the DNA of both potential mates is known.

Across-breed genomic predictions

Accurate genomic evaluations require both DNA and performance records on several thousand animals from each breed for which the genomic evaluations are required. DNA information and phenotypes from several thousand milk recorded crossbred Jersey cows has recently been collected with a view to generating genomic evaluations for Jerseys.

Conclusions

Genomic selection is leading to increased genetic gain in profit (i.e. EBI) by more accurate identification of genetically elite males and females. New DNA technologies will further increase the gains achievable.

Beef bulls for use in the dairy herd

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Summary

- Easy calving, short gestation bulls that produce vigorous healthy calves with a good sale value are desirable - such bulls do exist
- Sires with high genetic merit for gestation length (i.e., shorter) subsequently produce calves after a shorter gestation but with similar sale value
- A dairy-beef index to identify beef bulls suitable for use in the dairy herd is being developed

Introduction

With the abolition of milk quota and the advancements in sexed semen technologies, the identification of suitable beef bulls will become increasingly important for Irish dairy farmers to further increase farm profit. The main traits of interest to dairy farmers are calving difficulty, gestation length, calf mortality and vitality, and calf price.

Can we select for short gestation bulls?

Genetic merit for gestation length is currently included in both the EBI and the beef breeding indexes. A question commonly asked is if genetic differences among sires for gestation length translate into differences in gestation length of their calves? To test this, the genetic merit for gestation length from both dairy (Holstein and Friesian) and beef (Angus, Belgian Blue, Hereford, Limousin, and Charolais) AI sires mated to Holstein-Friesian cows of second lactation or greater from the year 2010 to 2014 were evaluated. Sire genetic merit for gestation length was based on the genetic evaluation from April 2010. The sires had to have at least 25 calves born in at least 10 different herds from 2011 to present.

Calves born from sires genetically predisposed to shorter gestation length had significantly shorter gestation length compared to calves born from sires genetically predisposed to longer gestation length (Table 1). Calves from the sires in the top 10% for gestation length within each breed based on genetic merit were born earlier than the worst 10% of sires in each breed for gestation length (Table 1). In fact, comparing the extreme groups, a one day difference in genetic merit for gestation length based the ICBF published figures was associated with a corresponding 0.96 day difference in actual gestation length in the field. No statistical difference existed between the two extreme gestation length groups in the incidence of stillbirth, calving difficulty or eventual calf price (Table 1).

Table 1. Differences in gestation length, stillbirths, calving difficulty and calf price for sires differing in genetic merit for gestation length

Group	Gestation PTA (days)	Gestation length (days)	Stillbirth (Percent)	Calv difficulty (1-4)	Calf Price (€)
Short gestation	-1.70	282.3	0.07	1.19	276
Long gestation	0.56	284.5	0.08	1.25	277

As much variation exists within breeds as between breeds

Holstein-Friesian sires have, on average, a shorter gestation length than beef breeds. The gestation length of some individual Holstein-Friesian bulls is longer than some individual beef bulls, however, highlighting the large within breed differences that exist (Fig 1). Continental breed beef sires have, on average, the longest gestation length (Fig 1). Nonetheless, Figure 1 clearly illustrates that considerable within-breed variability exists. For example some Belgian Blue sires have a shorter gestation than some Angus bulls. Therefore, if selecting sires for short gestation it is important to select them based on their genetic merit.

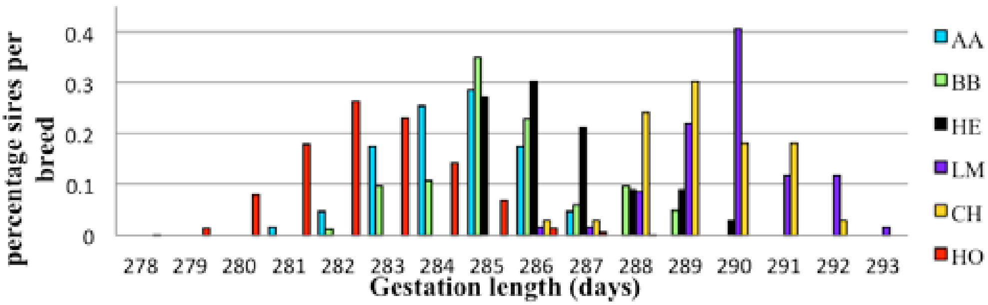

Figure 1. *The proportion of sires within breed (AA = Angus, BB = Belgian Blue, HE = Hereford, LM = Limousin, and CH = Charolais) differing in actual gestation length*

The value of short gestation

The gestation length of calves of beef bulls in the extreme top and bottom 10% in genetic merit for gestation length was compared; each breed was represented in the extremes. Cows bred to the short gestation beef bulls calved 2.18 days earlier than cows bred to the long gestation bulls; this is very close to the expectation of 2.26 days based on genetic merit. Based on the economic value for gestation length in the EBI this equates to a value of €16.35 per cow or €1,635 for a 100 cow herd. Ignoring breeds, the difference between the two extremes for gestation length in beef bulls available in Ireland with greater than 70% reliability for gestation is 10.9 days. Even within the Angus breed, a 7.5 day gestation length difference exists between the extreme bulls; this is worth €5,625 per 100 calvings.

Dairy beef index

The objective of the Dairy-Beef index is to identify suitable beef bulls for use in dairy cows to generate valuable calves but without adversely impacting the cow herself. The proposed traits within this index are calving difficulty, calf mortality, gestation length, and calf price. Calving difficulty accounts for costs associated with labour, a dead or barren cow, loss in milk and reduced cow reproductive success. Gestation length accounts for costs associated with loss in milk sales, the change in the feed budget and the impact on subsequent cow fertility. Calf mortality accounts for opportunity costs associated with the loss of a calf as well as disposal costs. Calf price is based on mart prices at approximately 28 days of age.

Conclusion

Selecting sires for shorter gestation based on the genetic merit will result in cows that will calve down earlier, therefore increasing days in milk. No differences in calving difficulty or stillbirth existed between short gestation and long gestation sires.

Identifying more profitable dairy cows using the new COW index

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Summary

- The Economic Breeding Index (EBI) identifies animals, both males and females, of superior additive genetic potential, i.e., likely to breed the most profitable next generation
- The Cow Own Worth (COW) was developed as a ranking tool to supplement the existing EBI
- Cows expressing favourable non-additive genetic effects (i.e., heterosis) as well as favourable environmental effects (e.g., calving at the optimal time of the year) should be ranked higher, as they will generate more profit in the remainder of their lifetime

Introduction

Culling can have a significant impact on profit from the dairy herd. Excessive culling results in increased costs being incurred to generate the necessary replacements, but also lost productivity and profit where the age profile of the herd is reduced as a result of lower production capacity from first lactation cows compared with their mature herd mates. On the other hand, delayed culling results in under-performing cows remaining in the herd while incurring opportunity costs by foregoing genetic gain and associated superior productive capacity from genetically superior replacement females. The economic breeding index (EBI) is a tool to identify superior parents of the next generation, whose progeny will be more profitable based on additive genetic makeup (i.e., genetic superiority directly passed on from the parents). However, no consideration is given in the EBI to other factors intrinsic to the maximisation of profit by maintaining optimal herd dynamics. For example, the EBI does not incorporate the contribution to performance of non-additive genetic effects. If a cow is crossbred, the added performance due to expression of hybrid vigour (heterosis) is not accounted for. In addition, non-genetic effects (i.e., environmental) that directly impact upon individual cow profit potential in the short to medium term such as calving date or expected future calving date, age or lactation number, or other environmental factors that can have a lasting impact on individual cow performance (referred to as permanent environmental effects) are not accounted for in the EBI. The EBI is therefore not optimal for ranking dairy females on expected remaining lifetime profitability, or optimising culling decisions for the more immediate term. This was the motivation for the development of the Cow Own Worth (COW) index. The COW index, which is expected to be launched by ICBF in the near future, will supplement the EBI in aiding decisions around the retention or culling of surplus females. The EBI is used to identify the most profitable animals for breeding replacements, while the COW index is intended to be used for culling the expected least profitable females in a herd, as well as making informed purchase and pricing decisions for trading of females.

The COW index

Our objective was to develop the framework for a tool to rank females on expected lifetime profitability, taking cognisance of total genetic merit of the animal (i.e., additive and non-additive genetic merit), as well as both permanent and temporary environmental effects (e.g., season of calving, parity). This tool will consider the profitability ensuing from: (1) the current lactation; (2) future lactations, taking into consideration the future anticipated longevity of the animal; and (3) the implications for the herd replacement strategy. A somewhat similar index, the Production Worth, exists in New Zealand and ranks cows on expected future profitability and was developed to aid decision making regarding culling and purchasing of cows. The consequence of calving month, irrespective of genetic merit, is of huge economic importance in seasonal calving systems. For example, based on the Moorepark Bioeconomic Model, a cow calving in May will, on average, be €522 less profitable than the same cow calving in February. The reduced profit of the later calving cow is predominantly due to a shorter lactation length (because of a fixed dry off date). Therefore, both the current month of calving and the expected future month of calving have major effects on the expected lifetime profit of a cow. This is emphasised by the large relative contribution of month of calving to the variation among cows in COW value. A comparison between the EBI and COW index values for cows within a randomly chosen herd (n = 169 cows) from the national database is presented in Figure 1. A positive correlation (r = 0.66) existed between the EBI and COW values. The majority of the highest ranking cows on the COW index calved in February. An example of the disparity between the indices was where a cow ranking in the lowest 15% for EBI was ranked in the top 15% for COW. Details of the cow's performance in 2012 revealed that this second-parity cow calved early in the calving season (February), produced 7,704 kg of milk containing 609 kg of milk solids, and had low SCC. The cow with the highest COW value had an EBI €59 less than the best EBI cow, whereas the second best cow on the COW index had and EBI €95 less than the best EBI cow.

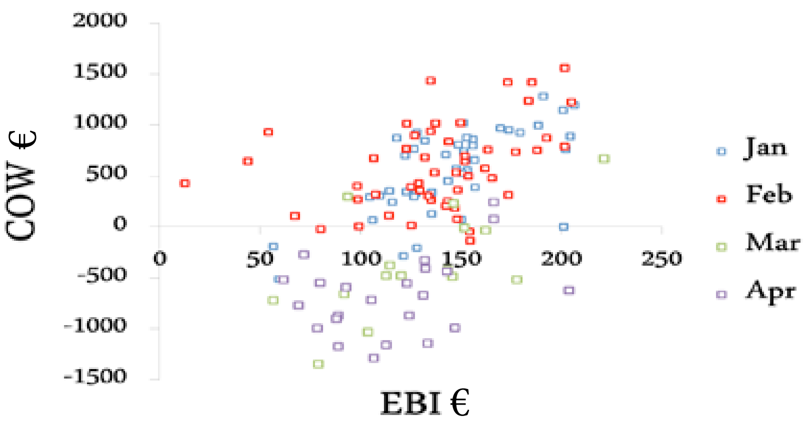

Figure 1. *EBI versus COW values by month of calving for an example herd from the national database (n = 169 cows)*

The opportunity exists to generate the COW index for a female at any time of the year incorporating all current information available. This can be further refined once pregnancy diagnosis data becomes available and information on fetal age (and thus more precise expected calving month) exists. Developments in the use of genomic information in genetic evaluations can also aid in improving the precision of the COW (and EBI) index.

Conclusions

The COW index will not be a replacement for the EBI. The EBI will remain the only index for identifying animals as parents of the next generation. The COW index will be used to identify cows for culling based on future profit potential. The calculation of future profit potential is based on a cow's genetic merit (EBI), her current and next expected calving date, parity and heterosis. Genomic information will increase the accuracy of both the EBI and the COW value of a female.

What are the characteristics of a high fertility cow?

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Summary

- Excellent fertility is vital for seasonal-calving, pasture-based milk production
- Holstein cows with similar genetic merit for milk production traits but either very good (Fert+) or very poor (Fert-) genetic merit for fertility traits were assembled at Moorepark
- Fert+ cows had better fertility performance due to a combination of earlier resumption of cyclicity, better uterine health, stronger oestrus expression and more favourable reproductive hormone status
- Selecting for a high fertility sub-index within the Economic Breeding Index will yield long-term dividends in the form of better calving pattern, fewer late-calving cows, reduced requirement for interventions and greater milk production

Introduction

A lactating cow model with similar genetic merit for milk production, but either good (Fert+) or poor (Fert-) genetic merit for fertility traits was recently developed and validated at Moorepark. These animals have similar proportions of Holstein genetics, and similar body weight, milk yield and milk composition. Fertility performance, however, is markedly poorer in the Fert- cows compared with the Fert+ cows. The research conducted to date with this animal model has clearly demonstrated that the causes of reduced fertility in Fert- cows are multifactorial.

Metabolic status and BCS

Insulin-like growth factor-1 (IGF1) is an important metabolic hormone, and circulating concentrations of IGF1 are a good indicator of bioenergetic status. Circulating IGF1 concentrations are greater in Fert+ cows throughout lactation. In addition to greater IGF1, Fert+ cows also have greater circulating insulin and glucose concentrations during the immediate postpartum period. Elevated glucose in the immediate postpartum period has been linked to likelihood of early ovulation and likelihood of conception at breeding. Consistent with their superior metabolic status, Fert+ cows maintained greater BCS during lactation and had reduced BCS loss after calving compared with Fert- cows. Maintenance of greater BCS in Fert+ cows is facilitated by greater dry matter intake during early lactation.

Uterine health

The reproductive tract of all cows becomes exposed to microbial pathogens while the cervix remains open after delivery of the fetal-placental unit. The development of uterine disease depends on the type of bacteria involved and on the immune response of the cow. We examined uterine health in Fert+ and Fert- cows by assessing vaginal mucus scores weekly after calving and also by examining uterine cytology at three and six weeks postpartum. Both the vaginal mucus scores and uterine cytology results indicated greater incidence of clinical endometritis in the Fert- cows. Despite similar management and housing, Fert+ cows had a more rapid recovery in uterine health compared with Fert- cows. This likely indicates that the Fert+ cows were capable of mounting a stronger and/or timelier immune response following exposure to microbial pathogens.

The oestrous cycle

The oestrous cycle was four days longer in Fert- cows compared with Fert+ cows (25 vs. 21 days). Circulating progesterone (P4) concentrations were similar during the first five days of the oestrous cycle, but from day five to day 13, circulating P4 concentrations were 34% greater in Fert+ cows. This difference in circulating P4 was associated with 16% greater corpus luteum (CL) volume in Fert+ cows. Greater circulating P4 concentration increases the likelihood of subsequent pregnancy establishment.

Oestrous behaviour

Oestrous behaviour was measured using automated activity meters and electronic mount detectors, and ovulation was verified using transrectal ultrasound. The main findings are summarized in Table 1. On average, oestrus intensity was greater in Fert+ cows. Fert- cows had more silent heats. In a dairy farm operation, these heats are missed, and at least three weeks is added onto the calving interval. A greater proportion of Fert- cows also displayed signs of oestrus, but subsequently failed to ovulate. In a dairy farm operation, these cows do get inseminated, but fertilization cannot occur, again adding at least three weeks to the calving interval. Of the oestrus events recorded, 36% fell into the combined categories of silent heats and heats without ovulation in Fert- cows, whereas only 2% fell into these combined categories in Fert+ cows. The intensity of oestrous behaviour is greater and there is better co-ordination between oestrous behaviour and ovulation in Fert+ cows. This is a major area of reproductive loss on dairy farms.

Table 1. Summary of oestrus-related differences between Fert+ and Fert- cows

	Fert+	Fert-	P-value
Silent oestrus	2%	22%	0.02
Oestrus without ovulation	0%	14%	0.04
Duration of oestrus (hr)	7.53	5.86	0.08
Peak oestrus activity	168	119	0.01

Conclusion

Compared with Fert- cows, Fert+ cows have greater dry matter intake after calving, greater BCS throughout lactation, more favourable metabolic status, earlier resumption of cyclicity and superior uterine health status. During the breeding season, Fert+ cows have stronger oestrous expression, are less likely to have silent heats, are more likely to ovulate after exhibiting heat, and have greater circulating P4 after ovulation. The next steps are to: (i) delve deeper into the different tissues to identify the genes and gene networks that regulate these phenotypic differences; and (ii) screen a large population of genotyped cows for some of these phenotypes to identify DNA markers. New markers can be rapidly incorporated into genomic selection techniques. After many decades of declining fertility, genetic merit for fertility and phenotypic reproductive performance now appears to improving.

Potential benefit of Sexed Semen to Ireland

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Summary
- Economic modelling identified faster and more profitable expansion using sexed semen over a 15-yr simulation
- Economic modelling indicated a greater net advantage for static herds utilising a combination of sexed dairy semen and conventional beef semen compared with using conventional dairy semen only

Introduction

Sexed semen use will allow farmers to increase the rate of herd expansion, to generate replacement heifers from the best dams only, and to essentially eliminate the low value male dairy calf. Sexed semen use should be targeted to heifers and the most fertile cows in the herd (≥9 weeks calved, ≥BCS 3.0). Since the 2013 sexed semen field study in Ireland, where conception rates achieved with sexed semen were 87% of conventional semen, improvements have been made to the sorting technology. More recent studies have reported better fertility performance with sexed semen indicating that sexed semen has the potential to equal conception rates of conventional semen now or in the near future.

Dairy herd expansion

Expansion from a herd size of 100 to 300 lactating cows was modelled over a 15-yr simulation period using three different breeding strategies, as described in Figure 1.

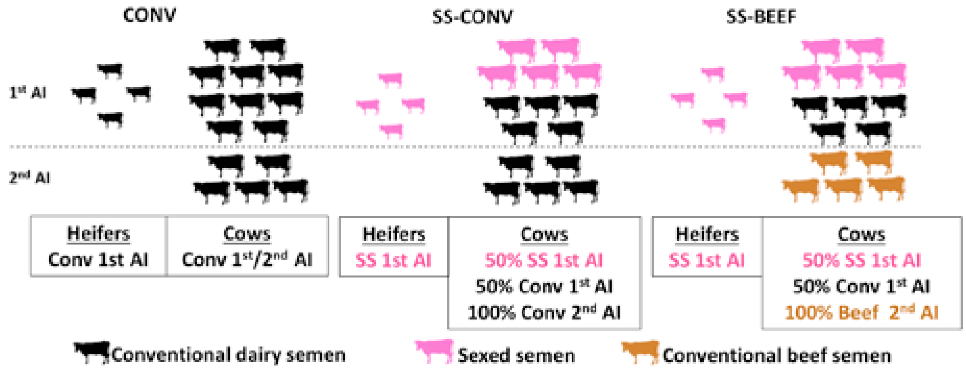

Figure 1. *AI usage for three different breeding strategies; i) conventional semen in heifers at first AI and cows for the first two rounds of AI (CONV); ii) sexed semen in heifers at first AI and targeted use in cows at first AI (50%), with conventional semen used in remaining cows, and in all cows for the second AI (SS-CONV); iii) sexed semen in heifers at first AI and targeted use in cows at first AI (50%), with conventional semen used in remaining cows, and conventional early maturing beef semen in all cows for the second AI (SS-BEEF)*

Assuming the conception rates achieved with sexed semen are 94% of conventional semen, SS-CONV facilitated the fastest rates of herd expansion. The rate of herd expansion was similar for CONV and SS-BEEF (Figure 2). Sexed semen use resulted in greater farm profitability over the 15-yr simulation period, either through faster herd expansion (SS-CONV + €135,418) or revenue from beef sales (SS-BEEF + €91,298). Rapid expansion using SS-CONV, however, increased the financial pressure on the farm business, particularly in the first four years of expansion.

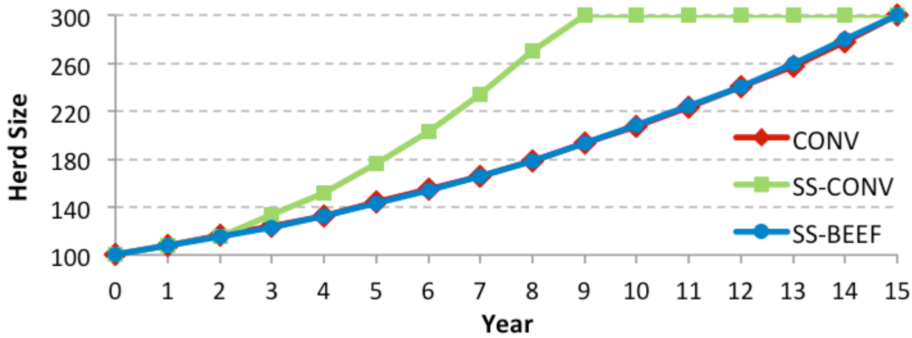

Figure 2. *Herd expansion over a 15-yr simulation when using conventional semen (CONV), sexed semen plus conventional semen (SS-CONV) or sexed semen plus conventional beef semen (SS-BEEF) in virgin heifers for the first AI and in lactating cows for the first two AI*

Static herd size: alternative breeding strategy

What about a dairy farmer that wishes to maintain herd size? A farmer with a herd size of 80 lactating cows could use sexed semen on all the heifers and target the use of sexed semen on the higher fertility lactating cows to generate sufficient replacement heifers in the first three weeks of the breeding season. All other non-sexed inseminations during the six week period of AI use on the lactating herd could be changed to short-gestation easy-calving beef sires (e.g. Aberdeen Angus, Hereford; SS-BEEF ONLY). The resulting beef calves currently attract a premium of approximately €150 over dairy bull calves. Assuming the conception rates achieved with sexed semen are 94% of conventional semen, instead of using 105 conventional semen straws, a farmer could use 48 sexed semen straws and 59 beef straws. Based on the change in type of calves born (Figure 3), the €150 price differential between a male dairy calf and a beef calf would result in a net advantage of €1,920 per year. If the conception rates achieved with sexed semen were equal to conventional semen, this figure would rise to €2,384 per year.

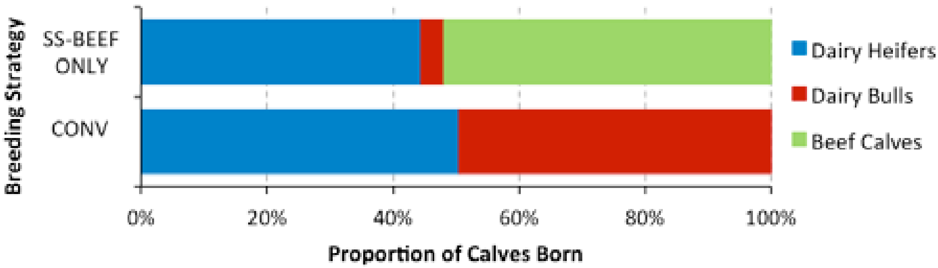

Figure 3. *Proportion of calves born as a result of AI in an 80 lactating cow static herd using conventional semen (CONV) or sexed semen plus conventional beef semen (SS-BEEF ONLY)*

Conclusions

Data generated from economic analysis indicated more profitable expansion when using sexed semen compared with conventional semen. For static herds, combining the use of sexed semen and conventional beef semen resulted in a greater net advantage over the use of conventional semen only.

The importance of body condition score for fertility in dairy cows

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Summary

- Good BCS (≥ 3.00) at the start of breeding increases likelihood of pregnancy establishment
- Thin cows (i.e., BCS < 2.75) at mating start date will have poorer submission, conception, and six week incalf rates compared with cows with BCS ≥ 2.75
- A cow that calves thin will stay thin through the breeding season
- Monitoring BCS during lactation and during the dry period is necessary to maximise fertility performance

Introduction

After calving, lactating dairy cows experience a rapid increase in milk yield and a slow rise in dry matter intake. The gap between energy output in milk and energy intake from the diet is called negative energy balance. It is normal for cows to undergo a period of negative energy balance in early lactation and this results in mobilisation of fat reserves. The period of greatest fat mobilisation is during the first two weeks after calving. It is typical for lactating dairy cows to lose 30-40% of their initial fat reserves after calving, but this figure can rise to as high as 80% with inadequate nutrition (e.g., inadequate pasture availability/insufficient concentrate supplementation in early lactation). Body condition score (BCS) and BCS change can be used as an indirect measure of the energy status of dairy cows during the early postpartum period and throughout lactation (Figure 1).

Figure 1. *Key periods to assess BCS are indicated by ★ Herd average BCS targets for various stages of the gestation-lactation cycle are as follows (range in parenthesis): 1) Pre-calving: 3.00 or 3.25; Start of breeding: 2.90 (2.75-3.25); Drying off: 3.00 (2.75-3.25)*

Importance of BCS in early lactation

Ensuring the target BCS is achieved at breeding requires correct management throughout late lactation and the dry period. If a cow fails to calve at the correct BCS, it is virtually impossible to achieve BCS gain in early lactation. Therefore, if a cow calves down thin, she will remain thin throughout early lactation and the breeding season. Cows in poor BCS at calving or cows that experience excessive BCS loss (> 0.5 BCS) early postpartum are less likely to ovulate before the planned start of mating, have reduced submission rates to AI, reduced conception rates, and increased likelihood of pregnancy loss (Table 1).

Table 1. Relationship between BCS and three week submission rate and six week incalf rate			
	< 2.75 (Poor)	2.75-3.00 (Acceptable)	> 3.00 (Good)
3 week submission rate (%)	76	84	83
6 week incalf rate (%)	50	57	63

Poor BCS cows often fail to exhibit oestrus during the pre-breeding period. Cows with extremely poor BCS (< 2.50) often present with small inactive ovaries at ultrasound examination. The recommendation is to allow these animals time to replenish body energy reserves and resume normal cyclicity. For cows with poor BCS (< 2.75), once a day milking may be an option until an animal is inseminated or confirmed pregnant to reduce energy output while maintaining cows on a rising plane of nutrition. Moorepark research indicates when using hormonal intervention, it is important to use progesterone-based synchronisation programs incorporating fixed time AI to improve fertility in poor BCS animals.

Importance of BCS in late lactation

Where grazed pasture is the main dietary component during lactation a variable proportion of the herd will be below target BCS in late lactation due to failure to regain BCS during lactation. Pasture digestibility deteriorates as the grazing season progresses suggesting a grass-only diet in mid to late lactation can be inadequate to support BCS gain, thus necessitating supplemental concentrate feeding.

Importance of BCS at drying off

The dry period is a rest phase in the lactation cycle of the cow and the objective is to set up a cow for a trouble free transition to the next lactation. Cows should have at least an eight week dry period; this should be extended for poor BCS cows. It is important to determine forage quality in advance of the dry period as the aim during the dry period is to maximise energy intake from silage to drive BCS gain. Decisions regarding supplementation of the dry cow should be made based on BCS, dry period length, and forage quality (Table 2).

Table 2. Supplementation rates for dry cows			
Silage DMD	BCS ≤ 2.50 10-12 weeks dry	BCS 2.75 8-10 weeks dry	BCS ≥ 3.00 8 weeks dry
> 72 DMD	Silage + 1 kg meals	Silage ad lib	Silage restricted
68-72 DMD	Silage + 2 kg meals	Silage + 1 kg meals	Silage ad lib
64-68 DMD	Silage + 3 kg meals	Silage + 2 kg meals	Silage + 1 kg meals

With milk quotas now gone, there may be a temptation to continue milking late lactation cows over the winter on average quality silage with high levels of concentrate supplementation. If this occurs at the expense of dry off BCS, calving BCS, subsequent milk yield, and fertility, the costs will quickly outweigh the short term financial gains to be achieved. A herd pregnancy diagnosis completed 5-7 weeks after the end of the breeding season should accurately determine expected calving dates. The earliest calving animals and thinnest animals should be prioritised for an earlier dry off date. Later calving animals can be milked for longer to avoid over conditioning and prevent associated metabolic disorders in early lactation.

Conclusion

The ability to assess BCS is a key skill that will allow you to closely monitor the energy status of your herd. This will allow you to make more informed nutritional management decisions in a timely manner to optimise the milk production and fertility performance of your herd in the current/subsequent lactation.

Mineral nutrition in pasture-based systems

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Summary
- Mineral nutrition is important for optimum production, health and reproduction
- Grass as a sole feed may be deficient in one or more minerals
- After the first grazing rotation, seasonal variation in mineral concentrations is minimal
- A variety of supplementation methods are available for small and large herds

Background
Grazed grass is the cornerstone of Irish dairy production systems. Clinical mineral deficiencies of macro- or trace minerals in dairy cattle are rare. However, subclinical deficiencies are common and these can manifest as poor reproductive performance and suboptimal herd health. Mineral deficiencies in grass can depend on region, season, soil pH, plant species and fertilisation strategy, and can translate into deficiencies in the grazing cow.

Main mineral problems
Phosphorus (P)
Phosphorus has many biological functions, and hence is one of the most important minerals. It is found in every cell of the body and it is required for a wide variety of functions within the body. Phosphorus deficiency is characterised by pica (depraved appetite) leading to poor weight gain or weight loss, decreased milk production and sub-optimal fertility. Lactating dairy cows require 4 g of Phosphorus per kg dry matter intake (DMI) (National Research Council, 2001).

Selenium (Se)
Selenium is necessary for growth and fertility in animals and for the prevention of a variety of disorders. Selenium deficiency can increase the incidence of retained placenta, metritis, and cystic ovaries. Adequate selenium nutrition of dairy animals in late lactation and during the dry period is important for preventing disorders and ensuring optimum selenium nutrition in the new-born calf. The only specific effect of reduced selenium supply in cattle is white muscle disease in young calves. Clinical signs of this disease include leg weakness and stiffness, flexion of the hock joints and muscle tremors. The requirement for selenium is 0.3 mg/kg of dietary DM for all classes of dairy cattle (National Research Council, 2001).

Iodine (I)
Low dietary iodine intake during pregnancy has been associated with an increased incidence of small and weak calves, increased incidence of goitre, decreased resistance to hypothermia, decreased survival and low immunity. Cows recycle iodine poorly, which means that iodine is not stored in the body and so must be supplied in the diet. The dry cow diet must contain 0.33mg iodine/kg of DMI (National Research Council 2001). The lactating cow diet should contain 0.45-0.5 mg iodine/kg DMI (National Research Council 2001).

Copper (Cu)
Copper is essential for normal biological function and is involved in many chemical processes within the body. It is needed for blood formation and copper dependent enzymes. Deficiency symptoms include reduced growth and milk yield, severe diarrhoea, stiff joints, changes in hair coat color and texture, loss of hair, and reduced reproductive

performance. The National Research Council (2001) sets the level of copper required in the diet of lactating dairy cows at approximately 15 mg/kg DMI.

On-farm study

In 2013, a survey was conducted on dairy farms to: (i) benchmark the seasonal variation in forage mineral concentrations across a range of pasture-based dairy herds; and (ii) determine the mineral value of these swards for lactating dairy cows. Forty four dairy farms were enrolled on the study across the main dairy regions in Ireland (Figure1). Grass samples and all other dietary feeds were collected four times during the grazing season and analysed for mineral concentrations. Based on the mineral requirements for lactating dairy cows, on average, a grass-only diet met 85%, 73%, 52%, 50% and 38% of the lactating cow requirements for phosphorus, copper, iodine, zinc and selenium, respectively.

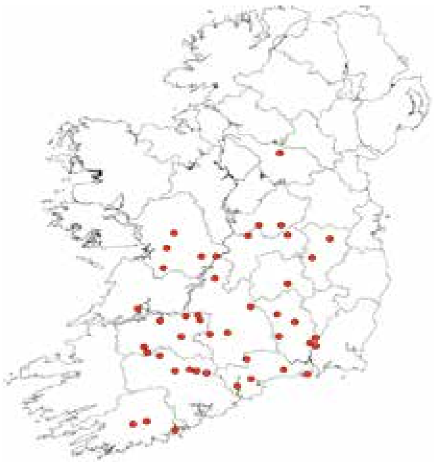

Figure 1. *Locations of farms involved in mineral study*

Seasonal variation

Farm visits were selected to coincide with normal grazing rotations and expected changes in the grass morphology. Visits occurred during: (i) the long first grazing rotation (March/April); (ii) short second and third rotations (May/June); (iii) mid-season (August); and (iv) the end of the grazing season (October/November). The seasonal variation in mineral concentrations did not alter greatly over the four sampling points. The main mineral that showed seasonal variation was selenium. Grass samples had greater concentrations of selenium in the first grazing rotation compared with much lower concentrations in the remaining samples collected. Application of slurry and farm yard manure increased concentrations of copper and phosphorus. However, the results indicate that, in general, grass grown on Irish dairy farms does not contain adequate P, Cu, I, Zn and Se to meet cow requirements when fed as the sole feed. This has implications for animal health and fertility performance.

Supplementation strategies

A variety of strategies exist to provide supplemental minerals to lactating dairy cows. These range from daily provision of small amounts of minerals (e.g., in the concentrate feed or the drinking water) to infrequent provision of large amounts of trace minerals in a slow-release format (slow release intraruminal boluses, slow release injectables). All strategies have advantages and disadvantages for different systems. For larger herds, the most cost effective and labour efficient way to supplement minerals is either through the drinking water or in concentrate feed if likely to be feeding cows throughout the year. Where a farm has an extreme mineral imbalance, it may require supplementation with ≥2kg of concentrate per day as mineral carrier to rectify the problem. Slow release intraruminal boluses and slow release injectables are more suited to smaller herds as a cheaper alternative to installing a water system and less labour intensive due to lower numbers of animals. A head scoop may be necessary for administration of rumen boluses.

Conclusion

Farmers need to be aware that on a grass-only diet, the dietary supply of some minerals may be inadequate. Grass mineral concentrations should be analysed regularly, and appropriate supplementation strategies established to deal with any deficiencies or imbalances identified.

The effect of stocking rate on reproductive performance for pasture based dairying

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Summary

- Stocking rate is the main driver of milk output per hectare, and will increase on many farms in the coming decade
- Farmers must identify the optimum stocking rate to maximise output/ha without compromising reproductive performance
- Many indicators of reproductive efficiency are affected by nutritional status, including resumption of cyclicity, oestrus intensity, likelihood of conception and embryo mortality

Introduction

Quota abolition has provided significant opportunity for dairy expansion, but has also created many challenges for Irish dairy farmers. Many farmers will expand herd size by means of increasing stocking rates (SR) to drive increases in milk production per hectare. This needs to be carefully managed, however, to avoid adverse effects on reproductive performance. It will be necessary to increase grass growth and grass utilisation to meet cow requirements for dry matter intake (DMI). As a consequence of increasing stocking rate, dairy cows are subject to increased competition for grazed grass. Inadequate nutrition in early lactation can negatively affect the overall performance of the dairy cow. Inadequate DMI in early lactation can result in reduced body condition score, and therefore poorer reproductive performance during the following breeding season. Shorter intervals from calving to first oestrus are associated with increased submission rate, conception rate, and overall pregnancy rates. A number of studies in both Ireland and New Zealand have reported that increasing stocking rate increased the incidence of anoestrous cows and the requirement for reproductive treatments at the start of the breeding season.

Study design

In 2013, a three year study was established at Curtin's research farm to investigate the effect of stocking rate on reproductive performance. The study compared three different stocking rates (Low; 2.5 cows/ha, Medium; 2.9 cows/ha, and High; 3.3 cows/ha) using two different breeds (Holstein Friesian and Jersey crossbreds). A total of 276 animals were used for this analysis. Each stocking rate was managed identically, receiving the same level of concentrate supplementation (400 kgs per cow) and equal fertiliser application (250 kgs N /ha) on each grazing block. The only difference amongst treatments was the post grazing sward height (PGSH), which was 4.5-5.0cm, 4.0-4.5cm, and 3.5-4.0cm, for low, medium and high stocking rates, respectively. Milk samples were collected three times per week for progesterone analysis, to determine the interval from calving to first ovulation. The fertility performance of each herd was monitored during a 12 week breeding season in 2013 and 2014.

Results

No difference existed between the three different stocking rates in the interval from calving to first ovulation (Figure 1a). However, there was a shorter interval to first ovulation for Holstein-Friesian cows compared with the Jersey crossbreds (Figure 1b). Reproductive performance for the three stocking rate treatments was similar for the majority of the measurements reported (Table 1). Jersey crossbred animals had a higher pregnancy rate to first service compared with the Holstein-Friesian cows. This increased pregnancy rate to first service also resulted in an increased six week in-calf rate.

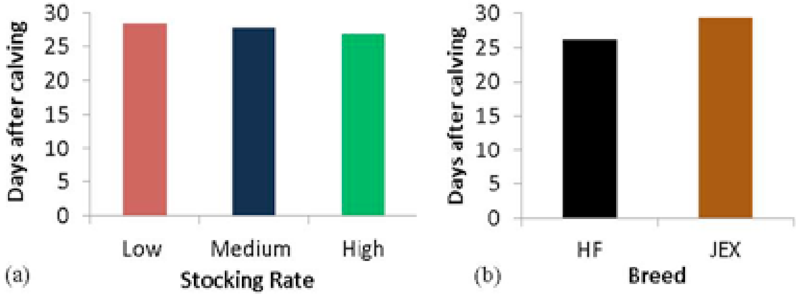

Figure 1. *The interval from calving to first ovulation: (a) for cows managed under three different stocking rate treatments (Low: 2.5 cows/ha; Medium: 2.9 cows/ha; and High: 3.3 cows/ha); and (b) for two different breeds of cow (Holstein Friesian (HF) and Jersey crossbreds (JEX))*

Table 1. The effect of stocking rate (Low: 2.5 cows/ha; Medium: 2.9 cows/ha; and High: 3.3 cows/ha) on reproductive performance for two consecutive years (2013 and 2014) using two different breeds (Holstein Friesian (HF) and Jersey crossbreds (JEX))

	Stocking Rates			Breed	
	Low	Medium	High	HF	JEX
Submission rate (%)	81.1	85.5	82.4	84.4	81.5
6 week in-calf rate (%)	56.7	65.6	57.0	56.3	63.1
Embryo loss (%)	10.0	6.7	8.8	9.6	7.1
Empty rate (%)	12.2	12.2	12.1	13.3	11.4

Conclusion

Holstein-Friesian dairy cows had a shorter interval to first ovulation compared to Jersey crossbreds, but this was not reflected in better reproductive performance. There was minimal variation in fertility performance results among the three stocking rates. We conclude at this stage of the study that there is no major effect of increasing stocking rate in a pasture based system on reproductive performance provided that nutrition is adequate. To maximise the potential and profitability of a pasture based system, the nutritional requirements of the dairy cow should be provided in the form of grazed grass where possible.

New cleaning protocols to minimize bacterial transfer at milking time

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Summary
- Disinfection of the milking cluster after each individual cow milking will reduce the microbial count on liners and the transfer of bacteria from cow to cow
- Pre-milking teat preparation will reduce bacterial levels on teat skin
- Where pre-milking teat disinfection is used, wiping of teats (paper towels) to remove the disinfectant is critical to avoid chemical residues in milk

Introduction

The two main sources of bacteria entering milk are the cow's environment and the milking machine. Inadequate cleaning of teats prior to cluster attachment will facilitate the multiplication of bacteria on the internal surface of liners. Bacterial transfer from cow to cow occurs at milking time via contaminated clusters. Large numbers of *Staphylococcal* and *Streptococcal* bacteria are normally present on teat skin when cows present for milking. The incidence of new intramammary infection is highly correlated with the number of mastitis pathogens on the teat-end at milking. Two new cleaning protocols, (a) pre-milking teat disinfection and (b) automatic cluster flushing between individual cow milkings, have recently been tested at Moorepark to establish the effectiveness in reducing the transfer of *Staphylococcal* and *Streptococcal* bacteria.

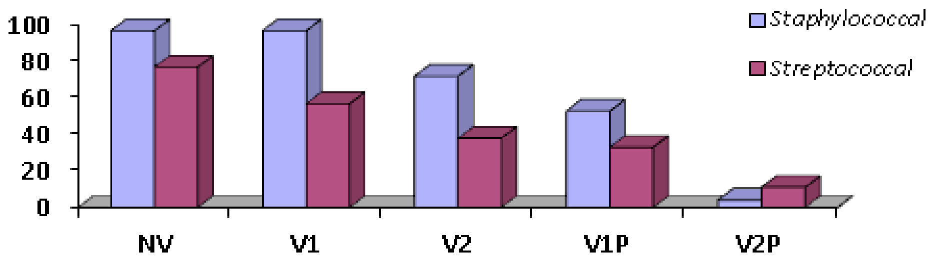
Pre-milking teat disinfection

Reducing the microbial count on teats prior to milking is an important step in the prevention of mastitis and minimizing bacterial levels entering milk. A study was carried out at Moorepark to investigate the effect of different pre-milking teat preparation procedures on lowering the *Staphylococcal* and *Streptococcal* bacterial count on teat skin prior to cluster application. Six pre-milking teat preparations were applied to spring calving Holstein Friesian cows during two herd management periods, while cows were housed (indoors) and while cows were grazed on pastures (outdoors). The teat preparation treatments included a wash and dry only treatment or included the use of disinfectants containing Iodine, Chlorhexidine, Chlorine and Wipes (Chloride) or no teat preparation. High bacterial numbers were recorded on teat skin prior to teat preparation. A significant reduction in bacterial numbers on teats after teat preparation was observed with all treatments except the 'No preparation' pre-milking treatment. When cows were outdoors, the largest reduction in *Staphylococcal* bacteria (95%) on teat skin was observed with the 'Wipes' treatment followed by the 'Chlorine' based disinfectant treatment (85%). Similarly, the largest reduction in *Streptococcal* bacteria (95%) occurred with both the 'Chlorine' and 'Wipe' treatments (95%). The 'wash and dry' treatment was significantly better than the 'no treatment' and reduced *Staphylococcal* and *Streptococcal* bacteria counts on teats by 60 and 45%, respectively. When cows were indoors the 'Chlorhexidine' treatment was much more effective than all other treatments in reducing both *Staphylococcal* (95%) and *Streptococcal* (75%) bacteria. Thus, the use of some disinfectant products for pre-milking teat preparation can have beneficial effects on reducing the levels of *Staphylococcal* and *Streptococcal* pathogens on teat skin and their effectiveness can be influenced by the environmental challenge. By reducing bacterial levels on teat skin it will minimize the transfer of bacteria from cow to cow via the milking cluster and minimize the numbers of bacteria entering milk at milking time. **However, where pre-milking teat disinfection is used, wiping of teats (paper towels) to remove the disinfectant is critical to avoid chemical residues in milk**. The effect of pre-milking teat disinfection on somatic cell and new intramammary infection is presently being investigated.

Table 1. Effect of pre-milking teat preparation treatment in reducing Staphylococcal and Streptococcal bacteria counts on teats at two time periods (indoor and outdoor) (% reduction)				
Treatment	Staphylococcal	Streptococcal	Staphylococcal	Streptococcal
	Outdoors		Indoors	
Wash/dry	60	45	50	60
Iodine	83	44	65	70
Chlorhexidine	75	55	95	75
Chlorine	85	95	55	65
Wipes (chloride)	95	95	75	65
No prep	0	0	0	0

Automatic cluster flushing

Milk liners contain high numbers of bacteria after each individual cow milking. A study at Moorepark investigated the optimal settings of an automatic cluster flush system that would give the maximum reduction in bacterial numbers on liners. The 'Clustercleanse' system has two water volume settings (V1=0.5 litres or V2=1.0 litres) combined with an air purge with the option of using a disinfectant solution. The following cluster flushing treatments were evaluated: No cluster flush (NV), volume 1 (V1) and volume 2 (V2) and with peracetic acid added (0.2%) (V1P and V2P). *Staphylococcal* and *Streptococcal* bacteria were detected on 97 and 75% of liners, respectively, prior to the flushing treatments. The application of treatment V2P resulted in the minimum levels of bacteria present on liners after cluster flushing. *Staphylococcal* and *Streptococcal* bacteria were present on 14 and 11 percent of liners, respectively, after flushing with this treatment (Figure 1). Automatic flushing of the milking cluster after each cow milking will reduce the microbial count on the liners thus reducing the potential for bacterial transfer from cow to cow. Manual flushing whereby the cluster is manually dipped in a bucket containing disinfectant solution, is labour intensive and could only be suggested in critical times of the year, for example to minimize spread of contagious pathogens during a mastitis outbreak or for clusters from individual cows known to have a high somatic cell count or be clinically infected.



(NV =No flush,V1 =0.5L, V2=1.0L, V1P= 0.5L + peracetic acid, V2P= 1.0 L + peracetic acid)

Figure 1. *Percentage of liners with Staphylococcal and Streptococcal bacteria after cluster flush*

Conclusion

Additional cleaning protocols such as pre-milking teat disinfection and automatic cluster flushing between individual cow milking's will minimize bacterial transfer at milking time.

Cleaning protocols to minimize bacterial counts in milk

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Summary

- Eighty five percent of farmers are not following a complete milking machine wash routine
- Four milking equipment wash routines are recommended
- Peracetic acid may be added to the final rinse water of a milking machine wash programme to reduce bacterial counts on equipment surfaces
- Weekly acid cleaning of milking equipment is necessary to remove mineral deposits and is critical in achieving low thermoduric counts

Introduction

Inadequate cleaning of equipment will facilitate the multiplication of bacteria including thermoduric bacteria in milk. Total bacterial count (TBC) is an indicator of on-farm general hygiene conditions and milking equipment hygiene. Satisfactory daily cleaning and disinfection of all equipment is therefore the most critical factor for the bacteriological quality of milk. The shelf life of pasteurized dairy products is influenced by the concentration of thermoduric spores in milk. The two main sources of thermoduric bacteria are the cow's environment and the milking machine.

Wash routines- what product to choose

Products chosen for use on dairy farms should be labeled with the following information (i) identity and content of active substances; (ii) instructions on usage; (iii) manufacturer details; (iv) date of manufacture; and (v) PCS number. To legally distribute a steriliser product in Ireland the product must be registered with the Department of Agriculture Food and Marine. Using unregistered products for cleaning equipment may have implications for farmers in a cross compliance check. The compositional ingredients, usage rate and water temperature used with that product, together with sufficient rinsing of equipment are the most critical parameters in maintaining a high standard of equipment hygiene, with absence of residues. Four milking equipment wash routines are recommended and are outlined on the Teagasc website http://www.agresearch.teagasc.ie/moorepark/milkquality/. The routines include: **Hot detergent-steriliser cleaning; Cold cleaning; Non-chlorine cleaning; Hot detergent-steriliser/acid cleaning**. Regardless of the composition of cleaning products or the wash routine chosen, if the detergent is not mixed at the recommended levels, then ineffective cleaning and/or issues with chemical residues in milk will result.

Farm survey of cleaning routines on farms

Sixty three farms were visited at milking time and the wash routines were observed. Large percentages (85%) of farmers were observed as not following one of the four complete milking machine wash routines. Such inconsistency in washing routines leads to variable total bacterial count results and fluctuating thermoduric counts. Fifty percent of farms did not use adequate rinse water to remove either milk or detergent residues, which could lead to trichloromethane (TCM) residues in milk. To avoid damage to rubber components and to avoid TCM residues, chlorine containing cleaning solutions should be rinsed from the plant immediately after the wash cycle has been completed. Alternatively, non-chlorine products require a longer surface contact time to be effective, so the stain of the solution should be allowed to remain on the plant until shortly before the next milking. Fifty eight percent of farms did not use the cleaning solutions as recommended. Previous studies at Moorepark have demonstrated that detergent sterilizer solutions may be successfully reused on one occasion; however 33% of farms are re-using cleaning products for more than one occasion. This practice has been shown to increase TCM residues as the residue accumulates in the reused cleaning solution. Many farmers add additional chlorine (16%) to the wash solution with the expectation that it will improve the effectiveness of the cleaning product. However, the majority of legally registered cleaning products, as outlined on the Teagasc website have adequate chlorine for effective cleaning (if used correctly) and the addition of more chlorine will have a detrimental effect on rubberware and will also increase the possibility of TCM residues. The concentration of the cleaning solution is dependent on the correct levels of detergent (as recommended by the manufacturer) being added to the correct levels of water (9 to 12 litres per unit). Alkalinity analysis, conducted on the cleaning solutions from the farms visited, indicated that 56 % of solutions had lower than the required alkalinity level, while 27% had higher levels than recommended. This indicated inaccurate measurement of detergent and an over estimate of water levels in wash troughs. Unless acid cleaning is part of the daily cleaning routine then an acid descale wash (milkstone removal) should be carried out weekly, and twice weekly in areas where hard water prevails. Acid cleaning is necessary to remove mineral deposits on stainless steel surfaces and is critical in achieving low thermoduric counts. However, only 56% of farms (where acid cleaning is not part of the daily routine) included a weekly descale wash as part of their cleaning protocol, with up to 20% not including a descale wash at any time of the year. Should peracetic acid be applied twice daily as a pre-milking machine rinse, then the weekly descale wash is no longer necessary.

Peracetic acid in rinse water

Peracetic acid is a fast acting disinfectant and contains a mixture of peracetic acid, water hydrogen peroxide and acetic acid and is sold under different brand names. Daily use of peractetic acid as a pre-milking sterliser rinse will help prevent build-up of biofilms on equipment surfaces especially where hard water prevails. The addition of a disinfectant in the final rinse water of a milking machine wash programme may also be recommended where the microbial count of a farm water supply is considered unsatisfactory. Peracetic acid has similar antimicrobial properties to chlorine, but without the added risk of residues. The major advantages of peracetic acid based products are the rapid disinfecting action and environmentally acceptable breakdown products. Teagasc research studies have shown significant reductions in total bacterial counts and thermoduric counts on plastic equipment surfaces and in milk, where peracetic acid was included as a pre-milking machine rinse. Precautions need to be taken when using chemical products especially acid based products. Before adding peracetic acid to the rinse water, the detergent wash solution should be properly rinsed from the plant in order to avoid any chemical reaction between the detergent solution and the acid.

Conclusion

A high percentage of farms are not following a recommended wash routine and fail in one or more cleaning steps. Acid cleaning is necessary to remove mineral deposits on stainless steel surfaces and is critical in achieving low thermoduric counts. Peracetic acid may be used as an alternative product to chlorine for the purposes of pre-milking plant disinfection, especially where the microbial count of a farm water supply is considered unsatisfactory.

Managing bulk tank SCC in late lactation

Aine O' Connell[1], Don Crowley[2], Jimmy Flynn[1], Niamh Ryan[1] and David Gleeson[1]

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Summary

- Due to a decline in milk production and increased prevalence of chronic subclinical mastitis on herds the monthly bulk tank SCC increases steadily from August onwards
- Successful control programs are based on reducing the prevalence of sub-clinically infected cows in the herd
- Reducing the proportion of cows with a high SCC in late lactation requires the identification and management of high SCC cows in the spring and summer

Introduction

Bulk tank somatic cell count (SCC) is strongly correlated with the proportion of cows with sub-clinical mastitis within a dairy herd. As bulk tank SCC increases above 100,000 cells/mL milk production declines and a loss in milk receipts is incurred. Cows with a high SCC will maintain a reservoir of infection that can result in increased exposure of potential pathogens to otherwise healthy cows.

Monthly trends in bulk tank milk SCC

A study was undertaken to measure the monthly trends in bulk tank milk SCC on 10,819 herds in Ireland. This dataset highlighted that the average monthly bulk tank milk SCC exceeded 250,000 cells/mL during late lactation (Figure 1). The proportion of monthly herd records with an SCC >400,000 cells/mL increased from 11% to 40% from August to December.

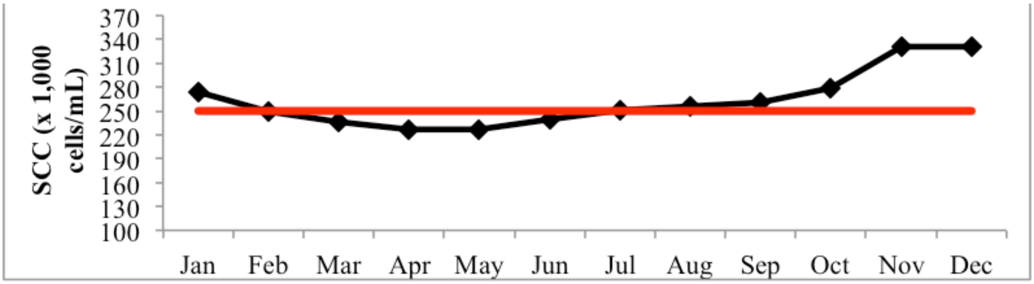

Figure 1. *Monthly trend for bulk tank SCC (- ◆ -) (n=10,819 farmers) with monthly averages above the red line >250,000 cfu/mL*

On seasonal herds, peak milk production coincides with the lowest monthly mean bulk tank SCC (April-May). At the herd level, dilution due to increased milk production can contribute to a reduction in bulk tank SCC. However, sub-clinically infected cows can still exist within the herd. Therefore it is very important to identify and manage high SCC cows in the spring and summer to prevent chronic infections from persisting into late lactation. The most common bacteria causing subclinical mastitis in Ireland are *Staph. aureus* and *Strep. uberis*. In the absence of preventative measures the prevalence of *Staph. aureus* mastitis is likely to increase as cows progress through lactation. Reducing bulk tank SCC in late lactation requires preventative action and specific management of high SCC cows throughout lactation.

Identifying problem cows

An SCC level of >200,000 cells/mL is generally accepted as an indicator of mastitis infection. It has been suggested that SCC for a healthy lactating cow should not exceed 100,000 cells/mL. Milk recording, 4-6 times throughout lactation will give composite milk sample SCC readings for all cows in the herd and these can be used to identify cows with subclinical infection. The infected quarter within the cow can then be identified using the Californian milk test (CMT). Microbiological analysis of quarter milk samples from chronically infected cows should be performed to identify the causative pathogen. Less than 15% of all cows in the herd should have a SCC >250,000cells/mL throughout lactation and <30% of cows should have an SCC >250,000 cells/mL at the end of lactation. The proportion of previously low SCC cows that have a SCC >250,000 cells/mL at the next test day should be less than 10%. Cows that have two or more episodes of clinical mastitis and that have a high SCC for >2 months in the same lactation can be considered to be chronically infected.

Treatment of chronic sub-clinically infected cows

Cows that develop chronic infections with pathogens that do not respond well to treatment (*Staph. aureus*) should be culled to reduce the risk of transmission to healthy animals. Risk factors that may decrease antimicrobial efficacy of sub-clinically infected cows include 1) age of cow, 2) pre-existing SCC before treatment, 3) duration of infection, 4) number of quarters infected and 5) the presence *Staph. aureus* infections. The use of intramammary antibiotics to treat sub-clinically infected cows with *Strep. agalactiae* is usually successful. It is not considered cost-effective to treat cows that are chronically infected with *Staph. aureus* or *Strep. uberis*, as cure rates during lactation are generally low. If a cow has only one chronically infected quarter, then drying-off that quarter during lactation (without antibiotics) is often a workable and a practical strategy. Clearly identify quarter/cow and monitor changes.

Limiting the spread of subclinical mastitis within the herd

Effective control programs that reduce transmission of bacteria to other cows should be implemented in conjunction with treatment of subclinical infections during lactation. Strict milking time hygiene is a high priority to reduce the spread of contagious bacteria. Teats should be clean and dry before applying the milking unit. Additional cleaning protocols such as pre-milking teat disinfection followed by wiping with a paper towel and cluster disinfection (peracetic acid) between individual cow milking's will minimize the spread of infection. Disposable gloves should be worn and disinfected throughout milking. All infected cows should be segregated and milked last or else clusters should be disinfected between individual cow milking's.

Maintaining a low bulk tank SCC

The application of an approved disinfectant post-milking ensuring complete coverage of the teat, appropriate treatment of clinical cases, proper maintenance of milking equipment, culling of chronic cows and strategic drying off of infected quarters are adopted management practices known to reduce the prevalence of subclinical mastitis in the herd. Cows should be dried off at milk yields <8kg/day. Dry cow antibiotic tubes and/or teat sealant should be used for individual cows based on milk recording SCC, length of dry period and housing conditions.

Conclusions

Monthly bulk tank SCC on dairy farms increases steadily from August onwards as the majority of cows enter late lactation indicating increased prevalence of subclinical mastitis. Implementation of well-recognized mastitis control programs can prevent the spread of contagious mastitis and reduce bulk tank SCC in late lactation.

Development of milking research techniques

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Summary

- The milking research programme at Moorepark will quantify the effect of milking machine factors such as vacuum, pulsation settings and liner compression on the teat tissue of cows through the analysis of milk flow rates, teat congestion and other physiological observations such as teat dimensions
- A novel quarter milking device was developed which is capable of providing precise measurements of milking vacuum, along with individual quarter measurements of short milk tube vacuum, pulsation chamber vacuum, mouth piece chamber vacuum and milk flow rate
- The natural biological variation in milk flow rates during the peak flow period at the cow quarter level was an order of magnitude lower than the variation in milk flow rates during the peak flow period at the level of the cow, enabling detection of slight variations in teat congestion caused by changes in vacuum or pulsation settings

Introduction

Measurement and analysis of milk flow rate at the udder level can provide insight into the milk ejection response as well as physiological response of teat tissues to milking. Moreover, understanding how milking machine settings influence the flow-rate of milk from the udder is important for the development of best practice parameters for their use and for appropriate sizing of milking facilities. The more accurately milk flow can be measured and analyzed, the more closely the effect of milking machine settings (i.e. vacuum level, pulsation settings, liner compression) and other conditions on the physiology of the udder and teat during milking can be studied. Congestion (i.e. the build-up of blood in the capillaries and other fluids in the teat tissue spaces) can be relieved by means of adequate magnitude and duration of liner compression around the teat end. The four phases of pulsation are defined by the International Standards Organisation as: a, liner opening phase; b, liner open or milking phase; c, liner closing phase: d, liner closed or rest phase. The duration of each phase is measured between the points at which the pulsation chamber vacuum plot intersects the abscissae drawn at 4 kPa below nominal system vacuum and above atmospheric pressure. During the d phase of the pulsation cycle, a compressive load facilitates venous flow and removal of excess interstitial fluid. The teat canals of congested teats close more slowly after milking, this delayed closure of the teat canal results in a longer window of opportunity for mastitis causing bacteria to pass through the teat canal. Thicker teats post-milking compared with pre-milking are associated with higher quarter somatic cell counts. The removal of mature keratin from the teat canal, which has been contaminated with, or colonized by, bacteria, at each milking is thought to play a significant a role in preventing bacteria from entering the mammary gland and causing infection.

Experiment description

A portable quarter-milking device was developed to apply various combinations of vacuum and pulsator settings during milking at the quarter level. Any liner/shell combination can be fitted to this device. In addition to precise measurement of milk flow rate (MFR) at the quarter level the device is equipped with vacuum transducers in the short milk-tube, mouth-piece chamber and pulsation chamber of each teat-cup. A custom Labview front panel facilitates selection of system vacuum and pulsation along with custom data logging frequencies and treatment interval periods. In order to estimate sample size requirements for future studies, we milked 18 cows with the device to quantify the variability in MFR during the peak flow period of milking (>80% of maximum MFR of each quarter). Milk flow rates were analysed for six second intervals during the peak flow period of milking. The standard deviations in MFR values were lowest when viewed within quarter. The mean MFR of all quarters was 1.056 kg/min with a standard deviation of 0.0459 kg/min. The range in MFR of the quarters was from 0.471 to 1.69 kg/min. The range of standard deviations observed was from 0.0225 to 0.0776 kg/min (Figure 1). In addition, when all quarters were grouped together, the standard deviation was 0.250 kg/min.

The mean MFR at the cow level was 3.79 kg/min with a standard deviation of 0.197 kg/min. The range in MFR at the cow level was from 2.10 to 51.0 kg/min. The range of standard deviations observed at the cow level was from 0.050 to 0.660 kg/min (Figure 1). In addition, when all cows were grouped together, the standard deviation was 0.771 kg/min.

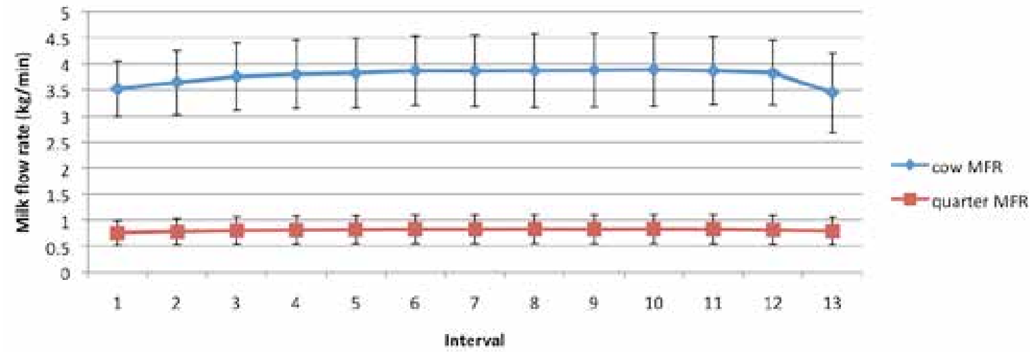

Figure 1. *Milk Flow Rate (MFR) for six second recording intervals during the peak flow period of eight cows (32 quarters) for milking vacuum level of 43 kPa and pulsator ratio of 0.70 (575 ms on-time, 250 ms off-time). Error bars represent the standard deviation (kg/min) within each six second recording interval*

Conclusion

This experiment showed that the natural biological variability in MFR during the peak flow period at the cow quarter level was an order of magnitude lower than the variability in MFR during the peak flow period at the level of the cow, which is important in choosing the sample size necessary to implement a robust experimental design. Implementing experimental treatments at the quarter level increases accuracy and ensures the device is suitable for estimating teat end tissue congestion induced during milking. This information is important for configuring milking systems which are gentle on teat tissue while maintaining acceptable milking speeds.

Performance of milking robots on Irish dairy farms

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Summary

- Automatic milking system (AMS) uptake is motivated by the perceived labour reduction, lifestyle change and potential to increase milk production
- Teagasc is currently profiling the performance of commercial monitor farms integrating AMS with grazing. Labour, milk production, water, electricity and economic data are being collected over 2014 and 2015 to assess the sustainability of AMS as part of grazing systems

Introduction

Sustainability of expansion requires a balance between an increase in milk production while ensuring economic viability, environmental stability, and social acceptance. Although an increase in production may result in an increase in profitability, it is often accompanied with an increased work load. Farmers are now looking alternative ways to expand or continue farming while maintaining sustainable labour input. However, investing in technology to reduce labour may counteract the economic benefits of expanding, due to high capital investment. Teagasc are currently conducting research to provide impartial evidence to assist farmers in their future decisions. This research is focused on the sustainable integration of AMS into grazing systems and reports the performance of a number of Irish dairy farms currently operating the technology with grazing.

Performance of AMS monitor farms

The AMS is linked to a computer which provides the farmer with instant information at both herd and individual cow levels. In this study there are seven farms with one to four AMS units. Results from 2014 were averaged per month for February to November. Milk production ranged between 224 and 1,930 kg milk/AMS/day (Figure 1) and between 15 and 33.6 kg/cow/day (Figure 2). The number of milkings ranged between 42 and 176/AMS/day (Figure 1) and between 1.5 and 3.2/cow/day (Figure 2). Concentrate supplementation ranged between 53 and 364 kg/AMS/day (Figure 1) and 0.9 and 5.9 kg/cow/day (Figure 2).

Labour input for AMS and conventional milking monitor farms

Seven AMS and seven conventional milking (CM) monitor farmers were given a SMART phone app to record time spent performing tasks three days each month between March 2014 and February 2015. The data were converted to hours per cow per month. The average labour input for AMS and CM farms was 1.32 and 2.04 (hours/cow/month) (Figure 3), respectively. The total dairy labour input for AMS and CM farms was 15.81 and 24.51 (hours/cow/year), respectively. There was a 36% reduction in total labour input for AMS farmers. The 'milking process' for CM farms involved herding cows, milking, yard and machine cleaning, for AMS farms it involved checking AMS data, fetching cows overdue for milking and robot maintenance and cleaning. Of the 36% reduction in total dairy labour, 27% is associated with the 'milking process' and 9% is associated with 'other dairy tasks' such as: calving cows, rearing of replacement stock, singeing of udder hairs/clipping of cows tails, grassland management associated with dairy - farm walk, topping, fertiliser spreading, slurry spreading and silage making, for example. Average daily time spent at the milking process was three hours for CM farmers and 40 mins for AMS farmers. The average daily time spent allocating grass was seven minutes for the CM farmers and 24 minutes for the AMS farmers.

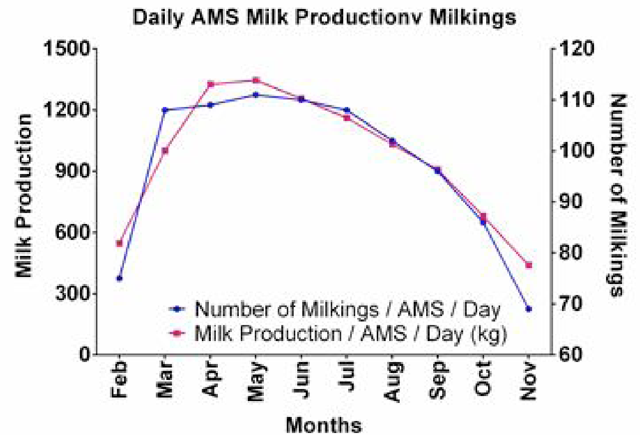

Figure 1. *Milk production and number of milkings per AMS unit per month for 2014*

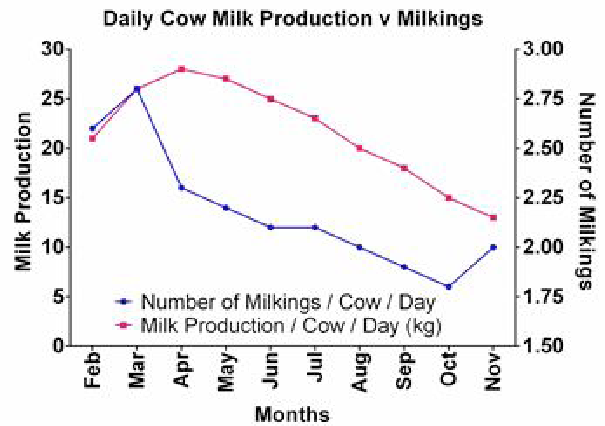

Figure 2. *Milk production and number of milkings per cow per month for 2014*

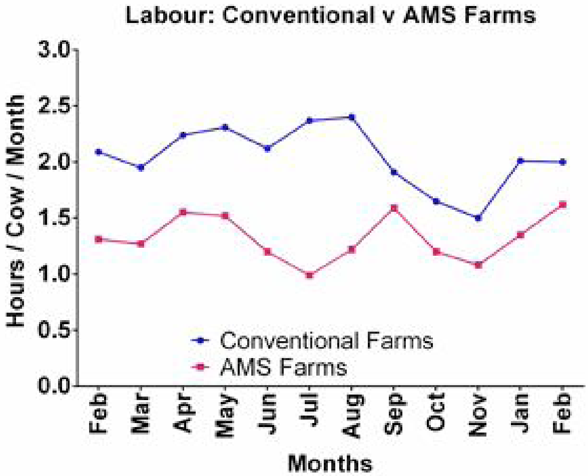

Figure 3. *Labour input for AMS and CM farms between March'14 and February'15*

Conclusions

Farmers integrating AMS with grazing, at peak milk production, have the potential to produce between 1,900 to 2,000 kg milk/AMS/day and achieve 170 to 180 milkings/AMS/day. Preliminary results suggest AMS reduced total dairy labour input by 36%.

CellCheck-the national udder health programme

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Summary

- A reduction of 10% in the national SCC would be worth €37.6 million for the Irish dairy industry
- Since 2011, when the *CellCheck* programme commenced, the proportion of Irish milk recording herds with an annual average SCC of 200,000 cells/ml or less, has increased from 26% to 53%
- The industry-agreed goal is that by 2020, 75% of the milk supplied by Irish farmers will have an SCC of 200,000 cells/mL or less

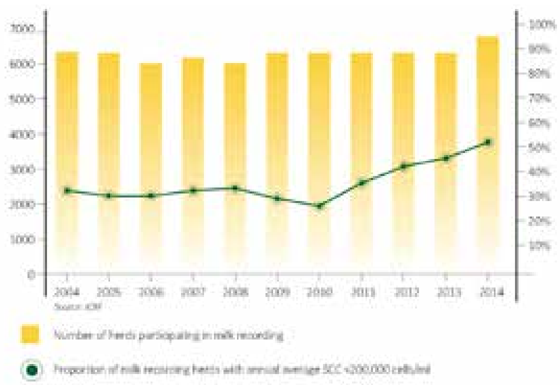
Background

Although Ireland is a relatively small dairy producer in global terms (accounting for less than 1% of world dairy production), the Irish dairy industry has a global reach, with more than 80% of all dairy production being exported. Over the last two decades, Ireland has become one of the world's leading producers of infant nutritional products. High quality value-added specialist dairy ingredients are also sold into the beverage, nutritional and bakery sectors globally, and continue to be a growth area, as is the sale of Irish branded dairy products direct to end consumers around the world. In 2014, the value of exported dairy products and ingredients was estimated to be in excess of €3 billion, a 55% increase since 2009.

Mastitis reduces milk yields and leads to poor quality milk. Together, these factors erode the milk income received by farmers and processors. In addition, antibiotic therapy used to overcome udder disease adds to dairy farmers' costs and stress. Both producers and processors stand to benefit strongly from reduced somatic cell counts (SCC): an SCC reduction from >400,000 to <100,000 cells/mL, results in an increase in overall returns to the farm of 4.8 c/L, including the farm and processor related effects. Nationally, if the SCC was reduced by 10%, it would be worth €37.6 million for the Irish dairy industry.

CellCheck programme

CellCheck is facilitating the industry in setting ambitious but achievable goals for the SCC of the national herd. Following consultation with stakeholders, it has been agreed that the common goal of the industry is that by 2020, 75% of the milk supplied by Irish farmers will have an SCC of 200,000 cells/mL or less. Preliminary analysis of data from Irish milk recording herds shows a positive trend in the udder health of Irish herds. In 2014, 53% of herds had an annual average SCC of 200,000 cells/ml or less, compared to 26% of herds in 2010.



Previous research in Ireland, such as the €uroMilk pilot mastitis control programme, identified inconsistent advice, a lack of a coordinated or "joined up" approach to mastitis control and a "normalisation" of high herd SCC as some of the obstacles at farm level, to improving udder health. A coordinated approach to improving udder health, such as that provided by *CellCheck*, thus provides many benefits for the Irish dairy industry, and individual farmers. The *CellCheck* Technical Working Group and other stakeholders have developed the following range of resources, aimed at assisting farmers and their service providers to manage mastitis:

1. Monthly articles provide key practical advice, as well as building awareness of the *CellCheck* programme and the value of improved udder health. The articles are available through the Teagasc Management Notes, co-op and IFA newsletters, vet clinic newsletters, the *CellCheck* website and social media.
2. *The CellCheck Farm Summary Report* uses dairy farmers' milk recording results to provide them with a clear overview of how their herds are performing in the area of mastitis control and udder health. It shows if a herd is on, above, or below target. It highlights the areas of excellence, and directs farmers towards areas that may require further attention.
3. *CellCheck Milking for Quality* Top 500 awards recognise the farmers with the lowest annual average SCC, based on the bulk tank SCC data. The SCC range for the winners of the inaugural awards, presented in 2014, was 25,000-103,000 cells/mL.
4. A series of *CellCheck* videos are available to view on the AHI website. These practical videos focus on key milking routines and practices that can reduce the risk of mastitis.
5. "*CellCheck Farm Guidelines for Mastitis Control*" contains independent, evidence-based information, providing clear, consistent messages. It is a practical management and advisory tool for farmers and service providers alike, available to purchase from co-ops or veterinary clinic for €15.
6. CostCheck is an interactive mastitis cost calculator, based on Teagasc economic research. It allows dairy farmers to quantify the financial gain that can be achieved by reducing SCC from current levels to a given target level. CostCheck can be found on www.cellcheck.ie and http://www.agresearch.teagasc.ie/moorepark/
7. *CellCheck* Farmer Workshops are designed to explore the causes of mastitis and highlight how making simple changes in everyday milking routines can improve and maintain lower SCC levels in your herd. The workshops are delivered by teams of four *CellCheck*-trained local service providers i.e. a farm advisor, a vet, a milking machine technician and a co-op milk quality advisor. Further details are available from *CellCheck* regional coordinators.

The work of *CellCheck* also includes the analysis of national bunk tank SCC data currently being collated by Department of Agriculture, Food and Marine. This work is essential in order to establish a baseline of national performance, and to identify trends.

Conclusion

While clear progress is being made, there are still opportunities to improve udder health nationally. *CellCheck* can play an important role in enhancing the quality of raw milk supply in Ireland, thereby improving profitability at producer and processor level. Elevated SCC levels do not have to be accepted as an inevitable part of dairy farming, and awareness is building among dairy farmers and within the industry that mastitis control is both eminently achievable and sustainable over time.

Importance of target weights when rearing replacement heifers

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Summary

- Achieving target weight is critical in any successful heifer rearing programme
- Wean calves based on weight - ~20% mature bodyweight
- Heifer weight needs to be continually monitored to ensure they achieve target weight
- Higher weight gains are achieved from grass thus early turnout is a critical component in achieving target weight at mating start date

Introduction

In seasonal calving systems of milk production replacement heifers should enter the milking herd at 22 to 24 months of age. The total costs associated with a replacement heifer from birth to calving is €1,545, this however increases substantially if the heifer enters the milking herd at greater than two years of age. A recent Moorepark study has shown that the most profitable replacement heifer rearing systems are those where heifers attain a target bodyweight (BW) which is 60% of mature herd BW at mating start date (MSD). As average daily weight gain during the pre-weaning or milk feeding period affects BW post-weaning this may have repercussions on the attainment of target weight at MSD. Therefore, it is critical that farmers aim to achieve target weights at specified time points from the day the heifer calf is born.

Target weights

Bodyweight (BW) and body condition score (BCS) are of greater importance at mating start date (MSD) than age. Recently a Moorepark study gathered BW and BCS information at MSD from over eight hundred and seventy Holstein-Friesian (HF) heifers on 48 farms across the country. It was clear that age (i.e. calving at <24 months) does not affect calving date, survivability or subsequent milk production performance. Heifers that achieve target weight at MSD were more productive and are more likely to survive to 2nd and 3rd lactation and ultimately result in greater profitability. Thus, ensuring maiden heifers achieve target weight at MSD is of critical importance. Every heifer rearing program should have a target BW or proportion of mature BW at MSD. At Moorepark studies have shown that heifers should be mated at 55 to 60% of mature BW and should calve at 85 to 90% of mature BW. A further target of 30% of mature BW at six months of age can also be set. Based on this research target BW at four critical periods are outlined in Table 1 for the more popular dairy breeds.

Wean by weight

Feed conversion efficiency of younger animals is a lot higher than older animals. Therefore, it is more economically efficient to feed young calves to ensure high rates of weight gain, particularly during the milk feeding period. A recent Moorepark experiment investigated the effect of weaning weight on heifer weight gain during the following summer months. Obviously, calves weaned at a higher BW will require a greater number of days drinking milk or milk replacer. Interestingly, calves weaned at 18% of mature BW (100 kg for a heifer with a mature BW of 550 kg) were still heavier than those weaned at <18% of mature BW when they were weighed again at 190 days (approx. six months old). The calves weaned at 18% of mature BW had a greater weight gain from birth to 190 days than the calves weaned at lighter weights. There was no difference in weight gain from weaning to 190 days of age between treatments, indicating that no compensatory growth occurred and that differences in BW at 190 days were due to differences in weaning BW rather than differences in post-weaning BW gain which may lead to differences at MSD. Thus, calves should be weaned at 18% of mature BW.

Table 1. BW targets (kg) for maiden heifers at weaning, six months, breeding and pre-calving					
	% Mature Weight	Weaning	6 month	Breeding	Pre-calving
HF	18	105	175	350	525
NZFR*HF	30	100	165	330	495
NR*HF	60	105	175	350	525
J*HF	90	90	150	300	450

HF = Holstein-Friesian, NZFR = New Zealand Friesian, NR = Norwegian Red, J = Jersey

Achieving target weights

The weight of replacement heifers needs to be continually monitored from weaning onwards. When heifers are brought back to the yard for dosing every 6 - 8 weeks their size and if possible weight gain should be observed. Some lighter heifers may require concentrate during the summer months to ensure that they maintain similar weight gains to the rest of the herd. If weanling heifers are below target weight they should be supplemented with concentrate in early autumn, discovering calves are under target weight at housing is too late. Recent Moorepark experiments show that calves supplemented with concentrate in autumn (September and October) gained 0.20 kg/calf more per day than those not supplemented during the autumn period.

A silage only diet is not suitable for heifers either at or below target weight over the winter months as weight gains are too low. Concentrate will need to be included to ensure heifers achieve target weight at MSD. The quantity of concentrate will depend on heifer BW at housing.

Early turnout

Regardless of diet offered over the winter weight gains achieved post-turnout are higher than that achieved during the winter. Heifers should be turned out to grass as soon as possible in spring, as they can gain up to 1 kg/day at grass compared to <0.70 kg/heifer/day while on their winter diet. Consequently heifers have a greater chance of attaining their target weight with early turnout.

Conclusions

Setting and achieving target weights are an integral part of any heifer rearing system. Frequent weighing of heifers is recommended to ensure that any underweight heifers are identified early.

Update on the latest calf mortality research from Moorepark

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Summary

- Managers of expanding dairy herds need to prioritise calving, calf health and biosecurity measures to prevent increased calf losses in larger herds
- New laboratory tests suggest infections may be more common than previously thought in aborted and stillborn foetuses
- The surprisingly high incidence of abnormal calves in this study has stimulated the setting up of national surveillance programmes by ICBF and DAFM

Introduction

With the current emphasis on herd expansion, reducing calf losses should be a critical management goal of every dairy farmer. In order to understand why calf losses occur, and to prevent such losses in expanding herds, Teagasc, Moorepark has recently conducted a large scale research study on calf losses in commercial dairy herds.

Research work in commercial dairy herds

This study was conducted on Munster dairy farms where farmers submitted all dead foetuses and calves for examination at the Post-Mortem Laboratory in Moorepark. This is the largest study of this type internationally. The main results for spring 2015 are reported.

Study results

The majority of calves submitted by farmers were stillborn (91%; n=355), the remainder aborted (9%; n=33). Aborted foetuses were defined as those which were born before full-term (<260 days) while 'stillborn' calves were born at full-term but died within 48 hours.

Month of abortion/calving

In the winter/spring of 2015, the majority of abortions occurred in January/February (94%) and the majority of stillbirths in February/March (77%). While we typically associate abortions with the autumn/winter, these data indicate that farmers need to be vigilant even during the calving season for abortions and to take appropriate biosecurity precautions.

Age-at-death

The majority of both aborted (91%) and stillborn calves (89%) were reported to have died within an hour of birth. However, even of stillborn calves reported as 'born dead', 29% had partially inflated lungs. This indicates that more apparently 'stillborn' calves may benefit from immediate, effective resuscitation than is generally realised.

Birth weight

As expected, the majority (97%) of aborted foetuses were <30kg. The majority (83%) of stillborn calves, however, were <40kg and only 1% were >50kg; over two-thirds (68%) were Holstein-Friesian/crosses and the remainder were Jersey/crosses (18%) or dual-purpose/beef crosses (14%). This suggests that relative foetal oversize is less important as a cause of stillbirth than in the past when more beef breeds were used in dairy herds.

Abnormal calvings

Consistent with the calf body weight data, almost two-thirds (63%) of stillborn calves did not suffer a hard calving and only 1% were delivered by C-section. However, over a quarter (27%) was not observed at calving. In addition, a quarter of stillborn calves were wrongly presented; these foetuses die in utero and so need to be picked up early and attended accordingly. To improve calving supervision we have started research at Moorepark on a biosensor to predict calving time. Over a third (36%) of aborting cows was assisted at calving; this carries biosecurity/zoonotic infection risks for the farmer.

Infections in the foetus

Bacteria or fungi were cultured from the abomasal contents of a third of aborted foetuses compared to only one in twenty stillborn calves (Table 1). Leptospira, Neospora, and IBR were either not detected or were detected in a negligible proportion of foetuses by traditional blood tests. Schmallenberg virus was not detected. However, new qPCR analyses picked up some 10 to 20% of test-positives. In addition, new biomarker tests detected that infections may be present in up to 20% of unexplained stillbirths.

Table 1. Infections detected in aborted and stillborn calves

Foetus (%)	Bacteria/ Fungi	Leptospira		Neospora		Schmallenberg	IBR
		Blood*	Tissue	Blood*	Tissue	Tissue	Blood*
Aborted	30	0	19	0	12	0	0
Stillborn	5	0	23	7	20	0	0

**excluding calves which consumed colostrum*

Congenital defects

There was a high incidence of abnormalities in both aborted and stillborn calves (Table 2). This finding has stimulated a joint research project between ICBF, Teagasc and DAFM. A national register for congenital defects has been set up to detect genetic defects (www.icbf.com) and the six Regional Veterinary Laboratories are conducting essential surveillance for both genetic and non-genetic defects nationally.

Table 2. Congenital defects in aborted and stillborn calves

Fetus (%)	Congenital defect present	Lethal congenital defect*	Multiple defects	Bowel defects**
Aborted	18	15	9	0
Stillborn	29	13	5	6

**likely to cause calf death, **blocked bowel, 'no back passage', 'waterbelly' calves*

Conclusions

Managers of expanding dairy herds need to be conscious of increased calf losses. New laboratory tests suggest foetal infections may be more common than previously thought. There was a high incidence of abnormalities in both aborted and stillborn calves.

Johne's disease control on Irish dairy farms

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Summary
- Control of Johne's disease on Irish dairy farms is important to maintain high milk quality status for international markets
- Control can be achieved by implementation of biosecurity and biocontainment measures such as restricting purchasing, strict implementation of diagnostics, strategic culling and improving calf management

Introduction
Johne's disease (JD) is an infectious bacterial disease of ruminants that occurs globally. It is caused by Mycobacterium avium subspecies paratuberculosis (MAP) and results in chronic wasting of cattle. It is invariably fatal. The disease primarily affects the wall of the gut causing it to thicken; this leads to poor absorption of nutrients by affected animals; hence the clinical signs of weight loss and diarrhoea. Infection with MAP predominantly occurs as a calf, with animals less than six months of age being most susceptible. Infection occurs when animals ingest a sufficient quantity of contaminated faeces, colostrum, or milk. Once an animal becomes infected the disease slowly progresses over years rather than months, with clinical signs normally only appearing in adult animals. It is estimated that approximately 25-30% of Irish dairy herds harbour JD carriers.

Control of JD
Diagnostic testing (see below) is essential to identify positive animals. Identification of positive animals aids herd management when implementing control strategies. Control of JD on farm involves two approaches depending on whether your herd is free of MAP or whether MAP carrier animals exist in your herd;

- For herds with no history of JD, it is necessary to prevent introduction through implementation of good biosecurity. The most common route of JD introduction is purchase of an apparently healthy, yet infected carrier animal. Purchase of stock should therefore be avoided. If new introductions are required for the purposes of expansion, purchased animals should be sourced from a low risk JD herd. A low risk herd is one that has never recorded a clinical case of JD and has had negative herd tests over five or more years. Many dairy herds now have JD results available due to participation in Animal Health Ireland's voluntary JD scheme or additional schemes such as those offered by milk recording companies and individual veterinary practices.

- For herds that have recorded confirmed or suspected cases of JD, biocontainment practices coupled to strategic culling become most important. Biocontainment is using practices which prevent the spread of disease within an individual herd where infection is already established. In the main, control is targeted at minimising transmission to calves as these are the most susceptible animals on the farm.

Biocontainment
In all herds regardless of status, control must be aimed at minimising the possibility of a calf consuming infected faecal material, colostrum, or milk. As dung is likely to hold the highest infectious bacterial load, hygiene is a key element for control, especially around calving. A clean, dry area for cows close to calving is essential as are clean and disinfected calving pens and calf pens. Regularly cleaning and bedding the calving pen is essential to

minimise the build-up of faeces and cross-contamination of newly born calves. In positive herds if a high risk cow has been identified or is suspected based on test results, it is important she is calved separately to the main herd. A small sheltered paddock that will not be used to graze youngstock can prove useful in this regard.

In all herds regardless of test status, calves should be removed from the calving area and cow as soon as possible and fed artificially. This minimises the risk of calves ingesting faecal material when attempting to suck. As MAP can be shed in colostrum, it is extremely important to ensure that each calf receives their own dam's colostrum, where practically possible. Under no circumstances should pooled colostrum be used to feed calves. This can lead to uncontrolled and untraceable spread of MAP to calves unrelated to the infected dam. In positive herds, colostrum or milk from a high risk cow should not be used to feed any calf including her own. A known low risk (young and test negative) donor cow's colostrum should be used. Feeding equipment such as buckets should be cleaned after each use to avoid bacterial build up and cross-contamination.

Prior to weaning, calves should be managed in group pens situated away from adult cows and adult manure. When calves are going to grass, use fields that have not been grazed recently by adult animals and/or those that have not had slurry recently applied. Ideally calf pastures should not have been grazed by adults in the last 6-12 months.

It should be noted that, not only will implementation of improved hygiene measures and colostrum management lower the risk of MAP spread on farm, it will also greatly improve calf health and will assist in the control of additional calf diseases such as scour and pneumonia.

Diagnostics

Herd testing of all breeding animals aged over two years is essential to determine levels of JD in your herd. Milk, blood and faeces samples can all be used for diagnostic testing. Diagnostics for JD are not clear cut and it is most useful to book a consultation with your veterinary practitioner to discuss results in detail. Significant progress can be made on Irish dairy farms through strict implementation of diagnostics, culling, and calving/calf management. Figure 1 outlines the reduction in the proportion of JD ELISA positive results in a single research herd over a three year period when strict biocontainment and biosecurity measures were implemented. This herd remains ELISA negative in 2015.

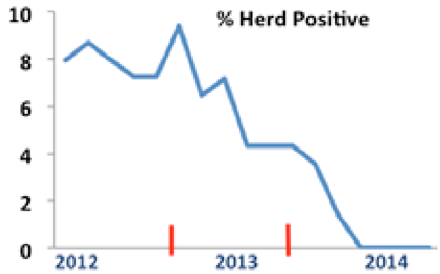

Figure 1. *Proportion of JD ELISA positive cows in a herd undergoing a control programme from 2012 to 2014*

Conclusion

JD control programmes must be aimed at breaking the cycle of transmission to susceptible calves. Identify high risk cows for either culling or specific management in order to reduce transmission and improve herd JD status. It works!

Healthy Herd - Healthy Milk

Prevalence of exposure to liver fluke in Irish dairy herds

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Summary

- Liver fluke result in significant economic losses on Irish dairy farms and strategic control programmes are required
- Prevalence data is critical to both raising awareness of parasitic infestations but also in designing appropriate control strategies
- In this regard, a survey of liver fluke prevalence was carried out in 2009; 75.5% of participating farms were bulk milk positive for liver fluke
- A prevalence up-date of dairy herds has been completed in autumn/winter 2014. The overall prevalence recorded was lower (55%), but highlights that effective control programmes are still required on dairy farms

Background

Liver fluke (*F. hepatica*) continues to impact on dairy, beef, and sheep farming enterprises worldwide. The cost of liver fluke globally is estimated at €3 billion with Irish estimates approximated at €90 million annually. The past number of years has seen the prevalence of liver fluke increase up to 12-fold across Europe. On this basis, Teagasc, Moorepark established a 'Herd Ahead' project in 2009, which generated epidemiological data on a number of infectious diseases including liver fluke. In this study an overall prevalence of liver fluke of 75% was found in dairy herds. An awareness campaign by both Teagasc and Animal Health Ireland has been underway since 2010 and as part of the Department of Agriculture, Food and the Marine (DAFM) funded *FLUKELESS* project, a prevalence update study was conducted in late 2014. This study involved determination of the prevalence of exposure to liver fluke in beef and sheep herds, in addition to the 300 dairy herds that partook in the 2009 Herd Ahead project.

2014 study

A total of 310 dairy herds took part in the study, the majority of which also participated in the 2009 study. Over 85% of study herds were spring-calving. This group of dairy herds are geographically representative of the Irish national dairy population. All participating farmers submitted a bulk milk sample in November 2014, using a standardized kit.

All the samples were analyzed for antibodies against liver fluke at Enfer Labs using an ELISA kit developed by University College Dublin. Prevalence was reported based on percentage of herds recording positive results against total herds tested. The prevalence was calculated for three different regions in Ireland (east, west, and south) of differing dairy animal density, soil type, and rainfall.

Results

Overall, 170 out of the 310 farms (55%) were positive for exposure to liver fluke. The prevalence in different regions ranged from 40% in eastern regions to 74 % in the west (Figure 1).

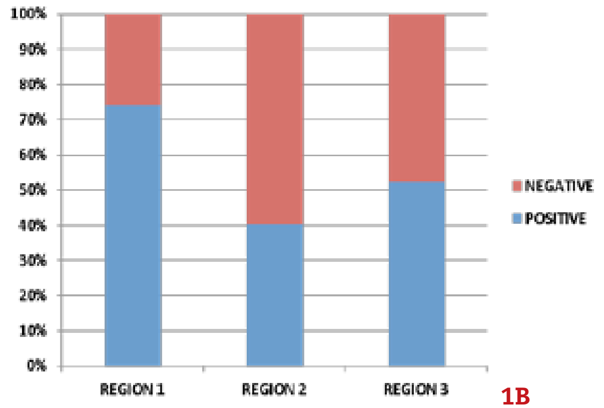

Figure 1a. *Map of Republic of Ireland outlining the location of study herds within three regions of differing dairy animal density, soil type and rainfall (obtained from Bloemhoff et al., 2014)*
Figure 1b. *Prevalence of exposure to liver fluke in dairy Irish herds in three different regions in 2014*

An overall prevalence of 75.4% was found in 2009, with the highest prevalence recorded in November. In comparison there has been a reduction in prevalence of bulk milk positive herds in the same period in 2014. The weather was undoubtedly a factor in the differing prevalences recorded between 2009 and 2014, but an improvement in liver fluke awareness and control at farm level is also likely. Having said that, over half of Irish dairy herds remain positive for exposure to liver fluke and control programmes remain a necessary part of dairy management.

Continuing to control liver fluke

Although the improvement in prevalence is notable, dairy farmers must remain vigilant and continue to strategically dose herds on the basis of test results. Teagasc research has found early November a useful time to sample herds using bulk milk analysis. This will allow administration of appropriate products while animals are housed over the dry period. It should be noted that dosing animals at pasture is not ideal as re-infection will continue to occur on contaminated pastures. The number of flukicide products available for use on dairy farms remains restricted to oxyclozanide, albendazole (both of which are only active against mature fluke and can be used during both lactation and dry period if correct withdrawals are observed), and triclabendazole (active against immature and mature fluke and can only be used during the dry period while observing strict withdrawals).

Conclusion

Although the prevalence of exposure to liver fluke was lower in 2014 than 2009, continuing vigilance is required based on recorded prevalence. All farmers should ensure that they have a control programme in place, even if the programme simply consists of diagnostic herd surveillance.

Management of the scouring calf

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Summary
- Calf scour results in mortality on Irish dairy farms annually
- Use an appropriate product to treat scouring calves and ensure it conforms to new EU legislation
- Continue milk feeding throughout the scouring episode
- Prevent scour by, implementing optimal colostrum and milk feeding, practicing good hygiene, and ensuring calves are bedded on deep clean dry bedding

Introduction

Calf scour results in calf mortalities on a high proportion of Irish dairy farms annually. Once scouring, a calf becomes rapidly dehydrated, acidotic, and low in essential electrolytes such as sodium (Na), Potassium (K), and Chloride (Cl). Treatment, therefore, should involve rehydration, correction of acidosis, and replacement of electrolytes. Some electrolyte products on the market, while assisting with rehydration and replacement of electrolytes, often fail to effectively correct acidosis which is essential to recovery of the calf. This has led to the introduction of new legislation across the EU (Regulation No. 1123/2014) which dictates a number of requirements that all scour treatments must conform to. Products meeting these requirements will state that they are fit for the "stabilisation of water and electrolyte balance to support the physiological digestion". Products not conforming will state that they are "complementary feeds" only. It is important therefore for dairy farmers to ensure that a product is appropriate to their requirements i.e. it will treat a calf with scour.

Causes and prevention of scour

Optimal daily feed requirements post-colostrum and transition milk feeding are approximately 15% of calf body weight i.e. 6 litres/day for a 40kg calf, below this will lead to reduced growth rates. Scour in calves can result from inconsistent feeding regimes or it can be due to an infectious cause. Infectious causes of scour are most common and Table 1 outlines common causes and when clinical signs are most likely to occur.

Table 1. Common causes of calf scour on Irish dairy farms with approximate times of occurrence

Cause of calf scour	Age clinical signs most commonly appear
Cryptosporidium parvum	First week of life
E.coli	First week of life
Rotavirus	1-3 weeks of age
Coronavirus	1-3 week of life
Salmonella	2 to 6 weeks of age
Coccidia	3 to 6 weeks of age

The most important means of preventing scour outbreaks are;

a) ensuring an adequate volume (three litres) of good quality colostrum is fed within two hours of birth. Aim for approximately 8.5% of birth body weight i.e. three litres for a 35kg calf. Use only the first milk from the freshly calved cow - subsequent milkings (transition milk) do not contain enough antibodies to develop the calf's immune system adequately and consequently the calf cannot fight off infection. It should be noted that

60-70 % of neonatal calves undergoing post-mortem at regional veterinary laboratories have inadequate absorption of protective antibodies.

b) practicing excellent hygiene of calf pens and feeding utensils. Keep calf pens clean and freshly top up with dry bedding. A damp, cold calf will be more susceptible to infectious pathogens in the environment. Feed buckets must be kept clean in order to prevent build-up of bacteria.

Treatment

Treatment of calf scour involves rehydration of the calf, replacement of lost electrolytes and correction of acidosis. Teagasc, Moorepark undertook an experiment in spring 2015 evaluating the effectiveness of a scour treatment that conforms to the new EU legislative requirements[1]. Blood gas measurements were taken from both normal and scouring calves for comparative purposes. Treatment was only administrated to scouring calves. Treatment was also administered and monitored on a number of commercial farms experiencing scour outbreaks as part of their routine calf management and disease control. In all, 99 dairy calves, aged between 0 and 5 weeks approximately, were studied. Calves were scored using the health chart below and all calves were tested using rapid blood gas analysis. The more severe the acidosis recorded by blood gas analysis, the worse the clinical calf score. Calves with poorer health scores have lower feed intakes which continues the cycle of dehydration and acidosis. Blood pH and base excess pre-and post-treatment was measured, the results of which are outlined in Figure 1. The product was administered by stomach tube to ensure that calves received the full dose required. Extra fluids over and above the normal two milk feeds will assist with rehydration. Additionally, as the majority of sick calves in this study were incapable of independent milk feeding, mixing the product with milk served no additional advantage.

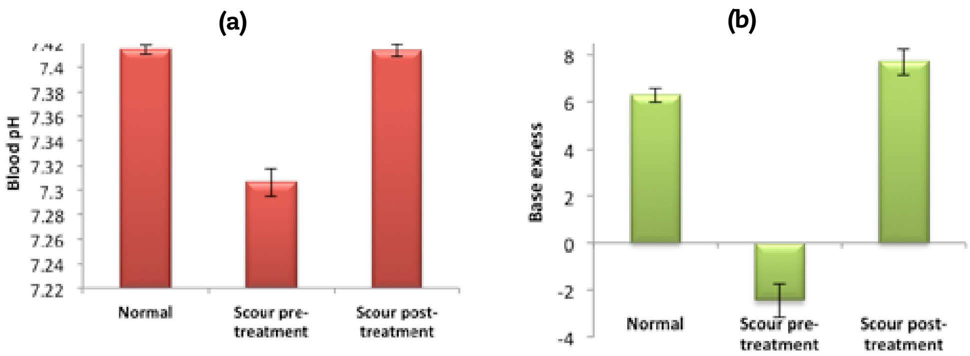


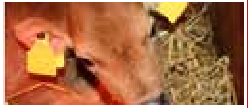
Figure 1. *Blood pH (a) and base excess (b) comparison across normal and scouring calves pre- and post- electrolyte treatment*

Conclusion

The results indicate that treatments conforming to new EU legislative requirements have the potential to restore blood pH and base excess within a 12-18 hour period thereby facilitating a quick recovery of calves from a scouring episode.

[1] *www.vitalifeforcalves.ie*

Assessing Scouring Calves

Score	0	1	2	3	4
		 	 	 	
Demeanour	Bright, alert, responsive	Dull, possibly depressed, less responsive	Dull, depressed, less responsive	Dull, markedly depressed, markedly unresponsive	Unresponsive to any stimulation
Ears	Alert and mobile	Slightly drooped	Drooped	Drooped and limp	Drooped and limp
Mobility	Actively mobile and able to stand without assistance or intensive encouragement	Capable of standing and walking independently with a little encouragement	Capable of standing and walking independently but encouragement required	Capable of standing with assistance but unable to walk	Recumbent
Interest in surroundings	Interactive when approached	Interactive when approached	Uninterested when approached	Uninterested when approached	Uninterested when approached
Suck Reflex	Good suck reflex	Diminished suck reflex	Markedly diminished suck reflex	No suck reflex	No suck reflex
Feed intake	Feeding well	Slow to drink and may not finish what is offered	Reduction in feed intake (not finishing what is offered)	No feed intake (not taking any of what is offered)	No feed intake (not taking any of what is offered)
Dehydration	Clear bright eyes	Eyes slightly sunken	Eyes sunken	Eyes markedly sunken	Eyes markedly sunken
Action	• None	• Isolate for monitoring and treatment • Monitor hydration status • Continue milk feeding	• Isolate for monitoring and treatment • Rehydrate • Correct blood acidosis and electrolytes • Continue to offer milk	• Isolate for monitoring and treatment • Rehydrate • Correct blood acidosis and electrolytes • Continue to offer milk	• Isolate for monitoring and treatment • Veterinary assistance required

Schmallenberg - is it history or could it re-emerge?

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Summary

- Blood-sampling has confirmed that there is no evidence of recent Schmallenberg virus circulation on Irish dairy farms
- However, vector trapping studies have shown that the insects (biting midges) known to transmit Schmallenberg virus are widely present on Irish dairy farms
- As a consequence, a large population of youngstock are now naïve to Schmallenberg virus and may be at increased risk of infection if the virus re-emerges in the future

Introduction

Schmallenberg virus (SBV) was first identified in north-western Europe in 2011. The first Irish case was confirmed in 2012. Subsequently, SBV rapidly achieved a pan-European distribution resulting in an epidemic of ruminant abortions and congenital deformities. Since then the epidemic has abated. But the questions now facing veterinary researchers are;

(i) Could SBV re-emerge?

(ii) Could other arboviruses come into the country?

(iii) How well prepared are we to deal with such national biosecurity threats?

In collaboration with the Department of Agriculture, Food and the Marine (DAFM) and UCD, we have been addressing these questions at Teagasc, Moorepark.

Current Schmallenberg status in Ireland

The virus most likely came into Ireland as a result of the windborne spread of SBV-infected *Culicoides* midges from continental Europe. Since the first case in 2012, 49 congenitally deformed calves were confirmed by DAFM in 2012 and 2013. Sero-surveys conducted in 2012 and 2013, demonstrated that much of the south and south east of the country had been exposed to SBV during 2011-2012, while the north and north-west remained predominantly unaffected. However, it is not known whether the virus continues to circulate in dairy herds following initial exposure to the virus in 2012.

Schmallenberg research in Teagasc

Immediately after the initial Irish cases, a large scale collaborative research project was set up on dairy farms in Munster. The overall project objectives included determining animal-level seroprevalence of exposure to the disease, determining the usefulness of bulk tank milk samples for Schmallenberg disease surveillance, investigating SBV insect vector species and habitats on Irish dairy farms, and determining the involvement of SBV in abortions and perinatal deaths.

Sero-surveillance study

In spring 2014, approximately 5,000 individual animal blood samples were collected from 26 dairy herds and tested for SBV-specific antibodies. Sixty one percent of animals were seropositive. Seropositive animals were primarily lactating cows greater than two years of age. Seronegative animals (39%) were predominantly replacement heifers (97.4%). This large population of seronegative animals were primarily less than two years of age (born in spring 2013), suggesting that they were not exposed to SBV during 2013 and could be at risk of SBV infection in future vector-active seasons should virus recirculation occur. Within-herd seroprevalence ranged widely (8.3% to 97.5%) across the 26 herds suggesting individual herds have variable risk of new infection.

Bulk milk testing study

Exposure to SBV was also evaluated in dairy herds using a bulk milk ELISA (BM-ELISA) test. Bulk milk samples were collected from study herds and analysed for SBV-specific antibodies. Twenty four herds were BM-ELISA positive (herd seroprevalence ranged between 30% and 100% in lactating cows), and two herds were BM-ELISA negative (seroprevalence 10% and 16% in lactating cows). This suggests that herds with a negative BM-ELISA result are not exempt from exposure to SBV. The usefulness of the BM-ELISA in predicting the within-herd SBV seroprevalence was also evaluated using statistical analyses. Results suggest that the BM-ELISA is a moderate predictor of within-herd seroprevalence and is a useful tool for farmers and veterinary practitioners in assessing herd exposure to the virus and for subsequent monitoring and risk assessment.

Foetal infection study

Surveillance post-mortems for in-utero SBV infection were also carried out on aborted foetuses and stillborn calves submitted from study herds in the spring and autumn of 2014. Lesions typical of in-utero SBV infection include deformed limbs, fused joints and vertebral and central nervous system malformations. All suspect congenital SBV cases were tested for the virus. In total, six suspect SBV cases and six aborted/mummified foetuses without lesions were tested but PCR analysis did not confirm SBV involvement. This does not rule out SBV due to the time lapse between infection and birth.

Vector epidemiology study

Culicoides biting midges are the main insect vector to transmit SBV from an infected animal to a naïve animal, potentially causing disease. *Culicoides* are also known to transmit other viruses (arboviruses) such as Bluetongue virus (BTV). Very little is known about the ecology of these types of midges on Irish dairy farms. A study was set up, therefore, to characterise the species and habitats of midges on farms where exposure to SBV had previously been reported. Ultraviolet midge light traps were set up overnight at selected locations on 13 of the study farms. Trapped midges were subsequently identified to species level. While identification is currently on-going, provisional results indicate that *Culicoides* were common on studied farms. The most abundant species identified to-date are members of the *Culicoides* pulicaris and *Culicoides obsoletus* groups. These groups are known to transmit SBV and BTV.

Conclusions

Comprehensive research studies at Moorepark have highlighted no evidence of SBV circulation during 2013. However, a large population of naïve animals is now present on Irish dairy farms. This increases infection risk should SBV circulate in future years, in which case vaccination may be proposed to protect livestock against infection. In addition, the species of midge known to spread SBV have been definitively shown to exist on affected Irish farms. So, while Schmallenberg may currently be history for farmers, it is still very much a live issue for veterinary researchers across Europe.

Johne's disease from an International perspective

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Summary
- Johne's disease (JD) is a chronic disease affecting cattle and other animals with the potential to cause substantial economic losses
- Considerable efforts are directed towards the control of this disease in many countries
- In Ireland, research is being conducted to assess diagnostic tests and to develop/assess control strategies at farm level

Introduction

Johne's disease (JD) or paratuberculosis is a chronic disease caused by Mycobacterium *avium ssp. paratuberculosis* (MAP), affecting ruminants and other animals. Johne's disease in cattle causes inflammation and malfunction of the intestinal tract leading to diarrhoea, weight loss, malnutrition and death.

Disease presence in Ireland and other countries

The animal-level prevalence of Johne's disease found in a study conducted in Ireland was 2.7% for dairy herds and 3.1% for beef herds, similar to that found in other countries (eg. USA and Canada), (Table 1). Reported apparent herd-level prevalence of Johne's disease varies widely e.g. for dairy cattle: 31.5% in Ireland, 70.4% in US, and 85% in Denmark (Table 2). However, comparable estimates of prevalence are difficult to obtain as they depend on factors such as sampling strategy and diagnostic methods.

The diagnostic tests more commonly used are milk-ELISA, serum-ELISA and faecal culture. However, false negative and false positive results represent a challenge for the correct identification of MAP infected animals and for disease control purposes.

Table 1. Examples of MAP animal level prevalence studies

Country	Year	Cattle Type	# Herds/ # Cattle	Reported Prevalence	Diagnostic Method
Canada	2002	Dairy	90/2,604	3.40%	Serum ELISA
Spain	2007	Dairy	1,210/ 38,077	4.03%	Serum ELISA
Spain	2007	Beef	1,497/ 22,964	2.07%	Serum ELISA
Ireland	2009	Dairy	165/not reported	2.74%	Serum ELISA
Ireland	2009	Beef	458/not reported	3.09%	Serum ELISA

Disease impact on farm performance and profitability

Johne's disease has the potential to cause substantial economic losses to the cattle industry. The economic impact of paratuberculosis in herds will depend on the number of animals affected, infected, infectious (shedding bacteria), showing clinical signs, or in the subclinical stage. Economic losses are mainly related to decreased milk yield, increased premature culling, higher replacement costs, reduced feed conversion efficiency, fertility problems, reduced slaughter values and increased susceptibility to other diseases or conditions. Several studies have reported a correlation between the prevalence of paratuberculosis within herds and milk production with reductions of mean milk yield between 500 and 1,400 kg per cow in the lactation when the infection was detected. A significant milk yield reduction of 24% (1,528 litres) was observed in a single Irish herd affected with paratuberculosis including both clinical and subclinical animals. In this particular herd, some animals had been previously imported from continental Europe. Most studies have found consistently larger effects in faecal culture-positive cows in comparison with ELISA-positive animals reflecting that the impact of paratuberculosis on milk production can also be influenced by disease status. In fact, the economic impact of the disease on farms will depend on the number of animals showing clinical signs or in the subclinical stage of the disease. The impact on profitability when there are clinical cases can be substantial, but the impact due to subclinical cases is less clear and the vast majority of infected Irish cows are sub-clinical. In the US, the costs attributable to the disease in positive herds (based on ELISA testing) was estimated to be US-$100 per cow compared with negative herds, while the cost of the disease in herds with clinical cases was reported to exceed US-$200 per cow. A French study estimated paratuberculosis associated yearly costs of €1,940 for a clinical case and €461 for a subclinical case. Because there is no clear consensus in the literature in relation to disease costs, particularly for subclinical cases, an Irish study is currently being completed in this area.

Table 2. Examples of MAP herd level prevalence studies

Country	Year	Cattle Type	# Herds/ # Cattle	Apparent Prevalence	Reported Prevalence	Diagnostic Method
US (CA)	2003	Dairy	65/1,950	68.0%	NR	Serum ELISA
Canada	2003	Dairy	50/1,500	40.0%1	26.8%	Serum ELISA
Spain	2007	Dairy	1,210/ 38,077	36.0%	27.8%	Serum ELISA
Spain	2007	Beef	1,497/ 22,964	10.7%	2.8%	Serum ELISA
Ireland	2009	Dairy	165/ not reported	31.5%	20.6%	Serum ELISA
Ireland	2009	Beef	458/ not reported	17.9%	7.6%	Serum ELISA
US	2013	Dairy	524 herds	70.4%	91.1%	Composite fecal culture

[1]*Based on two or more animals testing positive*

Control strategies

Countries like the Netherlands, Denmark, USA, Canada and Australia among others are implementing Johne's disease control programs. For example, the U.S. Voluntary Bovine Johne's Disease Control Program (VBJDCP) provides participant producers with guidelines and classifies herds based on risk assessment. The combination of farm management (e.g. providing hygienic housing for calves, a clean, well-bedded and adequately sized calving area, separating calves from the cows at birth, and use of individual cow colostrum) with diagnostic testing are features of virtually all control programs internationally. Animal Health Ireland is currently conducting a pilot Johne's Control Programme for dairy herds. Further details and how to enrol can be found at www.animalhealthireland.ie

Conclusions

Johne's disease is an important disease of cattle that has the potential to cause substantial economic losses. The main challenge identified for the control of Johne's disease in cattle is the limitations of current diagnostic tests. Nevertheless, improving biosecurity is highly recommended for the control of Johne's disease and to reduce the risk of introduction and/or spread of other infectious diseases. In addition, calf management practices that prevent the likelihood of disease transmission when the animals are most vulnerable have been recommended to break the cycle of Johnes transmission.

Rearing healthy calves

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Summary

- Good hygiene will reduce calf morbidity and mortality
- Feeding calves 8.5% of their birth bodyweight in high quality colostrum within two hours of birth is essential to ensure adequate immunity
- Calves should be fed 15% of their birth bodyweight in milk or high quality milk replacer daily after at least four feeds of transition milk
- Calves can be fed their milk or milk replacer once-a-day from four weeks of age, once they are eating concentrate and thoroughly checked twice per day

Introduction

Current mortality rates on Irish dairy farms are >7%, halving this figure would be worth >€3 million to the Irish dairy industry. To ensure future profitability and sustainability on Irish dairy farms, mortality rates of 3% or less must be targeted. High incidences of illness and disease on farms must also be reduced as disease outbreaks can reduce growth rates resulting in replacement heifers not achieving target weights and calving at >2 years old. Failure to achieve target weights can reduce farm profitability by over €7,000 (for a 100 cow herd). A recent Teagasc Moorepark study revealed that colostrum management practices were poorer on farms with higher mortality rates. Good hygiene is an important factor in the control of calf morbidity and mortality. Regular cleaning of both calf pens and feeding equipment is associated with lower incidences of persistent illnesses (e.g. scour), and lower mortality rates. Regular disinfection of calf pens will minimise cross contamination between calves and disease risk.

Colostrum management

Implementing an effective colostrum management plan is arguably one of the most important jobs completed on a farm. Calves are born with no developed immune system and depend entirely on the absorption of antibodies from colostrum to ensure adequate immunity to disease and infection before development of its own immunity occurs at three to four weeks of age. Adequate passive transfer (APT; i.e. adequate absorption of antibodies) has been shown to have numerous short and long term benefits, including reduced risk for pre- and post-weaning morbidity and mortality, improved rate of weight gain and feed efficiency, as well as greater milk production and survival in dairy animals. Failure to achieve APT can result in high levels of pre-weaning mortality during the first three weeks of life. Three main factors affect APT i) the volume of colostrum the calf receives, ii) how soon after birth the calf receives colostrum and iii) the quality of the colostrum.

How much colostrum does a calf need?

Calves should be fed 8.5 % of their birth bodyweight in colostrum. Typically this equates to three litres for a 35 kg calf. This can be either stomach tubed or fed using a bottle and teat. Colostrum should always be fed warm (body temperature). The calf **should not** be left with the cow to drink its first feed as the volume of colostrum the calf consumes is unknown and also, as the calf has no developed immune system it is more susceptible to contracting disease.

How soon should the calf be fed colostrum?

The calf should be fed colostrum as soon as possible after it is born. The ability of the calf to absorb antibodies halves by the time the calf is six hours old and once the calf reaches 24 hours old, its ability to absorb antibodies has ceased completely. Furthermore, the sooner calves are fed after birth, the more easily they will drink from a bottle and teat.

How can colostrum quality be maximised?

It is important to remember that only the first milk produced after calving is colostrum; milkings two to six are called transition milk and do not contain the antibodies necessary for adequate development of a calf's immune system. It is important to remember that colostrum quality decreases as the interval between calving and first milking increases, as the cow is producing more milk and diluting the antibodies. If calves are not fed their dams colostrum they should be fed colostrum from another single cow which has been tested and deemed free from Johne's disease and is in apparent good health. Colostrum should not be pooled as this increases the risk of spreading Johne's disease, as well as diluting good quality colostrum with poor quality colostrum. It is also worth noting that colostrum which is stored at room temperature grows bacteria inhibiting the absorption of the antibodies from the colostrum by the calf.

Milk feeding

Although no more antibodies can be absorbed after 24 hours, Teagasc Moorepark research has shown that feeding calves four feeds of transition milk can reduce the incidents of nasal and eye discharge, as well as drooping ears. Traditionally, calves were offered milk or milk replacer at 8-10% of their birth body weight (BW) per day (approx. 4 litres), which limits their growth and weight gain. Feeding milk at a daily rate of 13-15% BW (approx. 6 litres) should be sufficient to allow calves reach over 50% of their growth capacity. Calves can be fed milk once a day from three to four weeks of age but not before this as their abomasum is not big enough to deal with a large volume of milk. Also, their rumen is not developed so they cannot fully digest concentrate. Once calves are well managed and thoroughly checked at least twice per day no differences in calf performance or health should be observed between calves fed once or twice a day. This provides valuable information to farmers as it means labour input per calf may be reduced by utilising a once a day feeding regime in the knowledge that it has no unfavourable repercussions on the growth and health of calves.

Conclusion

Calves should be fed 8.5% of their birth body weight in high quality colostrum within two hours of birth. This should be followed by four feeds of transition milk. High quality milk or milk replacer should then be fed at a daily rate of 13 - 15% of birth body weight.

MANAGING EXPANSION

Professional diploma in dairy farm management

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Summary

- This programme aims to equip future dairy farmers with a broad range of skills, experience and practical knowledge
- The course is a two year paid professional work experience based programme on high performance dairy farms, with an option to travel overseas
- There are approximately 25 days per year of course work, where students develop skills covering a broad range of topics such as grassland management, animal breeding and reproduction, herd health, business and financial planning and developing people management skills
- Applicants must possess a Level 6 Advanced Certificate in Agriculture or an equivalent recognised agricultural award
- This professional diploma award programme is a full time two year course and is validated by University College Dublin (UCD)

Introduction

The targeted expansion in milk production on Irish dairy farms has been well documented. However, this growth can only be achieved with a supply of well trained professional farmers. Both farm owners and farm managers must have the experience and skills needed to cope with the many challenges facing the dairy industry. The Professional Diploma in Dairy Farm Management (PDDFM) course will provide the next generation of dairy farmers with the additional skills and knowledge to meet the challenges of an expanding industry in the future.

Professional diploma in dairy farm management: course structure and content

The PDDFM programme was developed by Teagasc in conjunction with UCD and in consultation with other dairy industry stakeholders to provide suitably skilled and experienced dairy farm managers for the expanding dairy industry. The programme is centred on experience based learning from host farmers and also incorporates both formal (lectures) and informal (discussion groups) training. The programme aims to equip future dairy farmers with a broad range of skills, experience and practical knowledge to become successful managers (both on home farms and as employed farm managers).

The core elements of PDDFM are a two year paid professional work experience based programme on high performance dairy farms, with an option to travel overseas to New Zealand to experience the calving and breeding seasons on large scale, grass based farms. While on work experience, students have the opportunity to implement their technical knowledge in a controlled learning environment. There are approximately 25 days per year of course work at the Teagasc Animal and Grassland Research and Innovation Centre at Moorepark and Teagasc Kildalton Agricultural College. Students develop skills covering a broad range of topics such as grassland management, animal breeding and reproduction, herd health, business and financial planning and developing people management skills. The contact element of the programme is delivered by an integrated team of highly specialised Teagasc staff including Moorepark researchers, college lecturers and knowledge transfer specialists. Guest lectures are invited from key industry stakeholders and highly successful commercial dairy farmers. The programme incorporates discussion groups facilitated by a Teagasc facilitator.

The aim of the programme is to maximise student's career prospects in the dairy industry. This is achieved by supporting them in gaining solid experience and career development. On completion of the PDDFM course, students will be able to manage a farm - either their own farm or as an employed farm manger. The students will have developed the skills required to build a resilient farm system that has the capability to not only adapt to change but also capitalise on any opportunities created. Additionally, they will have the ability to maintain productive capacity in the face of production, financial and market variability.

The first graduates from PDDFM course graduated in November 2014 and have been successfully employed in Ireland, New Zealand and Saudi Arabia as dairy farm managers, as share farmers or as managers on their own family farms.

Entry requirements and application procedures

Applicants must possess a Level 6 Advanced Certificate in Agriculture or an equivalent recognised agricultural award. Applicants will be shortlisted and those candidates will then be interviewed before selection for entry to the programme.

Course information

This professional diploma award programme is a full time two year course and is validated by UCD. Course fees are currently €800 per annum. Students on this programme enter into an employment agreement with the host farmer. The host farmer pays the student at least the minimum wage (currently €8.65) per working hour.

The block release days are generally held as either one day courses or three consecutive course days per month.

Collaborative farming: a suite of options to improve the structures of Irish dairy farming

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Summary

- Partnership:
  - A registered family partnership can be the first step in the succession process of the family farm.
  - Registered Partnerships are open to all enterprises from 2015 onwards.
- Contract rearing:
  - An opportunity for expansion and labour efficiency for the dairy farmer.
  - An alternative to drystock enterprises for retiring farmers and drystock farmers.
- Share farming:
  - Provides an avenue of entry to dairy farming for young trained people.
  - Option to continue in farming for farmers with no family or no successor
- Land leasing / CGT restructuring relief
  - Leasing gives security of tenure to the lessee and access to income tax benefits to the landowner
  - Restructuring relief is a financial aid measure to help make fragmented farms become more viable through consolidation of the holdings

Registered farm partnerships

A registered farm partnership is a profit sharing arrangement between two or more farmers that is registered on the new Register of Farm Partnerships maintained by the Department of Agriculture, Food and the Marine. In the context of the family farm, registered farm partnerships are an excellent transition arrangement that facilitates the succession process until the parents are ready to transfer over the farm entirely to a son or daughter. In the context of non-family situations, two or more farmers can combine their respective farming operations into one single operation and they each take a share of the profits.

Registered farm partnerships - family situations

Transferring the family farm is often complex and therefore needs early and careful planning. In many cases, parents are not in a position to transfer the farm to a son or daughter that has returned home after completing their agricultural education. The reasons for this are usually linked to concerns about the implications for family farm income and security for the parents and other family members. These concerns can be alleviated by forming a registered partnership between the parents and the son or daughter as an interim step before considering full transfer of the farm. There are advantages to forming a partnership for both the parents and the son or daughter.

Registered farm partnership - non-family

A partnership with other farmer(s) may offer the opportunity for increased scale in a sustainable manner. The main advantages include: making use of the existing facilities on farm, which may reduce the level of capital expenditure; a wider skills mix; greater labour efficiency; and a better lifestyle.

A key strength of registered partnerships is that it facilitates expansion without having a negative impact on lifestyle. Partnerships have been shown to improve lifestyle on dairy farms even in the absence of expansion through a fair and even distribution of workload between the partners. There is also greater peace of mind knowing that the other partner is carrying out the day to day operations satisfactorily, as they also have a vested interest in the efficient running of the business. Working in partnership often means there is a better range of knowledge and skills available to the partnership business. This facilitates better and more informed decision making on a wide range of subject areas. Discussions among partners mean that business decisions are teased out further and explored in greater depth.

Dairy share farming

The key feature distinguishing share farming from a partnership is that two completely separate farming businesses operate on one farm. The concept remains the same across all enterprises. In a share farming agreement, the milk is sold to the processor and each person gets an agreed proportion of the sale proceeds. In addition to this, each person in the agreement pays a proportion of the variable costs such as feed, fertiliser and veterinary costs. Some of the fixed costs such as machinery costs may also be divided.

The starting point for this arrangement is a financial budget to cover potential income and expenditure from the enterprise. The share farmer generally provides all of the labour and in some cases, the livestock and/or machinery. The land owner provides the land and the facilities required for the dairy enterprise to be successful.

With the abolition of milk quotas on the 31st of March this year (2015), a dairy share farming model has now been developed. A specimen agreement is available from Teagasc (http://www.teagasc.ie/advisory/share_farming_dairy/). A specific budgeting tool will also be available along with previous financial management aids to help interested farmers carry out a cash flow budget and a business plan for the arrangement.

Long-term land leasing

Tax incentives to encourage long-term land leasing (at least five years) have been introduced. These measures were strengthened in the 2015 Budget and Finance Bill as follows:

- Increased tax-free thresholds
- Removal of 1% stamp duty
- Confirmation that both the annual rent and the SPS entitlement value can be rolled together
- Limited companies can now qualify the lessor for the tax incentives
- Removal of the 40 year age limit.
- Land may be leased for up to 25 years.

Benefits to lessor

The key benefit to the lessor is that the income received from a long-term land lease and the value of any Basic Payment Entitlements is tax free income subject to the limits set out in Table 1. Another key benefit is that the lessor can qualify for retirement relief on capital gains tax when they do transfer the land to a family member or sell on the open market. Capital gains tax is charged at 33%. By entering into a long-term land leasing arrangement with the lessee, the landowners are providing a better incentive to the lessee to make investments in the land such as reseeding, fencing, and possibly infrastructure.

Table 1. Tax incentives for long-term land leasing			
2014		2015	
Term of Lease	Max Tax free Income/year	Term of Lease	Max Tax free Income/year
5-7 yrs	€12,000	5-7 yrs	€18,000
7-10yrs	€15,000	7-10yrs	€22,500
>10 yrs	€20,000	10-15 yrs	€30,000
		>15 yrs	€40,000

Benefits to lessee

The key benefit to the lessee is that the long-term lease provides security of tenure. This allows the lessee to plan the farm business with more certainty. For example, a long-term lease may increase the size of the grazing platform, and thereby facilitate expansion of the herd. To do this on a short-term rental involves a higher level of risk as the long-term availability of the land is uncertain. The extended term of lease allowable under the new provisions mean that the lessee can look at investment in the land in a new light. It may be easier to justify any investment carried out with a long-term lease, which can be up to 25 years.

Capital gains tax - restructuring relief

The aim of the scheme is to provide relief on Capital Gains Tax (CGT) to encourage farmers with fragmented farms to consolidate their holdings and thereby improve their viability. The relief is only available on the sale and purchase of qualifying lands that meet the key criteria of the scheme. Capital Gains Tax restructuring relief should be given serious consideration by farmers in parts of the country where farm fragmentation is an issue. It may involve a collaborative effort by a number of farmers to make it work in practice. Essentially, it allows parcels of land to be exchanged between farmers to reduce the number of fragmentations farmed by each farmer, and potentially increase the size of the grazing platform.

Restructuring relief operates where a parcel of land is sold by an individual farmer (or joint owners) and where another parcel of land is bought by the same farmer (or joint owners) and both of these transactions occur within 24 months of each other. The initial sale or purchase must have taken place in the period 1st January 2013 and 31st December 2016.

The combination of the sale and the purchase together must result in an overall reduction in the distance between parcels of land making up the farm, including leased parcels that have been leased for at least two years with a minimum of five years to run. The entire transaction must lead to a reduction in the fragmentation of the farm and an improvement in the operation and viability of the consolidated farm.

The scheme has been extended in the 2015 budget to include the disposal of an entire fragmented farm and its replacement with another farm subject to meeting the original criteria of the scheme.

Conclusion

Farmers wishing to get involved in collaborative arrangements should seek the advice of relevant professionals and consider each option carefully before choosing the one that is most appropriate to meet their farming circumstances.

Photo 1. *Frank, Kitty and Ivor Tanner: farming in a family farm partnership in Newcestown, Co. Cork*

Photo 2. *Jeffery Good and Peter Hynes: Farming in a family farm partnership in Aherla, Co. Cork*

Photo 3. *Gerard Creedon and Patrick O'Flynn farming in a non-family partnership in Aherla, Co. Cork*

Labour requirements on dairy farms

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Summary

The key findings to emerge from recent Teagasc research into labour usage on Irish dairy farms include:

- Labour efficiency increased as herd size increased
- An increase in hired labour was evident on larger farms
- Partner and family labour was supplemented by hired labour as herd size increased
- Labour input by the main operator remained relatively consistent across herd size categories
- The most labour efficient farms increasingly used contractors to perform tasks

Introduction

After milk price variability, the availability of skilled labour and labour costs are currently considered to be among the greatest challenges to dairy farming in Ireland into the future. Along with capital, land and finance, labour is a necessary resource for increased milk production. Labour productivity is a major factor driving farm profitability. Improved labour efficiency will be essential on farms if increases in scale are to be successfully achieved. In Ireland, this is particularly critical now because of the forecasted herd expansion following abolition of the milk quota system. It is expected that approximately 60% of farms will increase herd size. Labour efficiency will be critical for all farm sizes in the future. In the family farm scenario, overall hours worked and working day length should all be optimised to promote family farm sustainability, including quality of life. Labour efficiency is also important on larger farms, where the cost of hired labour needs to be minimised. Furthermore, it is critical to address labour demand, input and organization on farms in order to minimize any potential negative association with health and safety outcomes.

Labour demand on farms

The current average dairy herd size in Ireland is approximately 70 cows, with an average herd milk volume of 323,000 litres. The majority of Irish farms operate 100% spring calving systems, which has significant implications for labour requirements. To examine current labour efficiency, a survey study was conducted on 94 Irish dairy farms during 2012 and 2013. Farmers reported annual and seasonal labour input, in addition to farm practices and facilities. [Note: while some of the smaller herd sizes also had a second enterprise e.g. drystock, this study focused on the dairy enterprise only] Descriptive data were summarised and the most efficient farms were identified. Total dairy farm labour input increased with increasing herd size (Table 1). Average labour input of the farmer (main operator) was similar across various herd sizes from 20 to 250+ cows. Similarly, the labour input of partner and other family members did not increase as herd size increased, but was supplemented by hired labour (part time and full time) on farms with larger herd sizes (≥111 cows). Labour efficiency was increased on the larger herd size farms as the number of cows managed per labour unit increased. This was assisted by procedures such as once a day milking at particular times of year, once a day calf feeding and increased use of contractors. A distinct seasonal pattern in hours worked was also observed, with the highest labour input in spring and lowest labour input in winter.

Labour demand on farm can impact on the life and lifestyle of the farmer and the farming family. As part of the above study, farmers were asked how many hours they considered to be a desirable working week. The average response from farmers was 57 hours per week. The actual average labour input of the farmer (main operator) was 59 hours per week over the full year. The farmer's own labour input represented the equivalent of 1.7 labour units (when measured against the standard labour unit as defined by the national farm survey and the working hours of other professions). In fact, farmers worked considerably longer hours than desired in three of the four calendar seasons. Dairy farming needs to be perceived as an attractive career path by the next generation. It is important that the lifestyle of the farmer and farming family would appeal to younger people, to allow farming traditions within families to continue.

Table 1. Average yearly dairy labour input (hours) and dairy labour efficiency (hours/cow per year) across different herd sizes

Herd size (cow no.)	Total labour input (hours)	Farmer labour input (hours)	Family labour input (hours)	Employees labour input (hours)	Labour efficiency (hours/cow year-1)
19-55	3,891	3,154	576	22	89
56-110	4,255	3,206	594	310	55
111-250	5,403	3,118	984	1,106	35
>250	7,900	2,745	492	4,626	28
All	5,362	3,056	662	1,516	38

Labour research priorities

The priority labour issues identified by farmers in discussion groups include: (i) identification of procedures and practises to reduce peak labour demand in spring; (ii) benchmarking farms for labour efficiency; and (iii) examination of the most labour efficient farms to identify the structures and practices responsible for achieving high efficiency levels. In addition, research is needed to examine the physical nature of labour input; optimising the ergonomics of daily activities will benefit the long term health and welfare of farmers and farm staff.

Current work

Current work on labour requirements on dairy farms includes quantification of labour input on a core group of dairy farms (approximately 70) on a 'real time' basis. The final goal is to develop an online tool to allow self-assessment of labour input on the farm. This will promote measurement and benchmarking of labour input, and provide data for economic analysis. Research is also being conducted examining the use of professional contracting services on the farm as a labour saving strategy. For example, current and potential future levels of contractor usage are being compared; the 'best practise' methods for contractor usage will be identified; and cost-benefit analysis conducted to evaluate own versus hired labour. Managing human resources (i.e., recruitment and management of employed labour) on dairy farms is likely to become increasingly important in the industry. The career pathway of farm manager trainees is being examined to ensure the expectations of both the farm manager and the hiring farmer are met. The quantified labour models will then be analysed from an economic perspective.

Conclusion

Labour is a key input to the dairy production process. Consequently, it is important to ensure that it is used as efficiently as possible on the farm. Finally, it is critical that labour will not represent a future constraint to the sustainable growth of the Irish dairy industry.

Teagasc Dairy Expansion Service

Tom O'Dwyer[1], Patrick Gowing[1] and George Ramsbottom[2]

[1]Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork; [2]Teagasc, Oak Park

Summary

- Teagasc is currently establishing a new Dairy Expansion Service
- The new service will support client dairy farmers undertaking significant levels of expansion in milk production through an individualised, one-to-one technical and financial planning service

Introduction

Teagasc is in the process of rolling out the Dairy Expansion Service to dairy farmer clients. The new service will be headed up by a specialised adviser, Patrick Gowing. Patrick has widespread experience of assisting new entrants and expanding dairy farmers in his previous roles with Teagasc as a dairy adviser in counties Westmeath and Sligo. The new service will involve the delivery of an intensive "one to one" type service to client dairy farmers undertaking significant levels of expansion in milk production.

Background

Food Harvest 2020 sets out an ambitious target for the Irish dairy sector to sustainably grow milk output by 50% by 2020. While some of this growth has already been achieved, the removal of EU milk quotas will provide real opportunities for significant numbers of Irish dairy farmers to grow production in the years to the end of the decade. Indeed, recent Teagasc National Farm Survey data indicates that 60% of dairy farmers intend to increase milk production in the 2015 to 2017 period. Of these, 22% intend to increase production by between 20 and 50% and a further 3% intend to increase production by over 50% during that timeframe. In addition, it is estimated that there could be up to 900 new entrants to dairy farming. It is envisaged that these farmers will be most likely to avail of this new service.

It is vital that dairy farmers are guided along a sustainable development pathway. The dairy farm business must be resilient against milk (and input) price volatility and generate sufficient returns to re-pay large on-farm investments required to grow the farm business. Additionally, higher levels of borrowing, higher cash demands and increased animal numbers and higher stocking rates all increase the risk of business failure for rapid expanders and new start-ups.

Teagasc is committed to supporting dairy farmers planning significant strategic changes on their farms. As an organisation, it is uniquely placed to provide both a technical and financial planning service combined with on-going monitoring and mentoring support. Our independence, coupled with our expertise, will allow for the critical and objective examination of investment proposals. This new service will allow Teagasc to leverage its current network of dairy advisers, dairy and financial management specialists and researchers to benefit both the individual farmers receiving the service as well as the dairy industry and the wider economy.

Objectives of the Dairy Expansion Service

The new service will aim to: (1) reduce the risk of poor business decisions leading to business failure; (2) enable dairy farmers to grow their farm business in a sustainable manner that will allow for further growth in the future; and (3) protect existing livelihoods and future on-farm investments.

How will it work?

The new service will involve the preparation and regular monitoring of an overall "Farm Expansion Business Plan" that will pull together and connect a number of strategic and technical plans. These include:

- Overall Farm Strategic Plan
- Six Year Farm Business Plan including Investment / Debt Schedule, Annual Cash Flow projections and Monthly Cash Flow for Year 1, Stock Plan and Risk Analysis
- Farmyard and Infrastructure Plan
- Grassland Management Plan
- Herd Health Plan
- Workload Management Plan

These planning documents will be combined into one overall package in a suitable format to ensure it can be implemented and monitored on a regular basis.

Teagasc advisers are best placed to identify the type and level of support required by each individual farmer client. It is expected that Teagasc advisers will refer clients to the Dairy Expansion Service, especially those who need more individualised support and those undertaking more significant levels of expansion. The service will be delivered through a one-to-one engagement between the specialised adviser and the farmer client. At all times, the specialised adviser will work closely with the local Teagasc adviser, both in the preparation of the development plan, but more importantly in the provision of on-going support during the implementation phase of the plan.

Typical service offered

While the final details of the service packages are to be finalised, it is envisaged that farmers would be offered a choice of service offerings including:

- "Teagasc Farm Plan" service - to include one farm visit plus the preparation of a full financial business plan
- "Teagasc Gold" service - to include six farm visits (or equivalent office time)

Farmers availing of the new service would be expected to be clients of the Teagasc Advisory Service and pay the appropriate fees for the service selected.

Service delivery

Currently one specialised adviser has been identified to deliver this new service. Subject to demand, Teagasc will review the requirement for additional specialised advisers for the Dairy Expansion Service.

Further information

Further information will be available shortly on the Teagasc website, www.teagasc.ie and from Teagasc dairy advisers.

Discussion groups for improved productivity and profitability

Tom O'Dwyer[1] and Thia Hennessy[2]

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Summary

- Discussion groups are an effective mechanism for the delivery of advice
- Recent Teagasc research has clearly shown that discussion group membership is associated with increased technology adoption and higher farm profits
- DAFM are finalising details of a new programme to promote the membership of dairy discussion groups

Introduction

Farmers face many challenges to ensure the on-going success of their farm businesses. Research has identified the key technologies to be adopted for success. But practice adoption won't happen unless certain events occur: (1) knowledge is acquired; (2) skills are learned; and (3) attitudes are changed. Discussion groups can help in all three areas. They have been used throughout the world, in all agricultural sectors, as a way to transfer knowledge and support change. Currently Teagasc operates approximately 350 dairy discussion groups with approximately 5,500 members.

Benefits of discussion group membership

The benefits of discussion groups for dairy farmers are well known.

Discussion groups:

- enable dairy farmers to share ideas, learn from each other's experiences/ perspectives and benefit from the input of a skilled facilitator;
- support farmers in trying out new ideas;
- allow members to benchmark their farm's performance against that of other members;
- help improve both the lifestyle and performance of everyone in the group;
- help all members reach their goals faster than they otherwise would.

Table 1. Percentage of farmers adopting various technologies or practices in 2009 (Source: National Farm Survey, 2009)

	Member	Non-member	All
Milk recording	74	22	35
AI	87	67	70
AI with genomic bulls	39	14	19
Dry cow therapy	96	82	85
Teat disinfection	93	75	79
BVD vaccination	48	27	31
Reseeding (at least 10% in last 3-years)	40	26	30

While undoubtedly some groups work better than others, Teagasc research has shown that, on average, technology adoption is higher by discussion group members than non-discussion group members (see Table 1). But do these higher rates of technology adoption result in higher levels of farm profitability? Using the same 2009 National Farm Survey dairy farmer dataset, membership of a discussion group was associated with an increased gross margin of €247 per hectare. When the analysis was repeated using the 2011 National Farm Survey dairy farmer dataset, net margin was 2 to 3 cent per litre greater for farmers that had been discussion group members for at least two years (Figure 1).

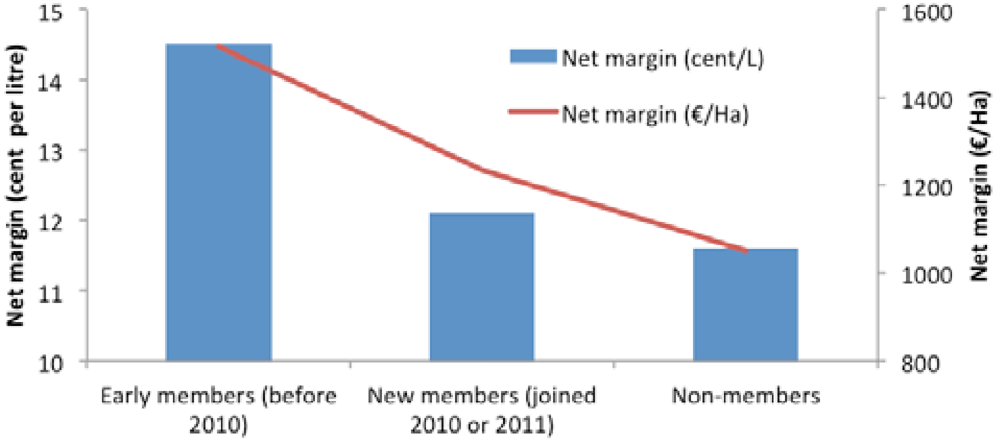


Figure 1. *Average net margin per litre and per hectare for early, new and non-members in 2011 (Source: National Farm Survey, 2011)*

Features of a well-functioning discussion group

What are the key features of an effective discussion group? There has been extensive research into the effective functioning of discussion groups in various countries including Ireland, Australia and New Zealand. This research indicates that the five key factors necessary for discussion groups to effectively deliver change are:

- being well organised with regular, scheduled meetings
- engaging in a range of well-planned activities with a clear purpose
- strong ownership of the group's direction by the farmer members
- reviewing the group's activities on an annual basis
- effective facilitation by a committed adviser

These five key factors are central to the delivery of Teagasc dairy discussion groups. Further details regarding the dairy discussion groups in operation in your area are available from the Teagasc Regional Manager or Teagasc dairy adviser.

New Knowledge Transfer groups

Currently DAFM are in the process of rolling out a new Knowledge Transfer Groups (KT Groups) Programme under the 2014 - 2020 RDP Programme. This new Programme will build on the success of the Dairy Efficiency Programme (DEP) while enhancing the focus on the key issues of profitability, environmental sustainability, breeding and animal health and welfare. It will facilitate greater one-to-one contact time between the farmer and his/her adviser, and will promote new membership of discussion groups. It is anticipated that the Programme will require farmers to attend five meetings on an annual basis and to complete a Farm Improvement Plan (FIP) in return for an annual payment. At the time of writing, the final details of this new initiative are not known, but it is expected that it will be launched later in 2015 and that farmers will be able to apply to join the Programme for a three-year period. Teagasc Advisers will facilitate KT Groups under this new Programme, and will look to ensure that both current discussion group members and those wishing to join a KT Group as a first time group member will be provided with an opportunity to join the KT Group Programme.

Contract rearing of replacement heifers

George Ramsbottom

[1]*Teagasc, Animal & Grassland Research and Innovation Programme, Oak Park, Carlow*

Summary

- The number of dairy farmers opting to have their heifers contract reared off-farm is likely to grow substantially in the years ahead
- The key advantage to both parties (the owner and rearer) is that contract rearing allows the heifer owner to become more specialised in dairying while allowing the rearer an opportunity to earn more money
- The risk of a disease outbreak remains the single biggest threat to the enterprise, and so replacements need to be tested well in advance of their return to the owner's farm

Background

Expansion on dairy farms may result in 3,000 to 5,000 dairy farmers looking at the option of contract rearing their replacement heifers. This will occur for two reasons:

- The average stocking rate on dairy farms nationally is expected to rise from the current 1.9 LU to 2.2 LU/ha within the next five years. By 2020, however, as many as one farm in five may be stocked at more than 2.5 LU/ha, placing considerable pressure on the farm to operate a largely self-contained system of grass based milk production.
- The average herd size is expected to increase to 85 cows, but one third of farms are likely to have more than 100 cows. Larger numbers of replacement heifers will take longer to rear and put pressure on available labour and facilities.

Pros and cons of contract rearing of replacement heifers

Advantages exist for the owner and rearer of the replacement heifers. For the owner these include:

- Freeing-up time and labour to focus on dairying on the home farm;
- Potentially allowing higher income to be made from the dairy unit.

Several advantages also exist for the contract rearer including:

- Improved cash flow due to a steady monthly income;
- Freeing up of capital required to stock the farm;
- The potential to increase farm income.

Disadvantages also exist for both the owner and rearer of the replacement heifers. For the owner these include:

- Identifying a suitable contract rearer and handing over responsibility to someone else to look after the heifers properly;

For the rearer these include:

- Identifying someone that can be trusted to pay for the service on a regular basis and treat the rearer fairly in their dealings with him throughout the period that the animals are on farm;
- Complying with the wishes of a third party (in this case the heifer owner) in how the heifers are raised;
- Engaging in a new enterprise with different liveweight and fertility targets and different husbandry practices compared to those associated with conventional drystock production.

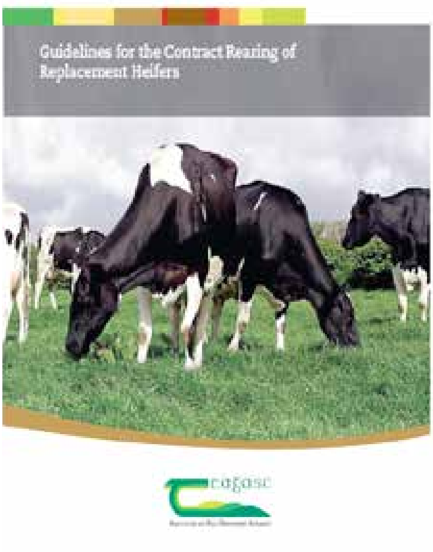
For both parties the most significant common challenge is animal disease. Both regulatory and non-regulatory diseases may represent a serious challenge to both the owner and the contract rearer of replacement heifers.

- Stock transferred using Form 31A or 31B;
- Ideally, heifers from only one herd should be taken by the rearer;
- It is considered best practice to carry out vaccinations before sending the heifers to the rearers farm;
- It is important to TB test early e.g. in May if returning to the home farm in November to allow time for repeat tests if necessary.

Case study

A farmer (mid-50's) retired from dairying in 2012 advertised a contract rearing business. He is now contract rearing c. 50 yearlings and 50 weanlings for a dairy farmer who lives approximately 20 miles away. He takes in the heifers weaned and returns them at 22 months of age. Tasks carried out include;

- Rotational grazing and meal feeding as necessary;
- Weighing every two months and comparing weights against targets;
- Primary course of Leptospirosis vaccination and dosing for worms and fluke; Housing for the winter with cubicles, feeding silage and supplementing with meal as necessary;
- Booster vaccination for Leptospirosis and vaccination against BVD;
- Heat detection, prostaglandin administration, identifying heifers for AI;
- Using stock bulls for mopping up (from owner's farm).



Further information

Guideline specimen contracts for flat rate and weight target contract rearing arrangements are available on the Teagasc website at http://www.teagasc.ie/collaborativearrangements/contract_rearing_of_heifers.asp

A supporting publication 'Guidelines for Contract Rearing of Replacement Heifers' is also available online at the link above or in hard copy at Teagasc offices.

'Grass rich' systems of milk production are more profitable

George Ramsbottom[1], Laurence Shalloo[2], Donagh Berry[2] and Brendan Horan[2]

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Summary

- Supplementation with concentrate in grazing systems reduces grass utilisation, as purchased feed in the diet substitutes grazed grass
- Despite increasing milk production per ha, dairy farms that use more purchased feeds have lower home grown forage utilisation, a shorter grazing season length and reduced farm profitability per cow, per litre and per hectare
- For every additional €1 increase in supplementation costs on dairy farms, total milk production costs increase by €1.60. This is primarily due to greater infrastructure and mechanisation costs associated with higher supplementation systems

Introduction

Higher stocking rates and greater milk solids yield per cow will be required to achieve the expected 50% increase in milk production by 2020. With quota abolition, dairy farmers will be attracted towards higher input systems of milk production. The impact of this on profitability, however, is not clear. Data from New Zealand indicates that the increase in milk production observed in the past decade has not resulted in any increase in profitability for dairy farmers in that country.

Study outline

Data from eProfit Monitor from over 1,500 spring calving dairy farms during the 2008 to 2011 period was analysed based on the proportion of grazed grass in the diet of the dairy herd. For example, a herd of cows producing an average of 400 kg milk solids per annum, fed 750 kg meal per head and stocked at 2.5 LU/ha are estimated to consume 4.6 tonnes dry matter per head with 16% 'imported feed' in the diet (i.e., 84% of the diet composed of grazed grass and grass silage).

To evaluate the effect of the proportion of grazed grass in the diet on farm profitability, eProfit Monitor farms were categorized based on the percentage of grass in the diet. The categories of grass used were ≥90%, 80 to 89%, 70 to 79% and <70%. The overall financial performance of the farms in the different categories was then examined. The first two categories (≥90% and 80 to 89%) were classified as 'Grass Rich' and the second two categories (70 to 79% and <70%) were classified as 'Grass Poor'.

Results

- The more 'grass rich' systems of milk production had lower milk solids yields per cow and per ha than the 'grass poor' systems (723 kg and 884 kg milk solids/ha for the most 'grass rich' and 'grass poor' systems, respectively)
- Grass utilisation rates declined from 8.8t DM/ha to 6.8 t DM/ha, with an estimated substitution rate of 0.6 kg DM/kg additional meal fed per cow
- Total costs of milk production increased from 18 c/litre to 22.1 c/litre for the 'grass rich' and 'grass poor' systems, respectively
- While gross output increased by €693/ha, total costs of production increased by €980/ha and net profitability was on average €215/ha lower for the most 'grass poor' system compared to the most 'grass rich' system of milk production

- Considerable variation exists in net profit per ha within each system. The proportion of farms achieving greater than €2,000 per hectare net profit was approximately twice as high in the two 'grass rich' systems (20%) compared with the two 'grass poor' systems of milk production (10%).

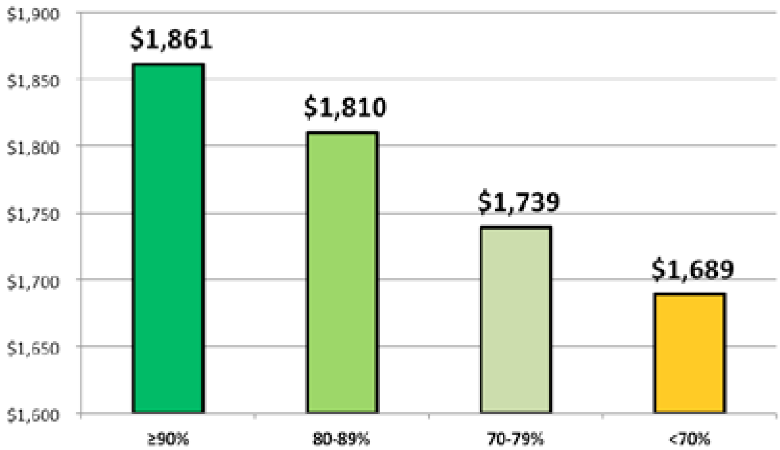
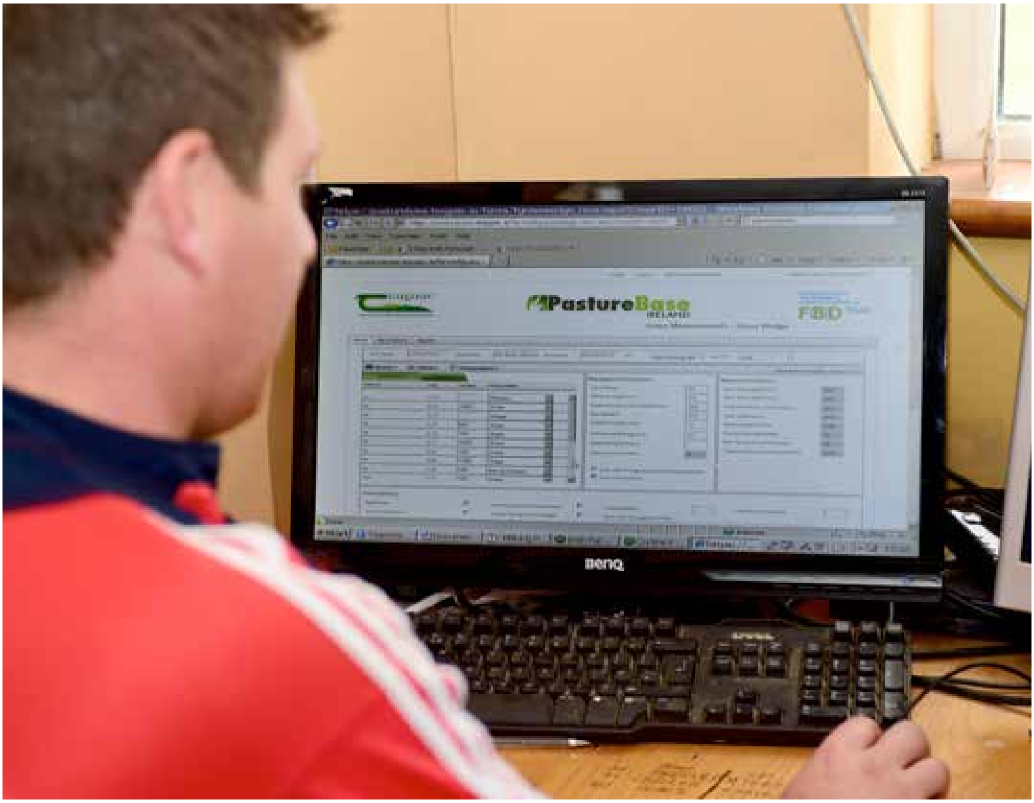


Figure 1. *Net profit (€/ha) of systems of milk production categorized based on % grass used*

Conclusion

For profit focused dairy farmers, achieving high grass utilisation rates per hectare rather than high milk yields is more likely to deliver high profits.



Infrastructural requirements for an expanding Dairy Farm

Tom Ryan[1] & Padraig French[2]

[1]Teagasc, Kildalton, Piltown, Co. Kilkenny; [2]Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Summary

- There will be a large range of demands for capital in an expanding herd. Investments in high performing pastures and grazing infrastructure should be prioritised to facilitate high grass utilisation, which is the key driver of profit
- As herd size expands, the grazing infrastructure of roads, paddocks and water systems will have to be modified to facilitate larger cow numbers
- A range of winter housing systems can adequately meet the needs of spring calving cows. The most cost effective option should minimise the combination of depreciation and operating costs

Introduction

The goal in dairy expansion is to minimise capital investment in non-productive depreciating assets while ensuring that the facilities and resources do not compromise the productivity of the farm. The key areas of farm infrastructure that will require capital for expansion to match herd size are milking facilities and milk storage, animal accommodation and slurry/soiled water storage and grazing infrastructure such as farm roadways, water systems and paddock layout. As the herd grows, many parts of the farm infrastructure will require either modification or replacement.

Grazing infrastructure

Size of paddocks

The ideal paddock system should be big enough so that there is sufficient pasture for the full herd for 36 hours when the pre-grazing cover does not exceed 1,300 to 1,500 kg DM per ha on a 21 day grazing rotation. This equates to approximately 1.0 ha per 55 cows in the herd. Paddocks should have multiple gateways from the farm roadways for paddocks on wet ground.

Farm roadways

As herd size expands, cows will have to walk longer distances in a larger group, which can put significantly more stress on cows if the farm roadways are not adequately designed and constructed for the enlarged herd. The objective is to have cows walking comfortably at 3 km/hr with their heads down so that they can see where they are placing their front feet (the back feet will step into the same place). Actual cow walking speed is determined by walking surface, cow training and cow fitness. The lanes from the parlour/farmyard to the paddocks should be as short a distance as is practical and have a raised, wide, smooth, dry, gently crowned surface with gradual sweeping bends. Roadways should be 4m wide for up to 200 cows and widest at the entrance to the milking parlour with a straight lead in and exit from the milking parlour of at least 30 meters. Roadways should be constructed to reflect the nature of the usage and never built on the shady side of hedges

Water infrastructure

The water requirement of grazing dairy cows varies enormously with weather conditions from 10 l/cow per day in cold wet weather up to 90 l/cow per day in warm dry weather. The water system has to be adequate to supply the demand of cows at peak as any restriction will lead to significant production losses and welfare problems for cows. Cows can drink up to 50% of their daily requirement in the hour immediately post milking so the target should be to have a water system that can deliver 33 l/min for every 100 cows in the herd.

This can be quite easily checked by emptying a trough and measuring the time taken to refill; this should be done before the peak requirement.

Table 1. Specification and size of water equipment		
Herd size	<100 cows	>100 cows
Main circuit pipe*	25mm	38mm
Branch pipe*	20mm	25mm
Length of branch lines	Less than 50m	Less than 50m
Ball valves	Full flow (12.5 mm)	Full flow (20 mm)
Trough size	900 l (200 gal)	9 l /cow (2 gal/cow)
Pressure	3 bar	3 bar

Wintering facilities

Teagasc research has shown that provided cows are adequately fed and has a comfortable lying area; wintering system has very little impact on productivity of spring calving dairy cows. Table 2 outlines the capital and operating costs of a range of alternative winter accommodation systems including a conventional cubicle shed with slatted slurry storage, an earth lined out-wintering pad (OWP) with an earth lined slurry store (ELS) and a low cost unroofed cubicle system with the slurry stored in a plastic lined lagoon (PLS). In the analysis, capital investment was depreciated over 15 years and the capital investment was financed with borrowed money at 6% interest and woodchip was charged at €12/m3. The analysis in Table 2 shows the estimated total annualized housing costs and evaluates the sensitivity to both interest rate and woodchip price.

The conventional system has the highest capital and annualized housing cost whereas the OWP/ELS has the lowest capital cost but the low cost cubicle system/PLS has the lowest annualized housing cost. The cubicle systems are much more sensitive to variations in interest rate whereas the OWP/ELS are most sensitive to changes in woodchip price.
Once the capital cost of the cubicle system is less than €850 per cow it is more cost effective than OWP/ELS over the lifetime of this business. The low cost cubicle system in this scenario has the lowest annualized cost and would therefore be the most cost effective option.

Table 2. The effect of winter accommodation system on construction cost, operating and annualized housing costs

	Conventional cubicle shed	Roofless cubicles/PLS	OWP/ELS
Slurry storage requirement (m^3/cow/year)	5.3	6.5	7.8
Total housing/slurry storage cost (€/cow)	1,218	708	371
Depreciation & interest (€/cow/year)	125	73	38
Bedding & slurry spreading (€/cow/year)	17	20	75
Total annualized cost (€/cow/year)	142	93	108
Sensitivity			
2 per cent rise in interest rate (€/cow/year)	159	102	114
€10/m^3 woodchip price (€/cow/year)	142	93	101

Update on the Greenfield dairy farm in Kilkenny

Abigail Ryan[1] Tom Lyng[2] and Eoin Finneran[2]

[1]Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork; [2]Greenfield Dairy Farm, Co. Kilkenny

Summary

- The herd EBI is 168, and is now predominantly a Jersey Crossbred herd. This year Kiwi Cross sires are being used due to the low availability of Jersey sires
- Herd milk solids production has increased each year to 122,000 kg in 2014
- Herd fertility has stabilised at 10% non-pregnancy rate for the past two years and the six week calving rate is close to 80%
- Herd health is generally very good. Somatic cell count (SCC) is the main issue but is improving. Rigorous monitoring and management has allowed SCC to be controlled
- Grass production is gradually increasing. In 2014, the farm grew 13.5 t DM/ha
- Business plan is updated and compared to the original business plan annually. Milk sales and costs are greater than originally budgeted

Introduction

This is an update on the Greenfield dairy farm performance from 2010 to 2015 covering financial performance, grass and milk production, herd fertility and herd health. Some of the key performance indicators for the farm are summarized in Table 1.

Table 1. Physical and financial figures from the Greenfield dairy farm

	2011	2012	2013	2014	2015
Herd EBI		123	144	161	168
Days to 50% of herd calved	20-Feb	1-Mar	12-Feb	19-Feb	19-Feb
Mating start date	26-Apr	16-Apr	24-Apr	24-Apr	22-Apr
Breeding Season (Weeks)	15	12	12	15	
Not in calf rate (%)	13	11	10	10	
Cows milked at peak (no.)	295	294	324	307	328
Replacement rate (%)	24	20	36	30	26
Milk solids sold per cow	368	377	378	396	
Butter fat/protein (%)	4.41/3.52	4.61/3.57	4.44/3.62	4.67/3.69	
Tonnes milk solids sold	109	111	122	122	
Grass grown (tonnes DM/ha)	11.8	11.8	10	13.5	
% Farm at Index 3&4 for phosphorus		87		55	
% Farm at Index 3&4 for potassium		51		56	

Herd health

Herd health on the Greenfield dairy farm is generally good. The herd health strategy plan is closely followed. Vaccination costs were 1c/l in 2014. The main herd health issue is SCC, which averaged 190,000 cells/mL in 2014. Strategies to reduce SCC are in place.

Grass production and soil fertility

Grass production is gradually increasing from 10 tonnes/ha in 2013 (poor spring followed by a summer drought) to 13.5 t DM/ha in 2014. Each paddock is soil tested annually. Phosphorus Index is not increasing despite using the maximum allowable phosphorus application under the Nitrates Directive. Approximately 90 kg/ha and 40 kg/ha of potassium and sulphur are applied annually, respectively. The soil pH has declined from 6.55 in 2014 to 6.0 in 2015.

Business plan update

The receipts are higher than in the original budget (planned in 2009) as milk price has been higher than originally budgeted. Cow milk production performance has also been ahead of originally forecast. Total costs (Figure 1) excluding capital repayments and development expenditure are also higher than the original business plan. Bought in feed (2013), investment costs, fertiliser costs, contract rearing costs (due to more heifers being reared) and on-going maintenance costs are all higher than originally planned.

Deviation from the original project plan

Costs have been €346/cow greater than forecast in the original business plan. Less grass (2.5 tonnes DM/ha) has grown than expected. There are two main reasons for this. First, the farm was previously used for constant tillage, which reduced soil organic matter content. Second, soil phosphorus and potassium indexes are suboptimal on >40% of the farm. Cows have produced more milk than expected as a result of improving genetics, a more compact calving pattern and good grassland management.

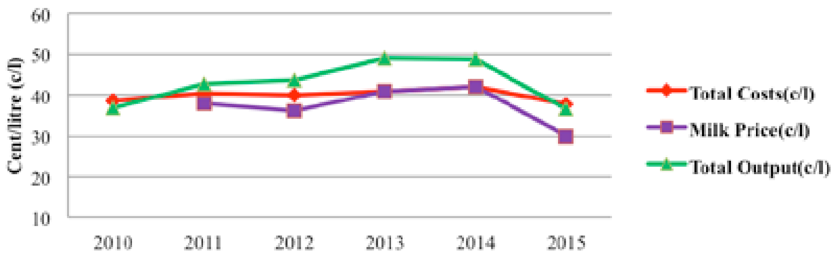


Figure 1. *Total costs on Greenfield Farm compared to total milk output (2010-2015)*

Key lessons learned to-date

Animals selected for purchase must be comprehensively screened for diseases. The key non-regulatory diseases to test for are IBR, BVD, Leptospirosis, *Salmonella*, Johnes and Mycoplasma bovis. Also, examine the herd history for mastitis and SCC. The stocking rate should be matched to the best estimate of the amount of grass likely to be grown. Annual soil fertility testing and regular reseeding are crucial to increase grass growth. Grass varieties that are highly palatable and on the recommended seed list should be used. All reseeding should be carried out at the start of the project/expansion.

Conclusions

Successful expansion, whether small or large in scale, is possible provided proper planning is carried out. It is vital that animals have good genetics for a grass-based system (high EBI). A proper herd health strategy must be adhered to. Early planning is essential, and avoid being overly optimistic about likely grass yield and milk production. Monitoring performance and logging lessons learned from the early stages of the project will determine how successful the expansion will be. Monthly monitoring of cash flow is essential to successfully manage the expansion. There are two more focus days in 2015 on the farm that people can register to attend (8^{th} and 22^{nd} October). All the lessons learned from the start of the project will be disseminated on these focus days.

Update from the Shinagh dairy farm

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Summary

Expansion lessons learned from Shinagh farm:

- Do a budget for the capital expenditure and update regularly. This budget will give financial discipline and ensure the essential items are delivered within budget
- The stock are the most important investment and should be bought on the basis of EBI in as few groups as possible. Invest in a herd health plan to minimise the key risk of a disease outbreak in the initial years
- Be extra conservative with herd performance and financial targets in the initial years after start up
- Devote time to creating a quarterly budget for each year, take each item of spending and decide on a realistic amount and price; don't just use generic figures. Monitor cash flow in the year against budget and adjust spending to keep in line with budget
- Managing a new project takes time; employ help to free up time to manage it
- Set the correct strategic direction of the farm from the start. If the objective is a grass based system, then graze to correct residuals from the start. Prioritise the key profit drivers of weekly grass budgets, high submission rates, cow condition etc

Introduction

Shinagh dairy farm near Bandon in West Cork is a Teagasc-led project demonstrating efficient spring milk production from pasture on a farm that was converted from a beef farm in 2010, with the first cows being milked in January 2011. The farm of 78 ha is owned by the four west Cork co-ops and was leased for 15 years by Shinagh Dairy farm Ltd. The Department of Agriculture, Food and the Marine provided the quota and the programme is supported by Carbery milk products. The total conversion costs for the farm was €820,000, with €260,000 of that provided by the West Cork Co-Ops and the remainder borrowed from Ulster Bank with a 15 year loan (first two years interest only). The main objectives of the project are to demonstrate the:

- financial viability of a stand-alone dairy farm;
- the profitability, cash flow and return on capital and equity from a start-up, well-run, pasture based, spring milk production dairy farm,
- the risks and risk management strategies associated with the setting up of a new dairy farm.

Performance to-date

The farm initially started with a herd of 1st lactation heifers. These animals had low yields in the first two years with consequentially low output and low profit (Table 1 and 2). However the fertility and survivability of these animals to-date has been excellent and as the herd matured the yields have increased significantly and the calving has become more compact giving more days in milk. A key management objective is to match the calving pattern to the supply of grass in spring to allow freshly calved cows to be fully fed on grass and concentrate in spring. As the calving pattern has got more compact each year, the start of calving has moved later to better match the supply of grass. The farm is now adequately remunerating all of the resources employed and giving a very attractive return on capital and the key driver to further progress in performance will be increased grass production and utilisation.

Table 1. Physical performance of Shinagh farm 2011 to 2015					
	2011	2012	2013	2014	2015
Cows milked (average)	195	197	227	215	225
Stocking Rate (LU/ha)	3.12	2.84	2.89	2.79	2.89
Grass Grown (t/DM/ha)	12.3	11.5	12.4	13.2	
Grass utilised (t/DM/ha)	10	9.5	10.5	10.8	
Kg MS / cow	265	326	354	381	
Kg MS / Ha	817	921	1,032	1,058	
6 week calving	58%	62%	78%	79%	93%
Empty Rate (%)	13	7	9.6	8.2	
Mean Calving Date	28-Feb	22-Feb	16-Feb	11-Feb	16-feb
SCC (000 cells/ml)	142	108	109	155	
Net Milk Price (€/kg/MS)	€4.62	€4.46	€5.35	€5.25	
Net Milk Price (cents/litre)	37.6	36.4	44.8	45.3	

Table 2. Financial performance of Shinagh farm 2011 to 2014				
	2011	2012	2013	2014
Milk Solids sold (Kg)	50,903	63,039	80,297	82,000
Milk sales (€)	235,557	281,510	429,964	434,645
Livestock sales (€)	33,429	37,906	62,276	77,092
Total Receipts (€)	268,986	319,416	492,240	511,737
Labour (€)	66,183	72,407	65,466	64,589
Land Lease (€)	35,530	35,530	35,530	35,530
Contract heifer rearing (€)		20,054	37,025	36,203
Bank Repayments (€)	9,022	12,515	49,596	46,869
All other Expenses (€)	135,486	177,137	209,624	183,551
Total Expenses (€)	246,221	317,643	397,258	366,742
Cash Flow (€)	22,765	1,773	94,983	144,995
Return on Capital	1.1%	-2.5%	18.2%	17.1%
Return on Equity	0%	-13%	53%	50%

BEING BOTH COMPETITIVE AND SUSTAINABLE

How does farm profitability influence the carbon footprint of milk?

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Summary

- To achieve sustainable growth in a quota free environment dairy farms will need to reduce the carbon footprint of milk as well as increase profitability
- The aim of our work was to assess the influence of economic performance on the carbon footprint of milk across 221 farms nationally, and to identify what factors influence this relationship
- Generally, the study showed that increasing farm profitability reduced carbon footprint and highlighted that the length of the grazing season and milk production/ha were the main factors that influenced this relationship
- Overall the results imply that Irish dairy farms can simultaneously improve farm returns and reduce carbon footprint by increasing milk output/ha from grazed grass

Introduction

The Irish dairy sector is a key source of national greenhouse gas (GHG) emissions (~10%), which are projected to increase with the expansion of the national herd. Ireland has agreed to reduce emissions from the non-emissions trading sector (includes dairy production) by 20% relative to 2005 levels by 2020, while increasing milk production. The goal of this research was to develop a footprint methodology that could be deployed within a nationally representative database to quantify the carbon footprint of the Irish national milk pool. This could then be used to identify emission hotspots and to evaluate the relationship between the carbon footprint of milk production and economic performance at farm level.

Calculating the carbon footprint of milk

The Teagasc National Farm Survey (NFS) was used to assess the economic performance and the carbon footprint of Irish milk. The NFS primarily collects financial data from a nationally representative sample of dairy farms and traditionally was used to estimate pre-tax profit margin and labour income on a gross and net basis. To simulate GHG emissions, the NFS was expanded in a number of areas to collect technical farm data (e.g., farm feeding practices). The survey was then carried out on 256 dairy farms in 2012. In total, sufficient data was collected on 221 farms to estimate GHG emissions. A GHG model was applied to the NFS nationally representative sample, and was subsequently independently certified to comply with the British standard for life cycle assessment (LCA). The model calculated annual on and off-farm GHG emissions from imported inputs (e.g., electricity) up to the point until milk was sold from the farm in CO_2-equivalent (CO_2-eq). Annual GHG emissions computed using LCA was allocated between meat and milk based on the economic value of dairy farm products sold and expressed per kg of fat and protein corrected milk (FPCM) to quantify carbon footprint of milk.

Higher economic performance is associated with a lower carbon footprint

The results show that the carbon footprint of milk on Irish dairy farms decreased as economic performance increased. Farms were ranked in terms of gross margin/ha. The carbon footprint of milk for the top one-third of farms was 7% lower than the mean and 15% lower than the bottom one-third (Figure 1). In addition, there was less variability in the carbon footprint of milk for the top performing group.

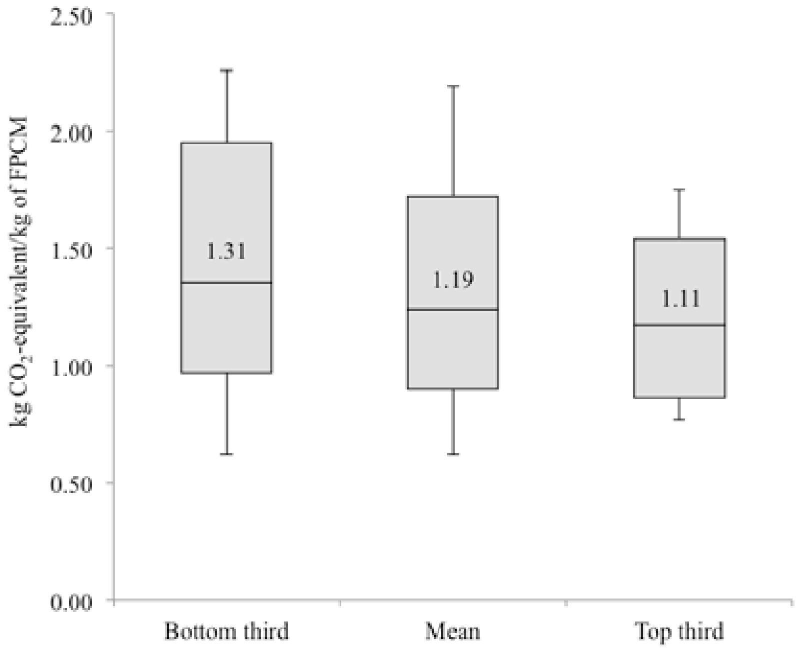

Figure 2. *The carbon footprint of milk for the bottom third, mean third and top third of Irish dairy farms ranked in terms of gross margin/ha. The grey shaded area represents 90% of the distribution of the carbon footprint of milk for each farm group*

The carbon footprint of milk and economic performance were strongly influenced by farm management practices. The main management practices that were associated with improved farm profitability and reduced carbon footprints were extending the length of the grazing season and increasing milk yield/ha. However, increasing milk production through greater concentrate feeding had a negative effect on profit and tended to increase the carbon footprint of milk. Therefore, this implies that to reduce the carbon footprint of milk and increase economic performance, grass-based dairy farms should aim to increase milk output from grazed grass.

Conclusions

Overall, this study indicates that the goals of improving economic performance and reducing the carbon footprint of milk are complementary and that grass-based dairy farmers can implement simple "win-win" strategies to mitigate the carbon footprint of milk and increase profitability.

A win-win for dairying - profitable expansion can deliver for the environment

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Summary

- The Agricultural Catchments Programme measured the environmental and economic performance of dairying in a Cork catchment over several years
- Farmers have improved their efficiency and reduced the risk to water by improving their nutrient management
- Dairying has expanded in the catchment; more cows are being milked and more land is in use
- Output and gross margins on dairy farms in the catchment have remained on a par with the top 10% of Irish dairy farms

Measuring sustainability

Sustainability is central to the 2025 Agri-Food Strategy and Food Harvest 2020. The Agricultural Catchments Programme (ACP) was set up to measure the effectiveness of the Nitrates Regulations and the derogation, and to support the development of sustainable farming. Using cutting edge science, the ACP is measuring the environmental and economic performance of farming across six stream catchments around Ireland.

Farmer support

The ACP works in partnership with farmers in six catchments to carry out its research and monitoring of how nitrogen (N) and phosphorus (P) are managed, and to measure how much of these nutrients are lost to water in either streams or in groundwater. The 760 ha catchment near Timoleague is mostly in dairying and is a good example of intensive milk production on good, free-draining soils. Over one third of the land is in derogation, and hence an excellent location to study the sustainability of intensive dairying and to monitor the impact of changing farm practices and increasing output.

The nutrient cascade

Very precise monitoring is needed to tease out what happens to N and P in the soil. Nationally, P is the nutrient that causes the most difficulty with water quality. The Nitrates Regulations (GAP Measures) limit how much N and P can be applied. With P, the objective is to reduce soil P levels where they are high (P Index 4) to reduce risk to water. However, the effects of reducing P can't be accurately predicted, as there are a number of loss pathways. Reduced P could reduce P washed into rivers during rainfall (very hard to measure) but could also reduce soil P levels below that which is optimum for grass growth, with possible knock-on reductions in farm profitability. This trail from P use and soil P level, through losses from soil during rainfall, subsequent ecological impacts in water and possible economic impacts is known as the nutrient 'cascade'. This is what the ACP has measured with high precision over successive years.

Progress made

Soils were intensively sampled in 2009/2010 and again in 2013. During this time, water quality in the stream was monitored, spring and autumn ecological surveys were conducted and nutrient use and production were monitored. This catchment had the highest number of soil P index 4 fields of the six monitored; in 2009/2010, 32% of soils were in this category. By 2013, this figure had fallen to 24% and the proportion of fields at index

3 (the recommended level for good grass growth and cow health) had increased from 27 to 36%. There was little change in the number of index 1 and 2 fields but these fields did show an increase in the average P test level, indicating that farmers were building them up gradually (Fig. 1). Overall there was a small P surplus of 2.4 kg/ha per year across the catchment, which is low by comparison with other intensive milk production areas internationally. The equivalent of 89% of the P that was spread left the farms in produce (mostly meat and milk), resulting in very high P use efficiency.

In other parts of the cascade, despite wetter years that provided more water to carry off P from the land to the water, the results of the water monitoring showed some reductions in the concentrations of P. These decreases occurred in soil surface and shallow underground water, where contact with soil P would be greatest (Figure 2). Over time, it can be expected that decreases in P index 4 fields will lead to improvements in water quality, but the ecological recovery is still not possible to predict.

Production and gross margins maintained

The farms remained on a par with the top 10% of specialist dairy farmers nationally; the stocking rate was 2.48 LU/ha (2.47 LU/ha for top 10%) and produced 1,125 kg milk solids/ha (1,045 kg milk solids /ha for top 10%). Importantly, gross margin from dairying was maintained at a high level, just slightly lower than the average for the top 10% (€3,130/ha versus €3,261/ha). Overall, these results represent a Win:Win for dairying in the Timoleague catchment. This can be applied nationally, showing that farmers can deliver on both environmental and economic targets and grow their businesses at the same time.

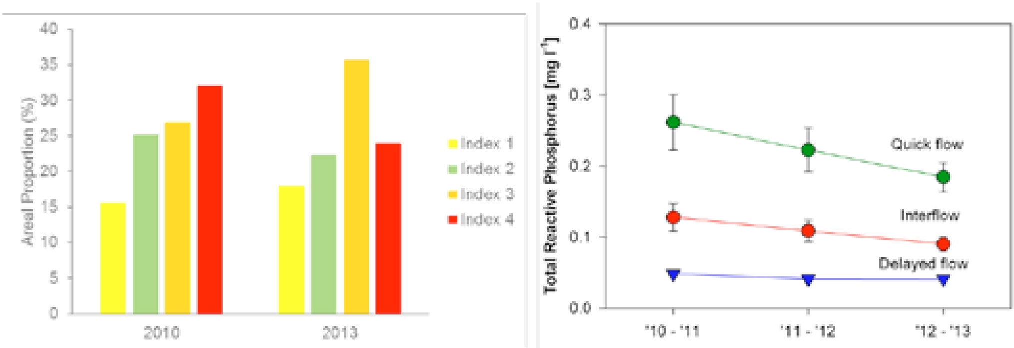

Figure 1. *P measurements in the Timoleague catchment. Left panel: soil P changes by index showing a decrease in index 4 fields (32% to 24%) between 2009-2010 and 2013. Right panel: decreasing flow-weighted mean concentrations of total reactive P (TRP) in flow pathways over three years during the winter period (closed period for slurry spreading)*

Increasing productivity of Heavy Soils

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Summary

- Approximately 30% of milk produced in Ireland comes from farms with soils that could be classified as heavy
- Similar to drier soils, increased herbage production should be the central focus on farms challenged with heavier soils through improved soil fertility (pH, P and K indices need to be at optimum levels) and land improvement
- Land drainage system design depends entirely on soil type
- A key constraint to expansion on farms with heavy soils is the variability in grass growth, and therefore feed supply, both within and between years

Introduction

A large proportion (~30%) of milk produced in Ireland originates from farms where the soils can be classified as heavy. Heavy soils add complexities to the production system that are aggravated by inclement weather conditions, similar to those experienced in 2009 and 2012. To ensure a robust sustainable system of milk production on heavy soils, herd fertility, soil fertility, land improvement and a capacity to build silage reserves is essential. Teagasc launched a heavy soils programme in 2011 and have detailed studies on-going on seven commercial farms located in Macroom, Kiskeam, Castleisland, Listowel, Athea, Rossmore and Doonbeg.

Farm performance

The performance of the seven farms on the programme between 2011 and 2015 is summarized in Table 1. Herd size has grown from 82 to 90 cows. The herds have increased their EBI from 84 to 150 with a strong emphasis on fertility. The six week calving rate remains stubbornly in the mid-seventies, which reflects the current focus on increasing herd size and a less strict culling policy. Year to year fluctuations in farm milk output due to weather conditions is starkly illustrated. The drop in milk solids production in 2012 was largely driven by reduced grass growth and poor grazing conditions.

Table 1. Heavy Soils Programme Farm Physical Performance 2011-2014

	Herd size	Stock Rate (LU/Ha)		6 Week Calving	Milk solids/ha (kg)	Grass grown (T DM/Ha)	Net Margin	
		Farm	MP *	%			€/Ha	c/litre
2011	82	1.69	2.25	72	917	10.0	1,460	15.8
2012	85	1.71	2.27	68	869	6.8	948	10.7
2013	86	1.68	2.31	76	968	8.9	1,322	13.7
2014	90	1.78	2.37	74	983	11.0	1,560	17.0

** MP = Milking platform*

A marked increase in costs in 2012 (high rainfall year) was caused by reduced grass production, resulting in increased farm expenditure on concentrates, silage, hay and straw. Farm profitability on heavy soils is highly weather dependent.

Soil fertility

There has been a notable decline in soil fertility nationally and the impact is even more pronounced on heavy soils farms. It is possible to increase annual grass production by 30% by optimising pH, P & K status on heavy soils. The economic value of an additional three tonnes of grass utilised/Ha is estimated at €500 per hectare per annum. A key strategy on these farms is to firstly focus on the soil pH, which will provide a relatively low cost soil fertility solution. Table 2 highlights the change in average soil fertility status on the programme farms in the period 2010 to 2015. On average the Potassium (K) status remained at target Index 3 with Phosphorus (P) status improving from low index 2 to target index 3. The pH status of the soils has increased slightly to pH 5.7. These farms are located in predominately high rainfall areas and require 5 tonnes of lime/hectare every five years just to maintain pH status; additional lime is required to increase soil pH to the target of 6.3 on mineral soils. Liming opportunities due to trafficability problems and limitations to application rates pose bigger challenges on heavy soils.

Table 2. Soil Fertility Status Heavy Soils Programme Farms 2010 v 2015

Year	K- Morgan	K index	P- Morgan	P index	pH	Lime Requirement (T/Ha)
2010	115	3	5.5	3	5.6	10.0
2015	119	3	7.0	3	5.7	7.8
Target	101-150	3	5.1 - 8.0	3	6.3	0.0

Land improvement

Much heavy land is in need of artificial drainage if its productivity is to be improved. The purpose of land drainage is to remove excess water from the soil as quickly as possible. The best strategy to achieve this will vary with soil type. We must move away from the short-sighted approach of installing broadly similar drainage systems in every wet field regardless of soil and site conditions. Such an approach leads to ineffective drainage systems in many cases. Therefore a key aspect of the programme is the design and installation of site-specific drainage systems on each of the programme farms to demonstrate appropriate land drainage systems for a range of soil types. The performance of these systems is being monitored.

Conclusions

Increased productivity on heavy soils requires renewed focus on soil fertility as well as land drainage. The capacity to grow adequate quantities of grass in a three year cycle is dependent on high utilisation of productive ryegrass and the provision of adequate silage reserves (at least 0.5 tonne DM/cow). Stocking rates must be matched to the grass growth and utilisation capacity of the farm. Based on potential grass growth of 12.5 tonnes DM/ha with all winter feed requirement conserved within the farm (including reserve) the optimum stocking rate is 2 LU/ha, thus providing adequate feed even if grass growth is reduced by up to 30%.

Land drainage design and installation

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Summary

- The first step of any drainage works is to carry out a detailed investigation into the causes of poor drainage using soil test pits
- Two main types of drainage system exist: a groundwater drainage system and a shallow drainage system. The optimum system and its design depend entirely on the drainage characteristics of the soil

Introduction

The objective of any form of land drainage is to remove excess water from the soil, to lower the watertable, and to reduce the period of waterlogging. This lengthens the growing season, the grazing season, the utilisation of grazed grass by livestock and the accessibility of land to machinery. A number of drainage techniques have been developed to suit different soil types and conditions. Broadly speaking, there are two main categories of land drainage:

- **Groundwater drainage system:** A network of deeply installed field drains exploiting permeable layers.
- **Shallow drainage system:** Where the permeability is low at all depths a shallow system, such as mole or gravel mole drainage, improves soil permeability by cracking the soil and encourages water movement to a network of field drains.

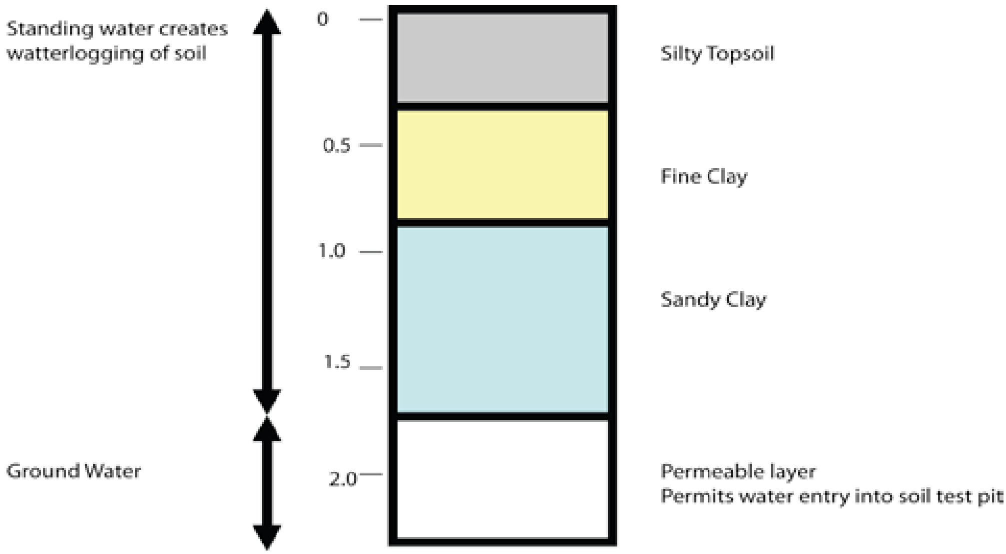

Figure 1. *A typical heavy soil profile. If a free draining layer (called "permeable layer" here) is present at any depth then a groundwater drainage system is the most appropriate solution, if not then a shallow drainage system is required.*

A number of test pits (at least 2.5 m deep) should be excavated within the area to be drained. These test pits should be dug in areas that are representative of the area as a whole. As the test pits are dug, observe the faces of the pits, establish the soil type and record the rate and depth of water seepage into the soil test pit (if any). Visible cracking, areas of looser soil and rooting depth should be noted as these can convey important information regarding the drainage status of the different layers. The depth and type of the drain to be installed will depend entirely on the interpretation of the characteristics revealed by the test pits.

Groundwater drainage system

In soil test pits where there is strong inflow of water or seepage from the faces of the pit walls, layers of high permeability are present. If this scenario is evident on parts of your farm, it would be best to focus on these areas first as the potential for improvement is usually very high. The installation of field drains at the depth of inflow will facilitate the removal of groundwater assuming a suitable outfall is available. Conventional field drains at depths of 0.8 to 1.5 m below ground level have been successful where they encounter layers of high permeability. However, where layers with high permeability are deeper than this, deeper drains are required. Deep field drains are usually installed at a depth of 1.5-2.5 m and at spacings of 15-50 m, depending on the slope of the land and the permeability and thickness of the drainage layer. Field drains should always be installed across the slope to intercept as much groundwater as possible, with main drains (receiving water from field drains) running in the direction of maximum slope.

Shallow drainage system

Where a test pit shows no inflow of water at any depth, a shallow drainage system is required. These soils with no obvious permeable layer and very low hydraulic conductivity are more difficult to drain. Shallow drainage systems are those that aim to improve the capacity of the soil to transmit water by fracturing and cracking it. These include mole drainage and gravel mole drainage. Mole drainage is suited to soils with high clay content that form stable channels. Mole drains are formed with a mole plough comprised of a torpedo-like cylindrical foot attached to a narrow leg, followed by a slightly larger diameter cylindrical expander. The foot and trailing expander form the mole channel while the leg creates a narrow slot that extends from the soil surface down to the mole channel depth.

The success of mole drainage depends on the formation of cracks in the soil that radiate from the tip of the mole plough at shallow depth. Gravel filled mole drains employ the same principles as ordinary mole drains but are required where an ordinary mole will not remain open for a sufficiently long period. This is the case in unstable soils having lower clay content. The mole channel is formed in a similar manner but the channel is then filled with gravel, which supports the channel walls. The gravel mole plough carries a hopper that controls the flow of gravel. During the operation the hopper is filled using a loading shovel or a belt conveyor from an adjacent gravel cart. Gravel moles require a gravel aggregate within the 10-20 mm size range to function properly.

Land drainage publications

The Teagasc Manual on Drainage and Soil Management is available from Teagasc offices or can be ordered online via the Teagasc website www.teagasc.ie/publications. Search “Teagasc Manual on Drainage and Soil Management”. A freely downloadable guidebook is also available. Search “Land Drainage”.

Strategies to reduce energy use in dairy milking facilities

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Summary

- The most profitable technology investment in milk storage and water heating consists of a direct expansion milk cooling system with pre-cooling of milk to 15°C before entry to the milk storage tank, and heating water with an electrical water heating system
- Electricity use, related costs and greenhouse gas emissions from electricity consumption can be reduced on-farm by adding a solar thermal water heating system. This will be associated with a reduction in farm profitability, however, because of the high initial investment costs

Introduction

Making informed business decisions in the domain of energy efficient and conventional technology will help to improve the profitability and environmental sustainability of the dairy sector. In order to develop strategies to reduce electricity consumption in dairy milking facilities, it was necessary to understand the electricity consumption trends within the farm. In a previous study, a total of 31.7 MJ of energy was required to produce one kg of milk solids from a sample of 22 commercial dairy farms in Ireland. Within that group, electricity accounted for 60% of the on-farm energy use (i.e. diesel, petrol, electricity, gas), and 82% of the electricity used was related to milk harvesting. The main components of electricity consumption are: milk cooling (31%), water heating (23%), milking (20%), pumping water (5%) and lighting (3%). Other miscellaneous areas of consumption, such as winter housing systems, consumed only 18% of the electrical energy. Hence, the electricity consumption directly related to milk harvesting (milk cooling, water heating and milking) accounts for 74% of on-farm electricity use. This paper evaluates three electricity reduction strategies from economic and environmental viewpoints.

Strategy evaluation

To examine potential strategies to reduce electricity consumption and costs, we used a model for simulating electricity consumption, associated costs, GHG emissions and profitability of dairy farms. The main inputs to the model were milk production, number of cows and capacity of the milk cooling, milking machine, water heating, lighting and water pump systems, the winter housing facilities as well as details of the management of the farm (e.g. season of calving, frequency of milking and milking start time). Three farm sizes were simulated; a small farm (SF) with 45 milking cows (255,278 L), a medium farm (MF) with 88 milking cows (499,898 L) and a large farm (LF) with 195 milking cows (774,089 L). The farms were spring calving herds operating grass-based milk production systems. Costs associated with the investment strategies were sourced from local equipment suppliers. The results of this analysis are presented in Table 1. Investment in technologies such as pre-cooling coupled with direct expansion milk cooling systems (DXPHE) reduced electricity consumption by 28%, increased overall ten year profitability by 0.8% (€3,960) and reduced annual CO_2 emissions by 4.8 tonnes on LF. Investment in ice bank milk cooling system with the addition of a pre-cooling system (IBPHE) and Solar Thermal Panels (SOLAR) both reduced electricity consumption, CO_2 emissions and electricity costs on all farms. IBPHE resulted in the largest annual electricity cost saving: 46% for SF, 38% for MF and 45% for the LF, but the return on investment (ROI) figures were all negative (-9% for SF, -3% for MF and -1% for LF). Likewise, even though the Solar strategy reduced electricity consumption, CO_2 emissions and electricity costs, the ROI figures were all negative (-25% for the SF, -18% for the MF and -16% for the LF). The most attractive ROI figures resulted from the DXPHE investment (17% for SF, 19% for MF and 21% for LF). The large farm could reduce electricity consumption by over 18%, saving over 3 tonnes of CO_2 per annum by using a solar thermal water heater. Over a ten year period subsequent to the investment, however, the farmer will have reduced cumulative profitability by 1.8% (€9,200).

Table 1. Summary of energy reduction strategies on total annual electricity consumption (kWh), associated CO_2 emissions (kg), associated costs (€) and return on investment (ROI) on three farm sizes, SF (small farm) MF (medium farm) and LF (large farm). Costs are based on the Day&Night tariff

Farm	Strategy							
Size		Energy (kWh)	(%)	CO_2 (kg)	(%)	Costs* (€)	(%)	ROI (%)
SF	Base[1]	10,413	0	5,519	0	1,445	0	-
MF		25,252	0	13,384	0	3,334	0	-
LF		32,670	0	17,315	0	4,571	0	-
SF	DXPHE	-2,876	-28	-1,524	-28	-570	-39	17
MF		-5,644	-22	-2,991	-22	-1,083	-32	19
LF		-9,010	-28	-4,775	-28	-1,714	-37	21
SF	IBPHE	-2,706	-26	-1,434	-26	-667	-46	-9
MF		-5,258	-21	-2,787	-21	-1,259	-38	-3
LF		-8,489	-26	-4,499	-26	-2,044	-45	-1
SF	Solar	-806	-8	-427	-8	-64	-4	-25
MF		-2,270	-9	-1,203	-9	-182	-5	-18
LF		-5,764	-18	-3,055	-18	-461	-10	-16

*[1]Base = investment in direct expansion (DX) milk cooling system, standard milking system vacuum pumps and electric water heating system; DXPHE = as per Base with the addition of a milk pre-cooling system; IBPHE = Ice bank (IB) milk cooling system with the addition of a pre-cooling system; Solar = as per Base with the addition of solar thermal panels. * Electricity costs.*

Conclusions

Of the options studied, the most profitable technology investment strategy consisted of a direct expansion milk cooling system with pre-cooling of milk to 15°C before entry to the milk storage tank and heating water with an electrical water heating system. Ice bank milk cooling systems can reduce electricity consumption by 45% on a large farm with about 195 cows without delivering a positive return on investment in the ten year period subsequent to the investment.

Increasing water use efficiency on dairy farms

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Summary

- The demands for freshwater in Irish agriculture are set to increase as milk production increases
- Quantifying freshwater use is the first step in understanding and thus reducing the demands for freshwater on Irish dairy farms
- Based on data from 25 farms, it was found that on average 6.4 litres of water was consumed for every litre of milk
- Increasing water efficiencies on farms can be achieved by utilising an optimum plate cooler ratio of water: milk of 2:1, recycling of plate cooler water for wash down, eliminating leaks and harvesting rain water for times of low water supply

Introduction

Agricultural practices are the greatest consumers of freshwater worldwide, accounting for 70% of the global freshwater usage. In terms of water resources, Irish agriculture has a significant advantage based on our temperate maritime climate. At a global level, fresh water availability is limited. Reducing consumption of water will improve the marketability of Irish dairy exports on the international markets, while at the same time reducing costs. Quantifying the water footprint of Irish dairy production and identifying hot spots of water consumption along the production chain is the first step towards reducing the strain of water use on freshwater resources.

Fundamentals of water use

The water footprint of a product, defined by the Water Footprint Network, is the sum of the volumetric water use along the entire supply chain of a product. The water footprint comprises the consumption of ground and surface water (blue water) and the consumption of soil moisture due to evapotranspiration (green water). The total water used during a production process can also be divided into direct and indirect water use. In the case of milk production, indirect water use includes evapotranspiration of growing grass and crops and water used in producing feeds (concentrates) brought onto the farm. Direct water use is the water used on-site to facilitate the milk production process. This includes drinking water for livestock, washing the milking machine, bulk tank and milking parlour and milk pre-cooling. This paper focuses on direct water use only.

On-farm water metering

Water meters were installed on 25 Irish commercial dairy farms in 2012. Data were collected from May 2012 to April 2013. Up to eight water meters were installed on each farm to record total direct water use for all aspects for the farm operation. Domestic water use was measured where necessary and subtracted from total water supply to give water supply to the farm only. Water meter data (m^3) were recorded on a monthly basis. The water meter data were categorised from the supply into parlour and other uses. Parlour use includes the water heater, plate cooler and wash-down areas. ‘Other’ use consists of livestock drinking water and miscellaneous water use on the farm. Milk production data was sourced from the Irish Cattle Breeding Federation (ICBF) records for the farms involved.

Water use efficiency

The average volume of water used for the production of milk per farm was 3,121,242 L, and ranged from 1,115,000 L - 7,041,310 L (Table 2). The results indicate the average volume of water required for each farm process. The average total volume of water consumed per litre of milk produced was 6.4 L.

Table 2. Direct water use on 25 commercial dairy farms between May 2012 and April 2013

Process	Total Water Use (L)[a]	Specific Water Use (L/L)[b] (Range)
Supply	3,121,242	6.40 (1.16 - 12.01)
Livestock & miscellaneous[c]	2,090,783	4.38 (1.18 - 9.51)
Parlour	1,030,459	2.02 (0.2 - 4.59)
	Within Parlour[d]	
Plate Cooler	918,469	1.69 (0.0 - 4.36)
Water Heater	91,045	0.17 (0.0 - 0.42)
Wash-down	685,103	1.28 (0.2 - 3.02)

[a]Litre; [b]Litres of Water / Litre of Milk; [c]consumed by livestock and other miscellaneous use; [d]Sum of Within Parlour processes does not equal Parlour, due to the reuse of water within the parlour network

Discussion

Water consumption is primarily driven by livestock and miscellaneous uses, plate cooler water use and cleaning procedures. Fresh water demands for animal drinking is determined by climate, dry matter intake and milk yield and varies from year to year. Teagasc recommend a plate cooler ratio of water: milk of 2:1 for optimum energy consumption. Milk cooling procedures using a ratio 2:1 or higher demand 56% less energy to cool milk than plate coolers that use <2:1 L water / L milk. Plate cooler water can be collected and reused for wash-down procedures and animal drinking water (provided the bacterial load of the supply is low). Our result is comparable to a direct water use of 5.4 L water/ L milk on a single Dutch farm. However, this Dutch study used assumptions regarding the water requirements for livestock and cleaning services. Our approach of measuring each process separately on multiple farms gives a more accurate account of the water demands for milk production.

Another consideration in efficient water use is the maintenance of the water supply network on a farm. Leaks that go unchecked can increase water pumping costs. A leak of 10 L/min could cost up to €526 per year in pumping costs alone and would be significantly higher if the water came from the mains network. A hot water leak of 60 mL/min (1 drip/ sec) could cost up to €240 per year in associated pumping and heating costs. With this knowledge it is possible to complete a water footprint that will allow the overall system hotspots to be identified.

Conclusions

This detailed approach will give an understanding of how and where water is utilised on both monthly and seasonal time horizons. Assessments of water use that rely on actual farm data provide more accurate indications of local water demand, and will identify 'hot-spots' of water consumption. Not all farm systems are alike, and the variability in water use between different systems will be explored in future research.

Fertiliser nitrogen: challenges, new options, and solutions

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Summary

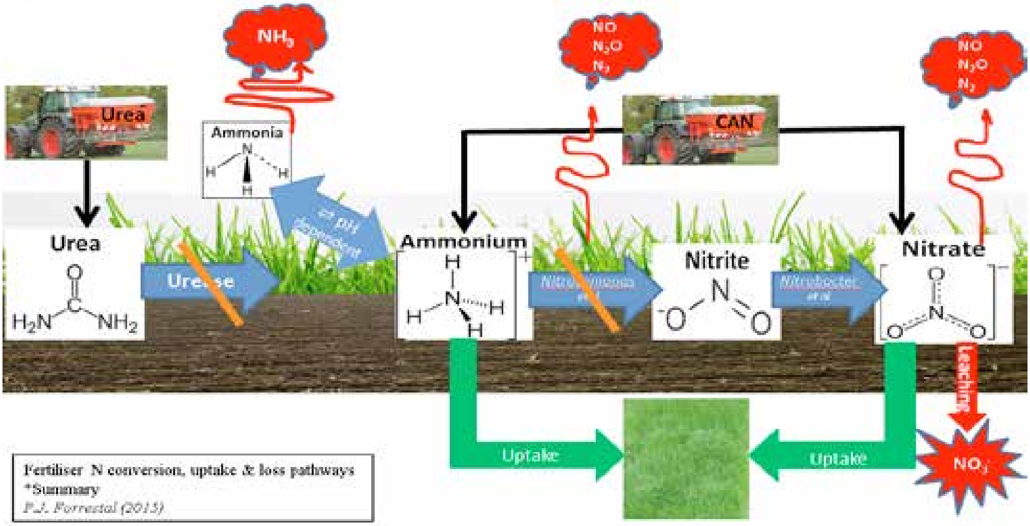
- Fertiliser N management presents the challenge of maximising farm profitability while also meeting national greenhouse gas (GHG) and ammonia loss commitments
- Fertiliser N contributes to the loss of the greenhouse gas nitrous oxide. Teagasc is testing fertiliser N options that will sustain production but address this loss
- Indications from current trial work are that urea based fertiliser plus stabiliser options hold potential for underpinning productivity and N efficiency while curtailing GHG and ammonia emissions. Urea is both less expensive and more available internationally compared with calcium ammonium nitrate (CAN). Consequently, there is potential for urea + stabiliser options to be priced at levels that compare favourably with CAN

Introduction

Fertiliser N is a key input on Irish dairy and grassland farms. Efficient use of N fertiliser and optimized soil fertility underpin the productivity of Ireland's largest crop, grass, which in turn is the foundation for our relatively low cost milk production system. Nationally, agriculture faces challenges to meet GHG reduction commitments and to curtail ammonia emissions. When fertiliser N is added to the soil system it contributes to loss of the GHG nitrous oxide. High levels of fertiliser N use efficiency along with N stabiliser technologies have potential to offer cost effective solutions for increasing or maintaining productivity, while addressing the challenges of GHG and ammonia in a practical fashion using existing farm equipment.

The fate of fertiliser N

Figure 1. *Fertiliser N input, transformation, uptake and loss Summary*



The challenge of fertiliser N management is to maximise the proportion of N that flows through the green arrows for growth and to minimise the competing N flows through the red arrows (Fig. 1). Synchronizing fertiliser N availability with crop N uptake by metering out N as the plant needs it is a key tool in improving N use efficiency. However, the practicalities of timing N applications along with weather complications limits our ability to perfectly synchronise fertiliser N availability and grass demand. Fertiliser N source and stabiliser choice provide additional options for managing the uptake and loss outcomes without changing current standard application schedules.

The research

Trials have been on-going at Teagasc in partnership with the Agri-Food and Biosciences Institute in Northern Ireland over the past two years to evaluate N source and stabilisers.

Fertiliser N sources

The N source options available in Ireland are either one or a combination of urea, ammonium and nitrate. Urea and CAN are currently the major straight N sources used. Other combinations of these N sources have also recently become commercially available increasing the options at farm level. The research has been focused on the two major N sources, CAN and urea.

N stabilisers

Nitrogen stabilisers (also known as inhibitors) are products that can be dressed or incorporated into the fertiliser N sources mentioned above. Stabilisers slow the microbially mediated transformation of the N sources. It is very important to understand that all N stabilisers are not the same. Stabilisers differ in a) what they do, b) how well they do it, c) their longevity and d) their chemical makeup. A limited number of stabilisers are currently available in Ireland, but there are a significant number of other stabilisers available or being developed internationally. Some of these are under trial at Teagasc Johnstown Castle.

Nitrogen stabilisers fall into two categories

A. Urease inhibitors: slow the hydrolysis of urea (first orange line Fig. 1) thus reducing ammonia loss from urea. To work, urease inhibitors must be added to urea containing fertilisers.

B. Nitrification inhibitors: slow the microbially mediated oxidation of ammonium to nitrate (second orange line Fig. 1). To work nitrification inhibitors must be added to urea or ammonium containing fertilisers.

Teagasc has been testing the following N source plus stabiliser combinations:

- Urea + NBPT
- Urea + DCD
- Urea + NBPT + DCD
- Urea + Nutrisphere (2014 at two sites)

NBPT (the urease inhibitor N-(n-butyl) thiophosphoric triamide)
DCD (the nitrification inhibitor dicyandiamide)
Both urease and nitrification inhibitors can be dressed or incorporated at low rates to the fertiliser granule resulting in a low active ingredient volume usage and a targeted delivery.

Preliminary research indications are as follows

- Urea based N formulations, particularly when used with a urease inhibitor provide a viable alternative to CAN in terms of both yield and N use efficiency.
- Use of urea, particularly when stabilised with a urease and a nitrification inhibitor reduce nitrous oxide emissions compared to CAN.
- Over a series of applications in spring and summer 2014 at Johnstown Castle and Hillsborough, the urease inhibitor N-(n-butyl) thiophosphoric triamide reduced ammonia loss from urea significantly and to levels comparable to CAN.

E-Ruminant - improving environmental efficiency of ruminant production systems

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Summary

- There is an increasing demand from national and international markets to measure the environmental sustainability of the entire food supply chain using life cycle assessment (LCA)
- To meet this challenge, the E-Ruminant project measured resource use and biodiversity on-farm and will use this information to develop internationally standardized LCA models capable of quantifying the environmental performance of dairy, beef and sheep farms across Ireland
- Once developed, these models will be applied nationally as part of a sustainability assessment scheme to measure improvements in milk and meat producer's environmental performance while quantifying the effect on productivity over time
- This proactive approach to sustainability will yield benefits for farmers, food processors, retailers and ultimately the consumers themselves, as they can choose products that are environmentally and economically sustainable

Introduction

The Food Harvest 2020 report sought increased output from the Irish dairy and meat production sectors, but it will be necessary to deliver this increased agricultural output while simultaneously reducing environmental impact. Currently, however, there are few tools or models available to assess the environmental sustainability of farms or benchmark environmental standards between Ireland and other countries. The goals of this research were to develop and validate whole farm models that can measure the environmental performance of Irish ruminant farming systems that will underpin Ireland's "Green credentials".

Measuring environmental performance and efficiency

Agricultural practices can affect several aspects of the environment (e.g. biodiversity, finite energy depletion, water consumption, greenhouse gas (GHG) emissions and nutrient loss). To assess the environmental performance of farms on a large scale over a long period of time, it is generally necessary to use a modelling approach. The most popular method to model farm environmental performance is known as LCA. Some methodologies identify strategies that reduce environmental pressures from one part of the production chain without evaluating possible unwanted changes elsewhere. For example, increasing the concentrate to roughage ratio in the diet reduces GHG emissions on-farm, but increases off-farm GHG emissions from feed production, leading to an increase in overall GHG emissions. The LCA method adopts a more holistic systems approach, considering all aspects of production (both on-farm and off-farm) to evaluate overall environmental performance.

Teagasc has developed LCA models for dairy and beef production systems, but these models are only capable of quantifying gaseous emissions. In order to develop LCA models for additional important environmental measures, data was collected on grass-based dairy, beef and sheep farms across the country. As part of this work, monitoring equipment was installed on 80 farms to meter water and energy use, and habitat surveys were conducted to measure biodiversity. In addition, this project measured the efficiency of farms by collecting data on livestock numbers, milk and meat production, feeding practices, fuel usage and fertiliser application. This data was obtained via web-based farm surveys and electronically via available national databases (e.g., ICBF).

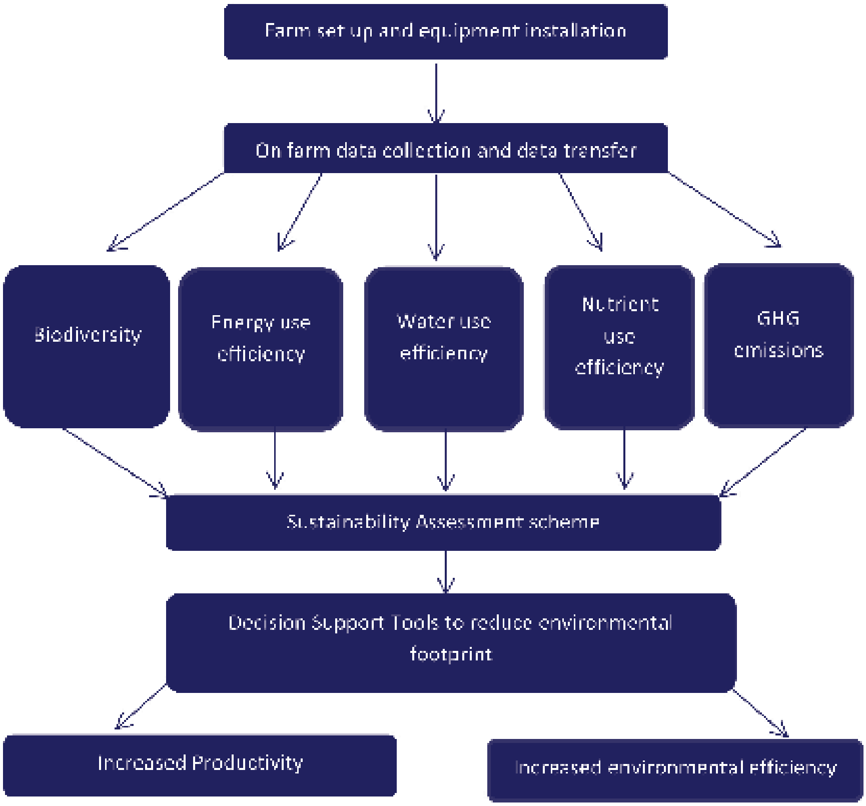

Figure 1. *Flow diagram of the E-Ruminant project*

Sustainability assurance

The LCA models developed as part of this project will be implemented as part of sustainability assessment schemes and will provide scientific integrity around sustainability based farm audits. The LCA models will benchmark the environmental performance of farms and will be used as a basis to develop decision support tools to aid producers improve the sustainability of their farming enterprise.

Conclusions

The development of a sustainability assessment via LCA will demonstrate our green credentials, which will potentially provide access to new markets for Irish milk and meat products. Furthermore, the decision support LCA tools developed from this research will help farmers to continue improving their environmental and economic performance.

Reducing greenhouse gas emissions on your dairy farm

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Summary

- Agriculture accounts for almost one third of Irish Greenhouse Gas (GHG) emissions
- Challenging targets have been set to reduce the impact of climate change, which include reductions in emissions of 20% by 2020 and 30% by 2030
- Increasing milk output in Ireland will make these targets even more challenging
- While agricultural emissions are difficult to mitigate, research has identified a number of technologies/practices that are available to farmers that reduce emissions and at the same time, through improved efficiency, increase profitability

Introduction

Agriculture accounts for almost 33% of Irish greenhouse gas emissions, with most of the remainder being contributed by the transport and domestic sectors. Even though agricultural emissions have declined by 9% since 1990, Ireland is committed to reduce GHG emissions by 20% by 2020 and by 40% by 2030.. The Irish grass based dairy and beef production systems are relatively carbon efficient. An EU study rated Irish Dairy Production as the most carbon efficient in the EU. With the expected increase in dairy cow numbers and dairy output by 2020 and beyond, the dairy industry faces a challenge to increase output in the face of reduced GHG emissions targets. While it is accepted that agricultural GHG emissions are difficult to reduce, farmers who adopt a number of key practices and technologies can significantly improve efficiency, improve profitability and lower GHG emissions.

Agricultural greenhouse gasses

Methane (CH4)

From rumen fermentation and slurry storage. Methane is 25 times more potent than carbon dioxide. It accounts for almost two thirds of agricultural GHGs.

Nitrous Oxide (N2O)

From organic manures and chemical nitrogen fertiliser and animal excreted N. It is 300 times more potent than carbon dioxide. It accounts for almost one third of agricultural emissions

Carbon Dioxide (CO_2)

Associated with the use of fossil fuels for energy and the manufacture of fertiliser. It accounts for a relatively small proportion of agricultural emissions

While agricultural GHGs are difficult to reduce, the good news is that a number of studies have shown that achieving improved technical efficiency, reducing emissions and increasing profitability can all be achieved together.

The carbon navigator

The Carbon Navigator is a decision support tool to help farmers to reduce their carbon footprint. The Dairy Carbon Navigator collects a small amount of information from the dairy enterprise and uses this to assess the performance of the farm against peers. It rates performance from poor to excellent. The Carbon Navigator estimates the percentage reduction in enterprise GHG emissions that can result from increasing technical efficiency in certain areas on the farm. It also estimates the improved profitability that will result from achieving the targets.

Five key areas: How they work

Grazing season length

Increasing the grazing season length lowers GHG emissions in two ways. Grazed grass in the early and late season is a higher quality, more digestible feed than grass silage, leading to improvements in animal productivity and a reduction in the proportion of dietary energy lost as methane. The shorter housing season leads to reduced slurry methane (CH4) and nitrous oxide (N2O) emissions from slurry storage and spreading. Energy used spreading slurry is also reduced.

Improving EBI

Increasing genetic merit through the EBI has the capacity to reduce the carbon footprint in four ways.- First, increasing milk solids yield per cow decreases emissions per unit of product. Second, improving fertility reduces calving interval and replacement rate, thus reducing enteric CH4 emissions per unit of product. Third, more compact calving can increase the proportion of grazed grass in the diet and reduces culling and replacement rates. Fourth, improved health reduces the incidence of disease and deaths, leading to higher production levels and lower replacement rate.

Nitrogen efficiency

Improving nitrogen efficiency leads to improved utilisation of N by plants and lowers losses to the air and water. Improving grassland management and matching crop uptake with fertiliser application are key factors. Urea requires less energy (and CO_2) to produce than CAN, and leads to lower N_2O emissions

Slurry spreading timing and methodology

Spring application of slurry reduces emissions, which are lower in cool conditions with low sunlight. The shorter storage also reduces losses of methane. The resulting reduction in ammonia losses increases the fertiliser replacement value, thereby reducing GHG losses associated with chemical N fertiliser. Low emissions application technologies, such as trailing shoe, also lead to reduced ammonia losses and increases the fertiliser replacement value of slurry.

Energy efficiency

Effective pre-cooling of milk through a plate heat exchanger, the use of variable speed drive (VSD) vacuum pumps and the use energy efficient water heating systems have the capacity to reduce energy related GHGs on Dairy farms

Summary

Irish farms have the capacity to significantly reduce GHG through the adoption of these technologies. For the Irish dairy industry, Carbon efficiency is important to promote the green image, farm profitability and for the freedom to grow the industry and increase milk output. Research is on-going into other technologies that may have the capacity to deliver further reductions.

Increasing biodiversity on Irish dairy farms

Daire Ó hUallacháin

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Summary

- Appropriately designed ecological measures, targeted for intensive dairy systems, can play an important role in halting the decline of biodiversity and achieving the goals of sustainable expansion
- Optimise the biodiversity value of existing farmland habitats before establishing new biodiversity measures on dairy farms
- New biodiversity measures could be targeted to less-productive areas of the farm

Introduction

Intensification of agriculture over recent decades has resulted in a decline of biodiversity within agricultural systems. Emerging global research and policy agendas are now based on sustainable management of agricultural land; there is a need to increase production to cope with increasing food demands, but without compromising the environment and ecosystem processes and services. Irish grass-based farming systems are well positioned in terms of the diversity that they support within the landscape, with on average 12-14% semi-natural area on pastoral farms. To date much focus has been centred on sustaining and enhancing biodiversity on more extensively managed farmland, with intensively-managed dairy systems being largely ignored when agri-environment schemes and measures are being designed and developed. 'The Green Opportunity' as outlined in the Food Harvest 2020 report indicates the pressing need for the development of effective methods for biodiversity conservation, as part of the development of sustainable production systems in both intensive and extensive systems. Incorporation of such measures could provide a very important and much overlooked branding and marketing opportunity to Irish farmers and retailers in terms of capitalising on Irelands 'clean, green' image.

Measures to enhance biodiversity on dairy farms

Intensively-managed dairy systems do not typically support the same abundance or quality of habitats and associated biodiversity as more extensive systems. However, appropriately-designed targeted ecological measures for intensive dairy systems could play an important role in halting the decline of biodiversity and achieving the goals of sustainable expansion.

Maintain and manage existing habitats

It is important to optimise the biodiversity value of existing farmland habitats before new biodiversity measures are established on dairy farms. Existing habitats, including woodland plots, ponds and wetlands should be protected from more intensive agricultural management. These areas should be appropriately managed and avoided when sites are being selected for 'new' biodiversity initiatives.

Hedgerow management

Appropriately managed hedgerows can have multiple benefits, including providing shelter for stock and improving biosecurity; intercepting overland flow and improving water quality; sequestering carbon; and acting as a refuge for biodiversity. Ensure that appropriate management is undertaken outside the closed period from March 1st to August 31st.

- Leave occasional trees or bushes to mature. Mature trees and bushes provide greater feeding and nesting habitats for birds, pollinators and a variety of insects.

- The sides of hedges should be trimmed, with the top allowed to grow taller. This approach provides greater shelter and stock-proofing for animals, but also improves the diversity of habitats for wildlife.
- Replant escaped or 'gappy' hedgerows with native species (e.g. hawthorn). Native species support a greater abundance and diversity than non-native species.

Watercourses and buffer strips

Riparian buffer strips are strips of permanent vegetation adjacent to watercourses that are typically excluded from intensive farming practices. Appropriately managed buffer strips play an important role in maintaining water quality, ensuring bank stability, providing a habitat for biodiversity and acting as a wildlife corridor. To optimally manage these strips:

- Avoid nutrient (fertiliser or slurry) or herbicide application in the strip.
- Allow vegetation in the strip to develop, but avoid the strips becoming dominated by scrub. Periodic cutting or grazing can improve the buffering capacity and habitat quality of the strip.
- Instream work should be targeted from July to September to avoid disruption to spawning fish. When cleaning the channel-bed, the spoil should be deposited away from the buffer strip.

Establish new habitats

New biodiversity measures play an important ecological role where there is a lack of existing habitats. New measures could be targeted to less productive areas of the farm.

- The banks of a cattle underpass could be sown with grass and wildflower mixes. This measure provides a habitat for plants and animals, but it also helps stabilise the banks and prevents undesirable plant species from encroaching into the field.
- Awkward field corners could be left uncut following silage removal. This temporary measure provides food and cover for a variety of species such as farmland birds and small mammals. Corners could be grazed-off when animals are re-introduced to the field.

Bird and bat boxes

Populations of farmland birds and bats are declining and efforts should be undertaken to enhance their populations.

- Avoid interfering with existing bird nests or bat colonies.
- Erect boxes for bats and birds on suitable trees and buildings.

Wild bird cover (GLAS measure)

Wild Bird Cover (a spring-grown mixture of cereals that is not harvested) could be sown on dairy farms, thus providing winter food and cover for declining farmland birds. Mixtures include a cereal (oats or triticale) and oilseed rape, linseed or mustard. The measure is part of the Green Low Carbon Agri-environment Scheme (GLAS).

Conclusions

Biodiversity is a primary environmental indicator of sustainable agricultural systems. There is a need for effective methods to promote biodiversity conservation, as part of the development of sustainable agri-production systems. This provides important branding and marketing opportunities for dairy farmers and retailers.

Additional information

http://www.bak.teagasc.ie/environment/biodiversity-countryside/

Carbery greener dairy farms project Summary 2012-2015

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Summary

- Key areas of sustainability, including nutrients, greenhouse gas emissions, water use, energy consumption and economics were recorded on 12 farms for a period of three years, from 2012 to 2015
- Soil fertility was identified as one of the priority areas for improvement, after it was found that 140 of the 159 soil samples analysed from the participating farms were deficient in either Phosphorus, Potassium or lime

Introduction

The Carbery Greener Dairy Farms (CGDF) project is a farm sustainability project led by the Carbery Group with support from Teagasc. The purpose of the project is to improve the economic and environmental sustainability of Carbery's milk suppliers. Data collection on the 12 farms involved in the CDGF project commenced in January 2012 and will continue through to the end of 2015. To date, three years of detailed analysis has been carried out looking at key areas of sustainability - milk production, nutrient use efficiency, water use efficiency, greenhouse gas emissions, energy use efficiency and economic performance. Of the 12 farms involved in the study, nine have a spring calving herd and the remaining three have a winter milk production system.

Soil fertility

Of the soil samples analysed as part of the CGDF project, 75% of soil samples had a pH of less than 6.0. The optimum soil pH for grassland is at or above 6, the release of nutrients from the soil and the response to applied fertilizers will be reduced where the soil pH is low. The average Soil Test Phosphorus (STP) level was 6.5 mg P/L in 2015, and overall 57% of all samples analysed were in Index 3 and 4 for Phosphorus (P). Soil Test Potassium (STK) was an average 121 mg K/l across all the samples taken. The use of fertilizer Nitrogen relative to fertilizer K was found to be excessive across all the farms and a ratio of 3:2, or 2:1 on low index soils, was recommended.

Energy audits

Electricity tariffs on the 12 farms were analysed and the potential saving that could be made by switching supplier was assessed. Farms on the project with an average electricity consumption of 20,000 kWh per year could save up to €430 by simply switching their electricity supplier. Analysis of the use of night rate electricity on the farms involved found that the average farm could save between €100-150 per year by heating water on night rate electricity alone.

Carbon navigator

The Carbon Navigator decision support tool was completed for each farmer based on 2012 data and targets to be achieved by 2016 were set. The targets set out in the Carbon Navigator aimed to achieve an average reduction in GHG of 8.9% and an average increase in net profit of €5,766 could be achieved per farmer over the three year period (or an average of €1,925 per farmer per year). Increasing the grazing season length of the Carbery farmers from a current average of 278 days to a target average of 286 days would result in a reduction in GHG emissions intensity by 1% while increasing net profit per farmer by €716 per year for a three year period. The average herd EBI of the CGDF farmers was €115 in 2012. They set a target of €156 to be achieved by 2016. This increase in EBI would result in an average increase in net profit per farmer of €1,826 over the three years and a reduction of 3% in GHG emissions.

Data ranges over the course of the study

During the study, the carbon footprint with sequestration was an average of 1.15 kg CO_2/kg energy corrected milk across all the farms and ranged on individual farms from 0.75 to 1.64 kg CO_2/kg. The main reason for the large range was that the farms involved in the study included both spring and autumn calving herds. The farms with autumn calving herds were importing soya bean to feed lactating cows during the winter months, therefore they had a higher carbon footprint than the spring calving herd whose diet is dominated by grass. The advice given in terms of raising the pH of the soils resulted in the average lime use on the farms in the study increasing from an average of 8 tonnes/farm in 2012 to 111 tonnes/farm in 2013. This impacted the carbon footprint increasing it slightly from 2012 to 2013. However, between 2013 and 2014 the carbon footprint reduced again as lime use decreased once adequate levels of soil pH had been reached. Other factors impacting the farms on the study included the fodder crisis which dominated 2013. The effect of this crisis was seen in 2014 with a large increase in the amount of fodder imported onto farms, which in some cases had never previously imported fodder, from an average of 661 kg/LU in 2012 to 1,722 kg/LU in 2014.

Table 1. Average figures across the 12 farms for three years (2012-2014 inclusive) with the minimum and the maximum figures shown representing the lowest or highest figure encountered on an individual farm in an individual year

	Average	Min	Max
Stocking density (kg organic N/ha)	198	143	261
EBI (€)	132	77	183
Milk solids (kg/cow/year)	427	317	536
Milk solids (kg/ha)	709	385	988
Butterfat (%)	4.16	3.83	4.52
Milk Protein (%)	3.56	3.42	3.89
Bought-in concentrate(kg/LU/year)	693	321	1,172
Bought-in forages (kg/anima/year)	1,194	0	6,503
Fertilizer N usage (kg N/ha)	253	112	273
Fertilizer P usage (kg P/ha)	8.2	0.0	16.2
Lime (tonnes purchased/year)	60	0	330
Carbon footprint with sequestration (kg CO_2/kg energy corrected milk)	1.15	0.75	1.64
kWh/ Cow	214	105	360
L Water / L Milk	6.4	3.9	10.7
Family Farm Income (c/kg)	18	8	27

Conclusions

This project has identified key areas for improvements across the 12 farms involved in the project. Making these improvements will serve to increase the sustainability of these farms for current and future generations of farmers in West Cork.

The value of pig manure as a grassland fertiliser

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Summary
- Fertiliser costs account for approximately 20% of the variable costs on dairy farms
- Pig slurry can replace some of the nutrients supplied by chemical fertilisers and reduce costs without compromising yields
- Preparation of a nutrient management plan early in the year is important in order to ensure compliance with the Nitrate Regulations

Introduction
Fertiliser costs account for approximately 20% of the total variable costs on dairy farms at approximately 2.53 cent per litre. Pig manure is an excellent source of the Nitrogen (N), Phosphorus (P) and Potassium (K) for grassland and has the potential to add savings by replacing some of the nutrients supplied by chemical fertilisers.

The value of pig manure
The value of pig manure as a fertiliser is dependent on the quantity of chemical fertiliser that is substituted with pig manure, the cost of the pig manure as well as the current cost of the chemical fertiliser replaced. The fertiliser value of pig manure at 4.3% solids is currently valued at €5.87 per m^3 (€26.65 per 1,000 gallons) when there is a requirement for N, P and K and based on an N availability of 50% (Table 1).

Table 1. Nutrient content and value of pig slurry (4.3% solids)

	Nitrogen	Phosphorus	Potassium
Nutrient content (kg/m^3)	4.2	0.8	2.2
Nutrient availability (%)	50	100	100
Fertiliser cost per kg (€)*	1.04	2.32	0.83
Value (€)	2.18	1.86	1.83

*Note: 1 m^3 equals 220 gallons. *Based upon Chemical Fertiliser prices in Feb 2015*

As the solids content increases, there will be a corresponding increase in the nutrient content and in the fertiliser value. The use of a hydrometer to measure manure solids will establish the true nutrient content. Typically 1,000 gallons of typical pig slurry (4.3% solids) can be considered equivalent, in chemical fertiliser terms, to a 50 kg bag of a 19-7-20 NPK product.

Transport and spreading cost of pig manure should always be deducted from the savings made to establish the true saving. The transport cost will vary depending on a number of factors such as transport distance.

Case study

A recent case study on a Cork farm showed that there was potential savings of €53 per acre (€130/ha) from using pig slurry on silage ground to reduce chemical fertiliser purchases. The slurry transport cost was reduced in this case as the farmers' own transport was used. This study compared grass dry matter yield and feeding value to establish if there was an effect on silage yield or quality, and costs of using chemical fertiliser only compared with substituting chemical fertiliser with pig manure. One plot received chemical fertiliser only (3 bags of CAN and 3 bags of 0:7:30 per acre), while the other half received 2,500 gallons of pig slurry per acre followed by a reduced level of chemical fertiliser (1.3 bags of CAN and 1.6 bags of 0:7:30 per acre). Grass dry matter was measured weekly and both plots had similar yields of 5,800 kg DM/ha at silage harvesting. There was no difference in any quality measures between the two silage crops.

Rules and regulations

All decisions in relation to all fertiliser use must be in compliance with the EU Good Agricultural Practice for Protection of Waters Regulations (often referred to as the "Nitrate" regulations). These regulations have been reviewed and updated, providing some flexibility to allow ruminant farmers use pig slurry. The latest Statutory Instrument (SI 31 of 2014) came into effect on 31st of January 2014, and will be in place for the years of 2014 to 2017.

In order to determine how much pig slurry a farmer may use, it is important to know the following:

- The area of the farm
- The organic N stocking rate
- The crops grown
- The nutrient status of the soil (assume a soil P of Index 3 if no soil sample results available)
- The proposed chemical fertiliser usage
- The tonnes of concentrate feed fed to grazing animals the previous year

How much pig slurry a farm may use will be determined by the limit of 170 kg organic N/hectare on the overall farm. Then the calculation of how much P is required may be the next limiting factor. If a farm is using chemical P it will greatly reduce the ability to use pig slurry on the farm. The amount of concentrate fed to grazing animals in the previous year must also be factored into the calculation. Farmers farming within a nitrates derogation (i.e. above 170 kg organic N/ha.) are not eligible to bring in additional organic N in manure.

Plan ahead

The preparation of a nutrient management plan to substitute chemical fertiliser with pig slurry early in the year is important in order to ensure compliance with the "Nitrate" regulations. It is necessary to discuss this with your agricultural adviser/consultant to ensure compliance with these regulations, and doing it early in the year can provide substantial savings.

More details

For more details on using pig manure as a fertiliser or to be put in contact with a pig farmer close to you, please contact your local pig advisor at http://www.teagasc.ie/pigs/staff/.

KEEPING YOURSELF SAFE ON DAIRY FARMS

Health and Safety for dairy farmers

John McNamara[1] and Patrick Griffin[2]

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Summary

- To the end of May 2015, six persons have lost their lives due to farm accidents; this follows on from 2014 when 30 persons died in farm accidents
- The farm death level in 2014 made up 55% of all workplace deaths while just 6% of the workforce is employed in the sector
- Prevention strategies use two broad approaches; firstly removing hazards and then adopting safe procedures

Introduction

In 2014 farm deaths made up 55% of all workplace deaths, even though agriculture only makes up 6% of the total national work force. Dairy farms have a disproportionately high level of fatal and non-fatal injury levels. Fifty eight percent of fatal farm accidents occur on dairy farms. The level of non -fatal accidents is twice as high in dairy farming compared with other cattle enterprises. This information should motivate everyone in the sector to manage health and safety effectively.

Health and Safety strategies

Prevention strategies use two broad approaches; firstly removing hazards and then adopting safe procedures. These strategies are vital for prevention of farm accidents as farms have a wide variety of hazards. As over 90% of accidents have a behavioural cause, farmer input in managing farm safety is the vital ingredient to preventing accidents.

Managing workload in dairying is also crucial to reduce accident levels. This is achieved by having a streamlined livestock system, good facilities and minimising machinery work. Having the workload under control allows adequate time for farm management including implementing health and safety measures, which prevents work being done in a rushed manner.

Vehicles and machinery safety

In 2014, 16 (60%) deaths were associated with farm vehicles or machines with the majority involving crushes or blows. There have been a number of crush deaths associated with tractors rolling-away in farmyards. These are silent killers as people don't see or hear the vehicle coming until it is too late.

To prevent crushing due to vehicle "run-away":

- Stop the engine and leave the fuel-control in the shut-off position and remove key.
- Apply the hand brake securely
- Park on level ground where possible. Leave the vehicle in gear. If on a slope, use the reverse gear if facing downhill and low forward gear if facing uphill.
- Use wheels stops if necessary to prevent a vehicle rolling from its parked position.
- As vehicles vary in operating procedures, always follow the handbook instructions.

ATV safety

ATV's or Quads have huge potential to reduce work time on dairy farms. However, they are lethal machines if used incorrectly. It is imperative that operators undergo essential training before using Quads, children should never be allowed to use them.

Revolving power shafts

The majority of accidents with PTO's or machine moving parts occur when the machine is stationary. Ensure complete covering of the power-shaft and adopt a work procedure where you do not have to work near the rotating shaft. Also, particular care is needed when adjacent to operating powered machines such as balers or combines when stationary. Always turn off the PTO and the power before leaving or approaching a revolving machine component.

Farmers health

A recent national study indicated that farmers as an occupational group have one of the highest "all-cause" mortality rate. In the study, the highest mortality rates were reported for the behaviour-related chronic diseases: cardiovascular disease and cancer. The finding of this study contrasts with Irish farmers perceptions of their health status.
Teagasc actively promotes health practices among farmers in association with other agencies with a role in this area. It is imperative that farmers monitor their health to ensure problems are picked up early.

Completing a risk assessment

The key document for managing farm health and safety is the **Risk Assessment Document**. Completing and updating this document is a legal requirement under the Safety, Health and Welfare at Work Act (2005). In this document, the key questions regarding safety and health are asked. Information on causes of accidents along with pictures of key controls are provided. Safety and health actions needing attention should be listed on the Action List and acted upon.

The document should be kept on the farm. A Health and Safety Authority (HSA) Inspector can examine the document during an inspection. The HSA recently announced that they plan to use a direct prosecution approach in the following situations: children less than seven years old being carried as passenger on tractors; uncovered power-shafts; and un protected slurry tanks.

Teagasc provides a half-day training course to farmers on completion of the Risk Assessment Document. The feed-back from half-day training courses is very positive. Ninety nine per cent of farmers agreed that it would be worthwhile to offer the course to all farmers, 97% of farmers agreed that the course motivated them to implement health and safety measures while 100% stated that they planned to make health and safety improvements on their farms.

Discussion groups

Discussion groups (or other groups) are particularly powerful in gaining health and safety improvements on the farm. These provide a facility to spot safety hazards and suggest better ways of farming safely. The exercise of bringing a number of peers into the farm allows an unbiased assessment of the farm at a relatively low cost. Why not ask a friend or neighbour to take a look at your farm and suggest ways to improve safety.

Conclusion

Farm accidents lead to tragedy, pain and suffering, disability and farm business loss. Farms are very dynamic workplaces and active safety management on an on-going basis is required to minimise the farm related risks. One accident is one too many. By putting safety first you are protecting your vital assets - your life, the lives of your loved ones and the family livelihood.

TEAGASC FOOD RESEARCH PROGRAMME

Image courtesy of Board Bia

Food for Health Ireland

Tom Beresford, Phil Kelly and Rita Hickey
Teagasc, Food Research Centre, Moorepark Fermoy, Co. Cork

Summary

- Food for Health Ireland is a successful industry led, Enterprise Ireland and Industry funded research project investigating health components within milk
- The carbohydrate component of bovine milk has anti-infective properties and promotes the growth of good bacteria in the gut. This is of particular relevance to the health of infants consuming infant milk formula
- Skilled staff and access to the Moorepark Technology Ltd., pilot plant has enabled the scale up of bioactive materials for validation by FHI partners and for industry partner evaluation
- Food for Health Ireland strives to translate research outputs in a way that industry can readily commercialise

Established in 2008, Food for Health Ireland (FHI) is a research centre for the development of nutritional functional ingredients to improve health, wellness and quality of life through innovation in food. Its purpose is to identify novel active ingredients in milk with a desirable biological function, and to develop these as functional food ingredients that will offer health benefits to consumers. The research is focused on the development of ingredients for infant nutrition, healthy cheese, appetite modulation, performance nutrition, healthy aging and reducing risk of developing Metabolic Syndrome. Food for Health Ireland also provides a contract research facility for small and large global food companies utilising the competencies, resources and technologies available in the consortium. The consortium is made up of academic partners (Teagasc Food Research Centre Moorepark, University College Dublin, University College Cork, University of Limerick, Dublin City University, National University of Ireland Galway and National University of Ireland Maynooth), and industry partners (Carbery, Dairygold, Glanbia Ingredients Ireland Ltd, Ornua and Kerry Group). FHI is funded by Enterprise Ireland and FHI's industry partners.

The market for FHI outputs is identified as the health and wellness markets, which are currently worth $156 billion and are expected to grow at a rate of 2-8% annually. The key food trends at present include dairy, weight management and senior nutrition, to which the research interests of FHI are perfectly aligned.

Infant nutrition research:
The work programme on Infant Nutrition is being led by researchers at Teagasc. Staff have been involved in researching the health benefits of the carbohydrates found in cow's milk (referred to as oligosaccharides). These oligosaccharides are a potential source of anti-infectives capable of neutralising the threat of bacterial infection in the gut and in the respiratory system. Results indicate that cow's milk oligosaccharides could have a major impact on human health. In addition to anti-infective properties, cow milk oligosaccharides stimulate the growth of Bifidobacteria, which are important beneficial bacteria in the human gut. Both of these properties are important for infant health. Scientists within FHI and industry partners who supply ingredients to infant milk formula manufacturers are working together to improve formula for infants that do not have the benefit of being breastfed, or have moved on to infant milk formula feeding. Novel formulas may be developed containing oligosaccharides that would promote the growth of beneficial bacteria in the gut during the early stage of life, which could have long-term beneficial outcomes for the infant, including resistance against infection.

Screening for bioactives from milk:

To date FHI has generated greater than 1,000 unique samples from milk. The samples generated are assessed for properties of interest to human health in a series of tests known as 'bio-assays'. Bio-assays are laboratory based tests that indicate potential effects on health for a particular sample. A number of the unique milk samples (75) generated positive results and have been identified as having potential commercial significance. These have been characterized and in some instances production of these bioactives has been scaled up to pre-commercial scale at the Moorepark Technology Limited pilot plant. Results have been made available to FHI industry partners for commercialisation.

Pre-commercial scale-up:

Teagasc Moorepark provides a key role in defining and developing scale-up manufacturing processes for bioactive materials discovered and validated by other FHI partners. Large pilot scale trials capable of generating approximately 100 kg of spray dried powders have been conducted at Moorepark Technology Ltd and have been evaluated in human studies. Additional processes employed include the use of advanced membrane separation technologies in order to enrich milk fractions possessing activity of biological interest. The Teagasc Moorepark scale-up group have been involved in the successful development of a toddler food aimed at infants that suffer from cow's milk protein allergy. This is currently under license for evaluation by one of FHI's industrial partners.

Food for Health Ireland promotes Knowledge Translation:

Research needs to be translated in a way that industry can readily commercialise. The FHI approach is to work with and alongside industry partners and in close connection with the scientists involved in the project. In FHI, a unique bridge has been built between high-class research organisations and industry needs. Ireland's small size and flexibility is a definite advantage. The national network of FHI experts in the food arena combined with the commercial expertise of the industry partners enhances the competitive advantage of the food industry in Ireland.

The CheeseBoard 2015 research project

Phil Kelly

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Summary

- Young females are attracted to reduced fat variants of cheese while more athletic individuals seek cheese with higher protein content
- Consumers also like to see simultaneous reductions in both cheese fat and salt contents, but that this is technologically challenging to achieve
- Considerable variation in cheese salt content may be addressed by adopting improved curd salting protocols during production

Introduction

The 'National Cheese Research Programme 2015' began in 2012 with the support of FIRM funding from the Department of Agriculture, Food & Marine. Five academic and research institutions combined their respective strengths to provide an integrated approach to cheese research challenges and future opportunities in what was to become known as the 'CheeseBoard 2015' project.

Focus on the consumer

There are many consumer trends currently in vogue that cheese is ideally positioned to exploit in terms of new product development. Aging population, sustainability and the positive health image that protein is currently experiencing play an integral role in developing new concepts for cheese products or marketing strategies. Teagasc is continuing to address current consumer issues that will impact cheese development and consumption during the next decade.

The findings from detailed studies of the cheese market in the UK and Ireland were similar. Natural cheese has a larger proportion of shelf space than processed cheese. Notably, the Cheddar variety is still the most common retail cheese sold. However, innovation, especially in the Cheddar variety, was low. Cream cheese, mainly under the Philadelphia® brand, is the most innovative category, especially with cooking and flavoured varieties currently on the market. Processed Cheese is important because of its appeal to the children's market. Private label cheese brands take up a large proportion of the retail cheese category especially in the UK.

In mainland Europe, Emmental and Camembert were the predominant cheeses in France, whereas Edam and Emmental were the most popular in Germany.

A review of product launches was completed in conjunction with Bord Bia. Fromage frais/ yogurt and almond/soya milk were the most popular launches that had a health benefit claim regarding bone health. New launches in the case of natural cheeses were much less frequent, supporting the earlier finding that there is room for more innovativeness in the cheese category.

New concept cheeses included high protein cheese, cheese for brain health, cheese with added novel functional ingredients and cheese for a range of eating occasions. These were tested by members of focus groups of varying demographic profile who considered themselves 'adventurous' in their cheese tastes. In general, the taste panels were positively disposed to the concepts presented. Recommendations arising from this qualitative research include:

- Lower fat products are more appealing to the younger female demographic
- High protein cheese has very strong appeal for fitness and younger segments

- Perceived need is a key determinant of health promoting cheeses
- Health benefits were most positively received among those with a carer role and older participants

Reduced fat/salt cheeses with improved texture and flavour

For some years, the emphasis was primarily on the development of reduced fat variants of cheese. Soon there was public demand for simultaneous salt and fat reduction arising from the intense debate concerning dietary salt intake and negative consequences for health. This posed considerable technological challenges. Interestingly, the outcome of an initial survey of commercially available Cheddar cheese established that there was significant variation within and between brands in salt content. Greater variation was found in the 'mild' rather than in the 'mature' labelled cheeses. Hence, a first recommendation was the need to exercise greater control over salt addition in the manufacturing plant. During experimental studies at Teagasc Moorepark, the negative consequences on quality by lowering the fat content of Cheddar from 33 to 16% could be readily seen with significant increases in the firmness, fracture stress and fracture strain of the cheese. On the other hand, reducing salt content from 1.7 to 0.9% had the opposite effect. Meanwhile, collaborators at the University of Limerick have been examining the effects of reducing salt and fat levels on the microbiology and enzymology of cheeses during ripening. Building up knowledge of how cheese starter strains respond to varying salt concentrations is critical when optimising the selection of starter blends for reduced salt and fat Cheddar cheese manufacture.

Cheese diversification

Greater cheese diversification opportunities are emerging as a result of using cutting edge molecular biological assays at Moorepark to characterise adventitious microflora during cheesemaking. This is expected to lead to enhanced quality and innovations in the manipulation of physicochemical, technological and microbial parameters for the benefit of existing varieties and new cheese types. Results show that the modulation and intensification of the flavour profile of novel dry-salted Cheddar variant cheeses could be influenced by screening and selecting microorganisms using cellular markers to indicate their metabolic potential.

Processed-style cheeses

Low-fat processed-style cheeses were successfully developed at UCD without the use of chelating salts. This was achieved using curds with controlled calcium concentration - a potentially important means of reducing the sodium (salt) content of such products. Further manipulation of curd calcium content along with casein interactions was undertaken to develop processed-style cheeses with different functionalities (meltability, sliceability) and textures (hardness, cohesiveness).

The CheeseBoard 2015 research project is now in its final (4th) year and is actively interacting with the cheese industry regarding innovative developments and problem solving. Further information is available at www.cheeseboard2015.com

CheeseBoard 2015 principal investigators:

Teagasc: Dr. Phil Kelly (Coordinator), Prof. Tim Guinee, Dr.Linda Giblin, Dr. Tom Beresford, Dr. Paul Cotter; Prof. Gerard Downey; Dr. Sinead McCarthy
UCC: Prof. Paul McSweeney; Dr. Mary McCarthy
UL: Prof. Martin Wilkinson
UCD: Prof. Dolores O'Riordan, Michael O'Sullivan
AFBI (N. Ireland): Dr. Ann Fearon

Global dairy opportunities

Mark Fenelon, Tim Guinee, Diarmuid Sheehan, Kieran Kilcawley and Phil Kelly

Teagasc, Moorepark Food Research Centre, Fermoy, Co. Cork

Summary

- Research is needed to support the 'premiumisation' of dairy commodities made from grass-based systems
- Research is also required to support expansion into new, but challenging market opportunities, such as Asia
- SMART dairy ingredient innovation and maintenance of optimal commodity product quality are vital for global success in dairy markets
- Cheese production will benefit from diversification into new cheese varieties

Introduction

The abolition of milk quotas is a momentous occasion for the Irish dairy industry. The removal of restrictions is expected to result in a 2.75 billion litre increase in milk production in Ireland by 2020. This increased output will enhance the value of primary production by an estimated €700 million, along with further downstream benefits in the form of increased dairy products, export earnings and employment.

Ireland is already a significant exporter of dairy products, and all of the increased milk output will also be destined for export markets. In an effort to maximise the potential of these markets, the Irish Government, dairy industry and research institutions have been exploring the needs and nuances of export markets in order to best service their requirements.

Development of SMART dairy powder ingredients for export

In order to utilise the extra milk produced, a major part of Ireland's dairy product portfolio will be in the form of powdered ingredients (e.g., skim, whole milk and milk protein concentrates) and fat filled / nutritional beverages (e.g., infant formula). Dehydrating (spray drying) milk, its components, or the nutritional products in which milk components are used is an effective way to reach distant and new markets. Hence, as a result of the importance of powdered ingredients, Moorepark Food Research Centre has increased its focus on core scientific competencies such as protein chemistry, membrane and spray drying processes. Specialised membranes can be used to fractionate milk into many different components with different composition and functionality for a range of different applications. This technology will generate new opportunities for development of smart, protein-based powdered ingredients for export. Teagasc defines a smart ingredient as high-value, milk-protein based ingredient that can have enhanced nutritional or physical properties (or both), and can be used as a base for manufacture of other food products such as cheeses or beverages elsewhere in the world.

Cheese diversification, quality and consistency in action

Cheese is a vital end-product for the increased milk pool. This is due to continued increases in global cheese consumption, high end-use versatility, potential for significant added value, and as a profitable outlet for surplus milk fat. Traditionally, the Irish cheese industry has been heavily focused on cheddar production. Through its cheese diversification research programme, Teagasc is seeking to underpin diversification of the national cheese portfolio to meet market demand for alternative cheese varieties. Through funding from the Department of Agriculture, Food and the Marine, the CheeseBoard 2015 research programme was established to explore the technical challenges posed by processing an increased milk supply to produce diverse, market-led products of consistently high quality.

In 2011, Teagasc and Ornua established a partnership to develop market-led product concepts that can be manufactured by Ornua members, which Ornua would then market internationally. This partnership draws on the capability of the Teagasc Food Research Centre at Moorepark to provide key scientific and technological advances, particularly in the areas of dairy chemistry and technology, through its dedicated research staff and research programmes. This research expertise is combined with Ornua's ability to identify new market opportunities and to harness consumer insights to drive innovation. The collaboration has led to the building of a new cheese plant at the Al Wazeen facility in Riyadh based on innovative milk protein ingredients recombined into fresh cheese. The collaboration has also resulted in a successful tripartite development, industrial scale up and commercial launch of Kildery cheese with Tipperary Co-op, which now manufactures the cheese for a key export market (available in Germany). The cheese was an immediate success, winning the 2013 Silver Medal in the continental cheese category at the Global Cheese Awards before commercial launch, and went on to win the 2014 Gold Medal in the same category following its introduction to the market.

Cross-cultural sensory studies

For Ireland to best leverage the opportunity presented by increased milk production, we must understand the requirements of its target markets and consumer perceptions. With China identified as a key destination for future Irish dairy exports, researchers at Teagasc have engaged in research collaborations with Chinese universities and institutes in the area of sensory science. These cross-cultural sensory studies are being undertaken to explore the effects of ethnic and cultural difference on flavour perception, acceptance and preference with regard to dairy products. The knowledge generated within this project will be critical for the future marketing of Irish dairy products, in China and beyond.

Consumer consideration

Consumer demand must always be taken into consideration. Teagasc and its food research partners at national universities explore opportunities that are driven by consumer trends and market interpretation for new product development. Continued consumer interest in reduced and low-fat dairy products and reduced sodium content cheeses presents both challenges and opportunities for innovation. Fat reduction in cheese poses challenges for the retention of desirable flavour and textural characteristics. Current research is focused on investigating optimal ways to achieve combined reductions in both fat and salt contents within cheese matrices while retaining consumer appeal.

Opportunities ahead

As it stands, Ireland's dairy industry is enjoying international success, with exports valued at €3.06 billion for primary dairy products such as butter, cheese and milk powders and value-added dairy-based products and ingredients, such as infant formula and casein. Meanwhile, dairy-based enriched powder exports are worth a further €710 million. Ireland's pasture derived milk is the choice of some of the world's leading infant formula manufacturers such as Danone, Abbott Nutrition and Nestle, which already have manufacturing facilities in Ireland. As the industry increases the output of a quality-assured primary product over the coming years, Teagasc will continue its work to generate the advanced technical know-how and research insights to maximise the value of Ireland's milk pool into the future.

Notes

PastureBase IRELAND

You can get more from your grass

Increasing Profit with Better Grassland Management
Making Ireland Grass Rich

Invitation to all Irish Grassland Farmers and Industry Stakeholders

PastureBase Ireland (PBI) is the National Grassland Database for grassland farmers. We are delighted to invite all grassland farmers who are interested in measuring grass and increasing their farms grass DM production levels, grazing management skills to sign up to the system.

Grass utilisation is a key driver of farm profit - every extra tonne of grass utilised is worth €161/ha net profit

All sectors of the grassland industry can improve grass utilisation, a one unit increase is worth €25 million to the sector, and huge potential exists to increase efficiency in grassland. The removal of EU dairy quotas represents the opportunity for the Irish dairy industry to increase milk production. But this expansion in dairying must be built solidly on grass based dairying. Grassland management can improve on all farms through grass measurement coupled with good decision making. Farmers who use PBI grow and utilise more grass.

Teagasc – Agriculture and Food Development Authority

FBD Trust

Dairy Research Ireland – funded by Irish Dairy Farmers

PastureBase Ireland offers grassland farmers key innovations with relevant grassland information:

- Regular updates on grass growth, DM %, grass quality and climatic factors
- PastureBase Ireland can deliver key feedback on the farm's weekly, monthly and annual performance
- Access to Grazing Coach workshops with Teagasc Advisory and Specialist Service

To sign up your farm to PastureBase Ireland – the following information is required

Farm name: ______________________________

Farmer's name: ______________________________

Farmer's email address: ______________________________

Farm address: ______________________________

____

Phone number: ______________________________

Teagasc client / adviser (if applicable): ______________________________

Herd / Flock number: ______________________________

Farming enterprise: ______________________________

Herd / Flock identifier (IE number): ______________________________

Grass measuring method (visual or platemeter): ______________________________

Current Discussion group (if applicable): ______________________________

Teagasc acknowledges with gratitude the support of

FBD Trust

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