Animal & Grassland Research and Innovation Centre

Moorepark

Irish Dairying

Resilient Technologies

Tuesday 4th July, 2017

Teagasc

Agriculture and Food Development Authority

MOOREPARK '17

IRISH DAIRYING – RESILIENT TECHNOLOGIES

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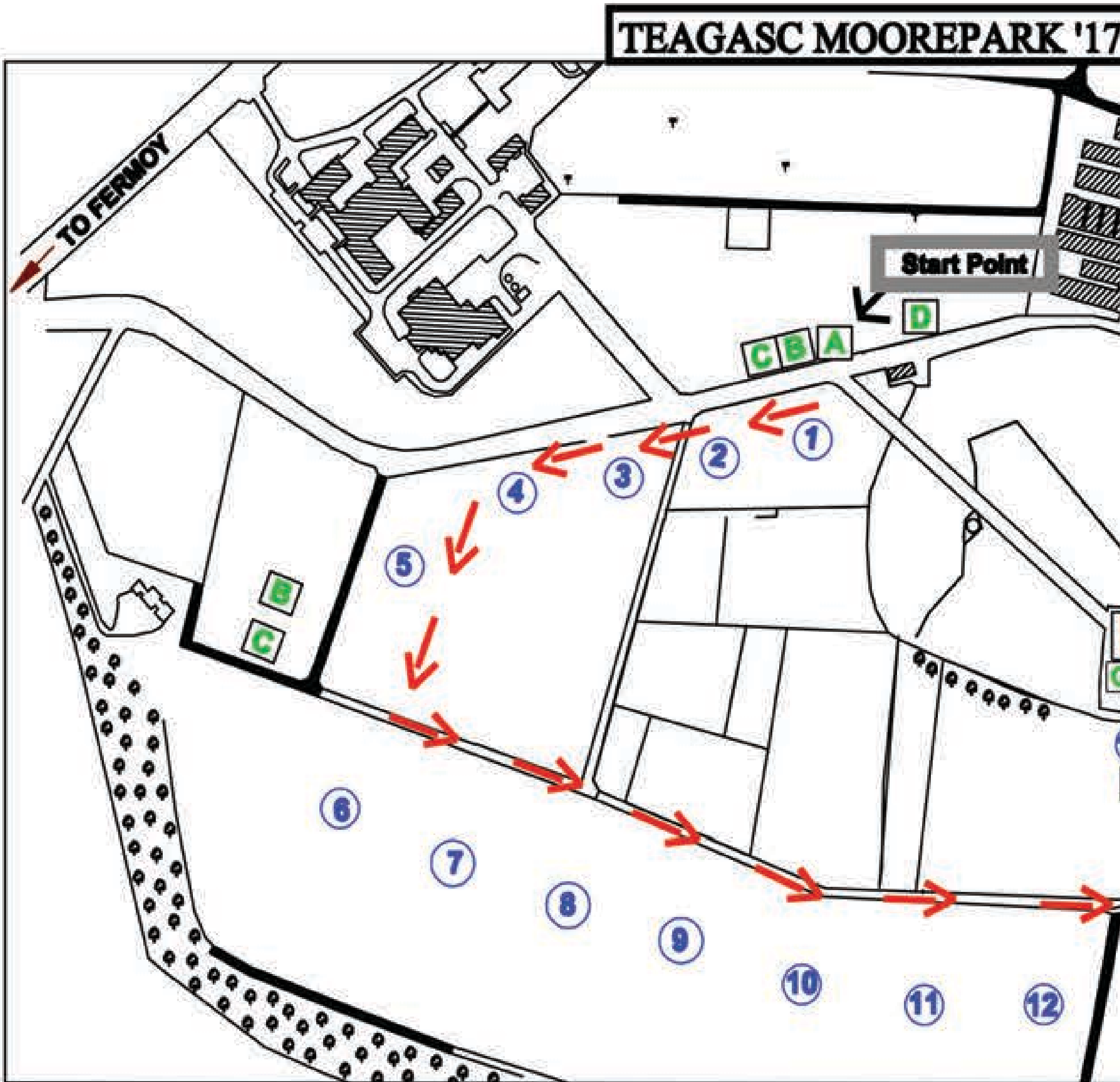


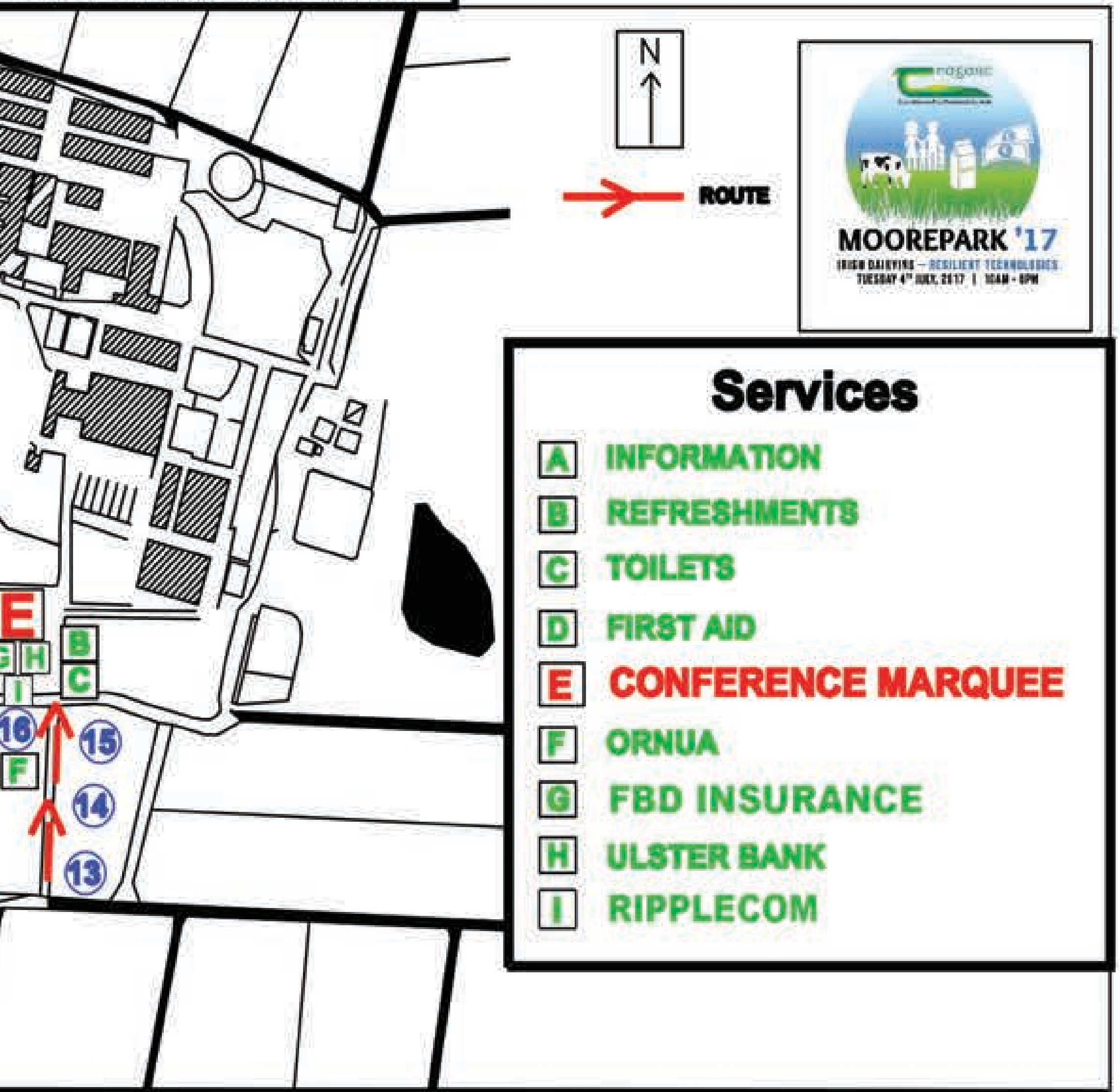
Stands

1. Principles of Resilient Dairying
2. People First
3. Feeding the Modern Cow at Pasture
4. The Perfect Cow

Villages

5. Grazing Demonstration
6. Grass10
7. Advancing Genetic Gain
8. Profitable Systems of Milk Production

OPEN DAY SITE MAP



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Teagasc,
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ADVANCING GENETIC GAIN

PROFITABLE SYSTEMS OF MILK PRODUCTION

Irish dairying - Challenges and opportunities

Pat Dillon

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The Irish dairy industry has expanded significantly over the last four years and further expansion is anticipated. The Food Harvest 2020 report forecast that milk production would increase by 50% by 2020 relative to the average milk production during 2007-2009 (4.93 billion litres). Based on 2016 milk production of 6.67 billion litres, Ireland has achieved 35% of the 50% increase in milk production (43% increase based on milk solids), and should easily achieve the 50% target by 2020. As a consequence of the increased milk production, the export value of Irish dairy products has increased from approximately €2 billion in 2009 to €3.4 billion in 2016. This increase in export value has come from primary industry using predominantly Irish inputs. This has, and will continue to have, a very beneficial effect on the Irish economy, especially in rural areas. The Irish dairy industry is currently facing a number of key challenges, however, including inadequate availability of skilled labour, milk price volatility and the requirement to further improve sustainability, while the potential impact of BREXIT is a significant concern.

The most important resource available to any industry is its people. Hence, it is crucial for the success of Irish dairy farming that there is an adequate supply of a highly skilled people to inherit, manage and work on dairy farms in the future. Recent rapid expansion has created a new and growing demand for people. Over the last 6-years, dairy farm numbers have remained static while dairy cow numbers have increased by 327,000. The structure of the Irish dairy industry has changed significantly in recent years; average herd size has increased from 45 cows in 2005 to 76 cows in 2016. If dairy farms milking less than 30 cows are excluded (not considered 'specialist dairy producers in CSO or NFS reports), the current average herd size is 87 cows. Likewise, the proportion of cows in herds of greater than 100 cows has increased from 13% in 2005 to 47% in 2016. This increased farming workload can no longer be serviced by family labour alone. In addition, the skill level required to manage larger herd sizes is substantially greater. There are indications that there is already an inadequate supply of skilled labour available at farm level. The dairy sector now needs a reappraisal of farm management, with an increased focus on efficient work practices, subcontracting of particular tasks and attracting an increased supply of highly skilled young people into the sector.

Irish milk prices have become increasingly volatile in recent years, primarily due to pronounced fluctuations in the supply of and demand for dairy products. In the decade before 2004, the average annual milk price received by farmers was 30 c/l, with little year-to-year variation (+/- 2 c/l). In contrast, during the decade since 2004, milk price averaged 31.2 c/l, but with much greater variation (+/- 8 c/L). While milk price volatility provides a competitive advantage to lower cost systems of milk production, it results in highly unstable family farm incomes. In a scenario of large volatility in milk price, maximum profit may not be the sole focus. Instead, the goal should be to achieve a balance between risk and profit, i.e. an optimum profit with an accepted amount of risk. In an Irish dairy production system, this will revolve around maximising grass utilised per hectare, which generally results in decreased costs of production. Other industry initiatives such as fixed milk pricing schemes are also very important.

The expansion opportunity for Irish dairying has the potential to contribute greatly to the national economy, and in particular to local rural economies, but this needs to be achieved in a sustainable manner. Concurrent with any expansion of the national dairy herd, strict environmental targets for water quality must be achieved under Water Framework Directives legislation, and Ireland has agreed ambitious binding targets to reduce emissions from the non-emissions trading sector (includes dairy production) by 20% relative to 2005 levels by 2020. In addition, global food companies are increasingly seeking food and food ingredients with high levels of quality assurance derived from farms with efficient and sustainable production practices. Maximising agricultural productivity, while minimising environmental impact, is the central principle of sustainable intensification objectives. For Ireland, this means improved efficiency of conversion of grazed pasture to animal products. National statistics reveal clear evidence of increasing productive efficiency on Irish dairy farms in recent years. This has been achieved through a combination of improved farm management practices combined with accelerated genetic improvement. Compared to 1990, milk and milk fat plus protein production per cow has increased by 24 and 39%, respectively. During this same period, cow numbers declined by 5.5%. The increase in dairy cow numbers in the post-quota era is largely expected to be offset by reductions in the numbers of other livestock within the national herd.

The UK is Ireland's largest market for food and drink, accounting for 41% of Irish food and drink exports. In 2015, the UK market was valued at €4.4bn, and has been a strong growth market over recent years. Between 2010 and 2015, Irish exports to the UK increased by €1 billion, largely driven by increased meat exports. The UK accounts for around 54% of total Irish meat and livestock exports, 30% of dairy, 70% of prepared consumer foods and 30% of beverage exports. Irish dairy is the fastest growing agri-food industry in the EU, delivering jobs and wealth to rural Ireland, and has grown by almost a quarter since the end of EU quotas in 2015. Up to 65% of Ireland's cheddar cheese exports go to the UK while large shipments of butter and infant formula are also exported to the market. Already, BREXIT and the related devaluation of the sterling have resulted in a fall of 12% in UK cheddar imports. Industry experts have forecast a rise in regulatory and administrative costs in the event of a BREXIT, while potential WTO tariffs may cost in excess of €130 million per year. The impacts of a hard BREXIT on trade are likely to be substantial. High tariff barriers on food exports could result in a 40 per cent reduction in dairy exports to the UK. In addition, increased complexity of trading and restrictions in transit through the UK would all add to the cost of Irish exports.

While the Irish dairy industry faces many challenges, there are significant opportunities for the industry to expand. The abolition of milk quotas in 2015 has provided dairy farmers in Ireland with the opportunity to significantly increase milk production. To date, the increase in milk production at farm level has not been associated with an increase in the costs of milk production. This would indicate that overall farm efficiency has increased, and much of the costs of expansion have been undertaken using existing resources. This increased output and efficiency has allowed the industry to be extremely resilient in dealing with reduced milk prices during 2015 and 2016 and places the industry in a very strong position to exploit the opportunities expected from higher milk prices in 2017. The key opportunities for the Irish dairy industry are based on competitiveness, continuing growth in world demand for dairy products and the scientifically supported perception that milk produced from grass-fed dairy cows is a premium quality product.

Looking ahead, global economic growth provides the foundation for increased demand for dairy products. Economic growth in developing countries is crucial, as dairy consumption is responsive to income growth in these countries. As incomes rise, consumers diversify their diets and consume more high-value products leading to a greater demand for more dairy products leading to a greater demand for more high-value products. Future dairy prices will change from being supply driven to demand driven, and will be more responsive to market signals and consumer demand. World demand for milk products will continue to rise as developing countries continue their economic growth, and in the medium term, world dairy prices are expected to average above the levels achieved during the early years of the current decade.

Only 10% of global milk production originates from grazing systems of production similar to traditional Irish systems. Recent research has found that milk and dairy products produce from grass-fed cows has significantly greater concentrations of fat, protein and casein, contain significantly higher concentrations of healthy fatty acids and are superior in appearance, flavour and colour to milk products derived from confinement systems. This is exemplified by the premium being paid for Kerrygold butter in both the German and US markets.

When considered together, the opportunities for further expansion of the Irish dairy industry far outweigh the challenges faced. Dairy farming continues to provide a good living standard to a family farm. Innovation will be critical in maintaining or increasing competitiveness of the Irish dairy sector. Analysis of Irish dairy farming shows a wide variation in performance efficiencies between producers. Further technological advances in areas such as animal genetics, nutrition and both grass breeding and management will be required in the future. These will become particularly important as scale increases. The adoption of new technologies together with the use of best husbandry practices will be important for dairying to prosper in a more open and volatile dairy market.

A summary of the most recent results from the comprehensive dairy research and development programme at Teagasc are provided in this booklet. Moorepark'17 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 and EU grants (RSF, FIRM, SFI and H2020) and dairy levy research funds is gratefully acknowledged. Similarly the support of FBD Insurance, the overall sponsors of Moorepark'17, is greatly appreciated.

PRINCIPLES OF RESILIENT DAIRYING

Principles of resilient dairying

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Summary

- Resilience denotes the capacity of a system to absorb shocks and thrive in a changing and uncertain production environment.
- Irish dairy farm businesses have made substantial productivity gains in the last decade through increased grass utilisation and genetic improvement of dairy herds.
- Farmers can ensure that the business remains resilient during expansion by undertaking all major investment decisions based on a comprehensive business plan and budget, maintaining cash reserves, availing of fixed price options and ensuring that the debt levels and structure are appropriate.

Introduction

Milk price volatility is a key feature of dairy farming today, and this is likely to continue as the world market responds to changes in product supply and demand. In the past, various levels of protection, operating mainly at EU level, provided market support at times when there was an imbalance in global supply and demand. However, this protection has largely been removed since 2007 (except in exceptional circumstances), and so the milk price received by farmers is much more volatile (See Figure 1). Currently, milk price is on an upward trajectory from a trough that lasted over two years and caused many problems for virtually all dairy industries around the world. Ireland's milk production represents approximately 0.8% of global production, and irrespective of our scale or how much we expand; we are price takers. Recent trade disruptive global events such as Brexit, a more protectionist United States and a Russian EU embargo suggest that increasing milk price volatility should be expected into the future. In response, dairy businesses need to refocus on resilient technologies and prioritise investment to make the farm more resilient for the future.

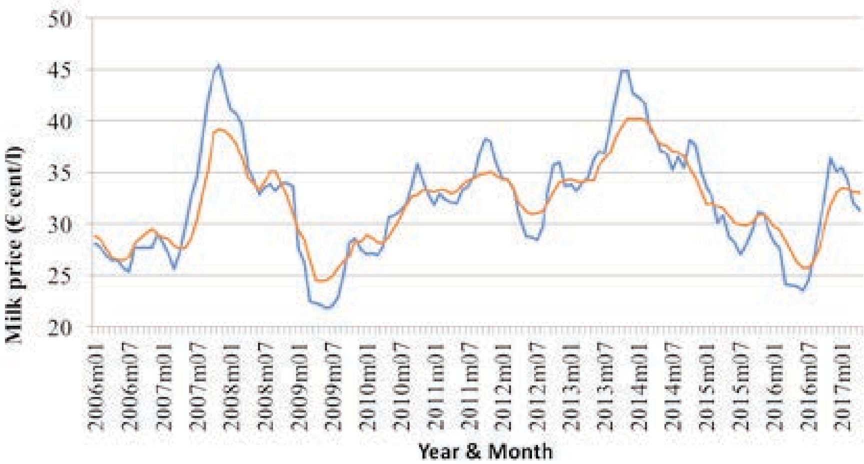

Figure 1. *EU-28 (red) and Irish (blue) farm-gate monthly milk price received at real fat and protein content (European Commission, Milk Market Observatory 2006 to 2017, inclusive)*

Resilience denotes the capacity of a system to absorb shocks and thrive in a changing and uncertain production environment. Such shocks may originate in the form of weather events, disease outbreaks, low milk prices, etc. How the farm business is structured will determine the capability of the business to respond to these events. Fundamentally, resilient systems must have a low production cost-base to insulate the dairy farm business from price shocks, and allow farms to generate sufficient funds in better times to meet requirements in lean years. This paper looks at current trends within dairy production systems in Ireland in response to the turbulent production and economic environment, and sets out the next steps required to further strengthen farm businesses for the future.

So what have farmers done to make their businesses more resilient?

The overall resilience and long term sustainability of the dairy sector is dependent on increased productivity and improved efficiency of conversion of grazed pasture to animal products. A wide variety of factors affect pastoral dairy herd performance and profitability including stocking rate, concentrate supplementation rate and animal genetic merit. Consequently, the selection of improved animals coupled with enhanced grazing management has the potential to yield further significant improvements in production efficiency on Irish farms. Over the last decade, the productive efficiency of Irish dairy farm systems has increased year-on-year through a combination of improved farm management practices combined with genetic improvement of the national herd. National statistics reveal that both milk fat and protein composition have increased resulting in an additional 2 c/l in milk price received by farmers (calculated based on a milk price of 29 c/l) (Figure 2; CSO, 2016).

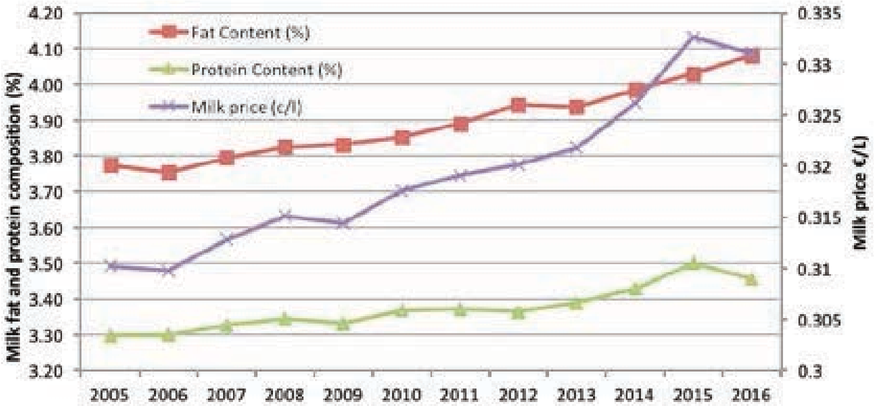

Figure 2. *Trends in milk composition on Irish dairy farms (CSO, 2005 to 2016, inclusive) and the calculated milk price based on a base milk price of €0.29/l*

Allied to these productivity gains, recent evidence also suggests that substantial improvements in grazing practices are also evident at farm level. An evaluation of technical efficiency within dairy farms based on a temporal analysis of Teagasc National Farm Survey (NFS) statistics shows that grass utilisation is increasing on Irish dairy farms. The average values for a number of key physical variables over the eight year period from 2008 to 2015 are summarized in Table 1. Over the eight years, average cow numbers increased from 57 to 70 cows per farm, with a lesser increase in average dairy farm size resulting in a slight rise in stocking rates. The quantity of purchased feed and chemical fertilizer Nitrogen (N) used on farms remained relatively static (990 kg and 169 kg N, respectively). The proportion of concentrate feed in the total diet also remained constant (~18%). The results of the analysis indicate that milk fat plus protein (milk solids; MS) production increased by 29% during the study period. This is primarily explained by increased pasture utilisation per hectare, which increased from 6.7 to 7.8 t DM/ha. In a separate analysis of the Teagasc Profit Monitor database during the same period, similar results indicating increased intensity of production and increased grazed grass utilisation were also observed.

Table 1. The temporal trends in dairy farm productivity during the period 2008 to 2015 (NFS, various years)

Year	Herd size (No. cows)	Stocking rate (LU/ha)	Concentrate fed (kg/cow)	Nitrogen (kg N/ha)	Estimated grass utilised (t DM/ha)	Milk fat plus protein production (kg/ha)
2008	57	1.71	1,115	147	6.7	602
2009	57	1.95	872	160	7.3	640
2010	56	1.67	975	161	6.6	594
2011	66	1.74	870	167	7.1	641
2012	67	1.72	1,037	163	6.8	622
2013	68	1.76	1,166	183	6.8	651
2014	69	1.78	960	180	7.2	675
2015	70	1.93	926	169	7.8	776

During the period 2008 to 2015, there have been significant changes evident on Irish farms: increased scale and stocking intensity, improved milk composition and milk solids production and increased grass utilisation. This has led to an increase in milk output at farm level that accounts for approximately 43% of the baseline reference point for Food Harvest 2020. During this period of expansion, production costs per kg MS actually reduced. Evaluating the change in financial performance over the period is difficult due to changes in milk price. The analysis has shown that over the period, each additional tonne of grass DM utilised was worth €173/ha. In contrast to the general trends observed, where increased milk production arose through increased use of purchased supplements, net profit actually declined by €95/ha for every 10% increase in purchased supplements.

Genetic improvement of the national dairy herd is a key component of the smart and green objectives for agriculture as stated in Food Wise 2025. The successful adoption of the Economic Breeding Index (EBI) and related genetic progress of the national dairy herd has been an area of significant progress, with benefits for both the productivity and sustainability of grass-based dairy production in Ireland. Over the last decade, the science of genomic selection has already enabled more accurate genetic selection of dairy cattle. Previous studies have documented that animals of greater EBI were both more productive and profitable than lower EBI contemporaries, but much of this research was undertaken within the controlled environments of research herds. Industry data now readily shows that the investment in genetic improvement using EBI on Irish dairy farms has paid dividends, with increased protein and fat production in milk recording herds (Figure 3; ICBF, 2017). Calving interval represents a key animal fertility and survival trait within the EBI, and has declined by about 16 days from a peak of 406 days in the late 1990's to approximately 390 days for females born in 2012 and milking in 2015. With the introduction of genomic technologies to advance the rate of genetic progress, even greater improvements in animal productivity and survival can be anticipated over the next 10 years. Higher productivity dairy cattle with improved fitness and survival, and consequently reduced progeny rearing rates, will greatly contribute to the sustainable intensification of the dairy sector in Ireland over the next 10 years.

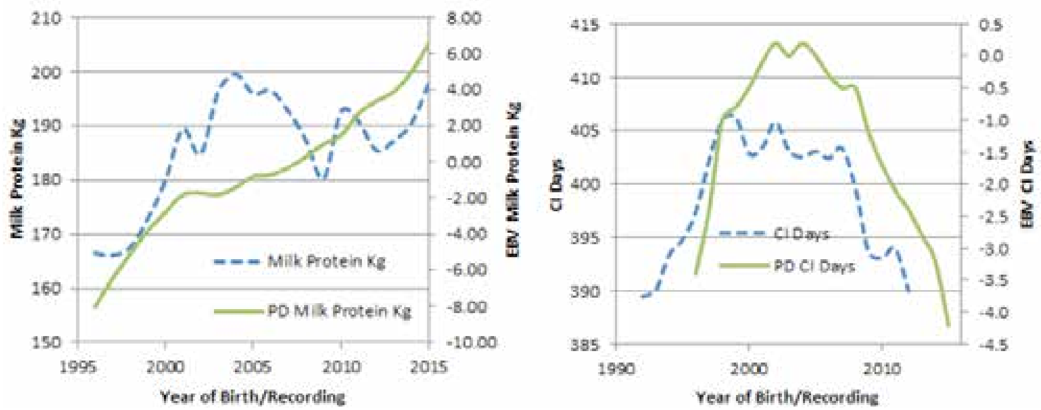

Figure 3. *Genetic and phenotypic trends for milk protein and female fertility in the national dairy herd (ICBF, 2017)*

The findings of these studies using relatively large nationally representative datasets show significant improvements in biological efficiency on Irish dairy farms. This strengthens farm resilience via increased animal performance, increased grazed grass utilisation and more robust higher EBI dairy cattle. In addition to the financial benefits, this pathway towards the sustainable intensification of Irish dairy production systems will also allow the industry to grow without adversely impacting on the environment.

Irish dairy farm systems 2017-2025: immediate areas for improvement

Future prospects for the continued development of Irish dairy farm systems look positive, with milk production expected to grow significantly over the next decade based on continued genetic improvement coupled with further increases in pasture productivity. Our grass-based milk production system remains our key comparative advantage over international competitors. Expected progress in farm level performance improvement to 2025 is shown in Table 2. At common milk prices, the analysis shows that substantial gains in average farm profitability can be achieved during the next decade where farms continue to focus on genetic improvement using EBI, increasing average grass utilisation and increasing the productivity of the overall farm system through more compact calving patterns coupled with a mature herd age profile.

Table 2. Expected trends in dairy herd improvement (2016 - 2025)

	Current Average	2025
Herd economic breeding Index (€)[2]	55	180
Stocking rate (Livestock Units/ha)[1]	1.96	2.15
Herbage utilised (t DM/ha)[1]	7.4	10.0
Concentrate supplementation (kg DM/cow)[1]	900	670
Six week calving rate (%)[2]	57	75
Mean parity (No. lactations/cow)[2]	3.1	4.5
Milk fat plus protein delivered (kg/cow)[1]	370	450
Milk fat plus protein delivered (kg/ha)[1]	730	960
Net profit at 28 c/l (€/kg MS)[3]	0.34	1.57
Net profit at 28 c/l (€/ha)[3]	250	1,500

[1]*Three-year average for years 2013, 2014 and 2015 sourced from the National Farm Survey.*
[2]*Calving statistics 2008 - 2016 sourced from the Irish Cattle Breeding Federation (ICBF) http://www.icbf.com/?page_id=313*
[3]*Including full labour charges.*

Investing in the future of the farm business

To make the transition from the current average to the target performance, additional capital investment will be required on many farms. Farmers are frequently unsure which investments to prioritise for maximum immediate benefit. To answer this question, the impacts of alternative investments on farm profitability were investigated.

A number of expansion scenarios were examined:

- The base scenario: the farm remains at the current status quo.
- **S1:** expansion is achieved by increasing grass growth through improved soil fertility and reseeding of unproductive pastures, increased N use and better grassland management.
- **S2:** expansion is achieved by combining S1 with the removal of heifers from the milking platform by contract rearing.
- **S3:** expansion occurs by combining S2 with the rental of an additional 20 hectares on the milking platform.
- **S4:** the base scenario, but with increased cow numbers without any increases in grassland productivity and with increased feed supply arising from increased purchased feed. Cow numbers are increased to the same number as the S1 scenario, and large additional quantities of forage and concentrates are purchased. There is significant buffer feeding in this scenario and so labour requirement per cow is increased by 20%.

In each scenario, the following assumptions applied:

- base milk price was 29.5 c/l.
- concentrate costs were €250/tonne.
- contract rearing was costed at €1.12 per animal per day.
- additional land was rented at €500/ha when required.

The key herd characteristics and financial performance for the baseline and three expansion scenarios modelled are summarised in Table 3. Grass utilised ranges from 7.9 to 12.9 t DM/ha and herd size increases from a baseline of 90 cows to a maximum of 192 cows in S3. Labour assumptions included in the analysis are based on herd size, with additional labour available when heifers are contract reared. In each of the scenarios, it was assumed that on-farm technical performance improved, resulting in increased MS production relative to the base scenario. Milk solids produced in the base scenario was assumed to be 392 kg and 451 kg per cow in each of the expansion scenarios.

In the base scenario, the farm generated €38,309 in annual net profit including full labour costs, which corresponded to a Return on Investment (ROI) of 2.8% for the overall investment (including all land, stock and infrastructure required). In S1, net farm profit increases by 117%, including an additional investment of €157,482 and additional labour costs of €10,831. The overall ROI increases to 5.2% based on the substantial increase in net farm profitability. In S2, net farm profit increases by 158% relative to the base scenario, and includes an additional investment of €201,706 and additional labour costs of €8,627, resulting in an overall ROI of 5.9%. In S3, farm profit increases by 247% relative to the base scenario with an additional investment of €397,134 and additional labour costs of €24,693, while overall ROI increases to 7.2%. Finally in S4, where significant expansion is undertaken without increases in grass growth or utilisation, and with all additional feed being purchased, net farm profit increases by four per cent relative to the base scenario and includes an additional investment of €110,204 and additional labour costs of €17,948. Unlike the other expansion scenarios, overall ROI does not change in S4 relative to the base scenario.

Table 3. Physical and financial performance of alternative expansion scenarios					
	Base	S1	S2	S3	S4
Grass utilised (t DM/ha)	7.9	12.9	12.9	12.9	7.9
Herd size (No. cows calving)	90	121	137	192	121
Stocking rate (LU/ha)	2.06	2.76	2.64	2.64	2.76
Fat plus protein sales (kg)	34,079	52,624	60,625	84,726	50,692
Labour (hrs/year)	2,570	3,445	3,267	4,466	4,021
Total receipts (€)	187,028	280,639	299,823	419,014	217,773
Variable costs (€)	80,043	104,993	109,538	163,109	136,042
Labour (€)	31,787	42,618	40,414	56,480	49,735
Deprecation (€)	16,183	23,395	23,607	30,104	20,029
Net profit (€)	38,309	83,321	98,703	132,989	39,933
Total investment (€)	1,514,294	1,671,776	1,716,006	1,911,428	1,624,498
Return on Investment (%)	2.8	5.2	5.9	7.2	2.9

It is clear that different expansion scenarios result in substantially different capital investment requirements and net farm economic returns (Table 3), while also affecting how the business can adjust to changes in the external environment. In general, expansion options that minimise capital expenditure and increase pasture productivity will provide very substantial returns with minimal business risk. Expanding based on the purchase of external feed will result in increased costs and workload, but with no additional benefits in terms of net farm profitability or return on investment.

Financial management and business resilience

In a low milk price year, the price received for milk is likely to be less than the total cost of production including the farmers own drawings. As long as the industry maintains its competitiveness, it is likely that periods of low milk prices will be relatively short lived as supply correction in less competitive industries brings the market back to balance. In order for a dairy farm to be resilient, it must operate a resilient system of milk production and the dairy business finances must also be managed in a prudent manner. When milk price volatility is not pro-actively managed on farms, periods of significant acute cash deficit are likely to arise. These will occur during low milk prices, when additional costs are incurred during expansion and during prolonged periods of adverse weather. This will sometimes also be exacerbated by the requirement to make tax returns in periods of low milk price based on profits generated during previous periods of higher prices. Quite apart from the increased costs arising, such circumstances are associated with chronic stress and place undue pressure on the personal health and wellbeing of farmers and family members. To avoid such problems, the farm business finances must be carefully managed. In this regard, dairy farms that are extremely cost efficient, maintain appropriate debt levels and utilise the available volatility tools will be much better placed to manage volatility. Beyond farm management practice, there are a number of additional mechanisms that a farmer can use and these are outlined here.

Creating a cash reserve

A key strategy to become more resilient involves creating a cash reserve when prices are high – the rainy day fund. Ultimately, this puts power back in the farmer's hands and creates a situation where the farmer is less vulnerable when milk price drops. While this strategy is possible at farm level, it currently creates a tax liability. Consequently, there is a requirement to have the taxation structure of the business set up in an efficient manner to allow the business to create cash reserves prudently. Internationally, there are a number of taxation structures (such as the Farm Management Deposit Scheme and Income Equalisation Scheme operated in Australia and New Zealand) that facilitate the creation of cash buffers in a tax efficient manner. Similar schemes are required for Ireland to assist farmers to manage the new reality of milk price volatility.

Fixing milk price

The introduction of fixed price contracts has become commonplace across most milk processors over the past number of years. While these pricing mechanisms are new in Ireland, various formulations have been available in other countries for a much longer period. A study completed by the United Farmers of America in 2014 reported that, on average, milk price was 0.9% lower over a 14 year period when opting for the fixed price contract. The same study noted, however, that much of the extreme fluctuations in milk price movement were avoided by fixing the price. In contrast, results from the Greenfield farm, where fixed milk pricing has been availed of since 2011, has shown that the overall milk price paid by the fixed price schemes have been higher than the variable market prices, and the effect in any individual year was significant. Consequently, fixed milk pricing has significantly reduced the exposure of the Greenfield business to price volatility.

Appropriate debt

On average, Irish dairy farmers do not have a high farm debt burden. Overall average indebtedness at the end of 2015 was €75,000, corresponding to just €2.58/kg MS produced. Indeed, relative to the milk production, debt levels have declined by over 20% on Irish farms between the period of 2008 and 2015. The increase in farm milk output has not been associated with big increases in farm debt, meaning that much of the expansion which has occurred has been facilitated from cash flow. Having the correct funding level and structure is a key feature of the resilience of the business. A common question asked is "What is the appropriate level of debt per cow on a dairy farm?" There is no one answer to this question. A comfortable level of debt should be calculated based on farm efficiency (which drives free cash production from the business), family drawings, tax, on-going capital development, term of the debt and the purpose of the debt. The appropriate debt level can be calculated based on these different metrics, and should be stress-tested at low milk prices to ensure resilience. Ensuring that the appropriate debt structures are put in place will be central to resilient businesses into the future.

Conclusions

Irish dairy farm businesses have made substantial improvements in productivity in the last decade. Productivity gains have arisen through increased grass utilisation, increased milk value and reduced production costs at farm level. To further build upon these productivity gains into the future and ensure that the overall business remains resilient requires a continued focus on increasing grass utilisation, matching the increasing feed availability with appropriate overall farm stocking rates and higher EBI dairy cattle. Further capital investment in grazing infrastructure will be required to achieve these objectives on many farms, and this will deliver a significant return to the farm business. Finally, farmers can ensure that the business remains resilient during expansion by undertaking all major investment decisions based on a comprehensive business plan and budget, maintaining a cash reserve, availing of fixed price options to manage price volatility and ensuring that the debt levels and structure are appropriate.

People first: Sustainable workloads to create an attractive and competitive career

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Summary

- Almost half (47%) of all Irish cows are now milked in herds greater than 100 cows.
- Recruitment and retention of well trained and skilled farm operatives and managers will be the limiting factor for expansion for many farmers in the future.
- Dairy farming must be considered an attractive career option, provide competitive returns per hour worked, adequate time-off and a sustainable workload for everybody working on the farm.
- To provide adequate remuneration to all those working on farms, farmers will need to focus on increasing the profit achieved per unit of labour input to the farm.
- People management skills will be an essential requirement of successful large farm owners/managers.
- Planning and preparation for compact spring calving is essential to minimise the stress associated with the peak workload.

Introduction

Irish dairy farmers have expanded rapidly over the last six years. Since 2010, there are over 300,000 extra cows being milked on Irish dairy farms, and 47% of all the cows in Ireland are now milked in herds of >100 cows. These extra cows have increased the overall workload on farms and especially increased the spring workload as six week calving rate has improved nationally. If not properly managed, this increased workload can create acute stress on family farms. For 30 years Irish farmers were limited by quotas, and many perceived that land would be the most limiting factor post-quota. Following the expansion that has already happened, however, many farmers now feel that the labour required for greater cow numbers is not readily available and will require alternative solutions.

Competitiveness of Irish dairying

Much is talked about the competitiveness of low-cost grass based Irish dairying relative to our competitors, which allows us to achieve viable prices on the global market. As unemployment rates decline in the Irish economy, however, the dairy industry will have to compete with all other sectors for young people to enter the industry. Teagasc estimates that between now and 2025, over 6,000 people will be needed to enter Irish dairying as either successors or employees (Table 1). The number of young people that choose dairy farming as a career will be influenced by their perception of the dairy industry. To attract these people to the industry, dairy farming must be an enjoyable and rewarding career that offers a good work/ life balance comparable with other careers.

On top of the need to attract extra people is the need to ensure the workload of every existing person in dairy farming (owners, family members and employees) is sustainable. This is a challenge given the recent pace of expansion. Hence, dairy farming requires a new focus on what farms are like as places to work, what farmers are like as people to work for, and what a career in dairy farming has to offer. This paper will focus predominantly on maintaining a sustainable workload and being an employer of choice.

Table 1. Projected increase in labour requirement on dairy farms to facilitate dairy expansion to 2025

Year	Cows (in herds >30 cows)	Farms	Cows/ farm	hrs/cow	New FTEs	Replacement FTEs	Total
2013*	1,090,440	14,490	75	42.1		414	414
2014*	1,142,781	14,793	77	41.8	483	423	906
2015*	1,230,775	15,096	82	41.0	904	431	1,336
2016*	1,338,461	15,339	87	40.0	1,144	438	1,582
2017**	1,365,230	15,352	89	39.6	226	439	665
2018**	1,392,535	15,364	91	39.2	220	439	659
2019**	1,420,386	15,376	92	39.0	347	439	786
2020**	1,448,793	15,386	94	38.6	228	440	668
2021**	1,477,769	15,396	96	38.3	296	440	736
2022**	1,507,324	15,406	98	37.9	231	440	671
2023**	1,537,471	15,414	100	37.6	301	440	741
2024**	1,568,220	15,420	102	37.2	233	441	674
2025**	1,599,585	15,426	104	36.8	233	441	674
Total 2013 to 2016					2,531	1,706	4,238
Total 2017 to 2025					2,315	3,958	6,273

** June cow numbers in herds >30 cows from the CSO for 2013 and 2016, estimate for 2014 and 2015;*
*** Projected forward at +2% per year*

Why is a sustainable workload important?

- When adequately rested, everyone enjoys farming more and are more likely to make good management decisions that will improve farm performance and profit.
- The farmer has adequate time on a weekly basis allocated to making key management decisions (e.g., to measure grass and decide on any actions required).
- To ensure a person can spend quality time with family, friends and at their other interests outside of farming.
- There are health and safety and well-being risks when working too hard. Farming currently has the very undesirable title of being Ireland's most dangerous profession.
- There is likely to be significant competition between farmers for full and part time employees in the future. Those who provide attractive work packages will be more successful at attracting and retaining good people.

What is a sustainable workload?

- Planned start and finish times for each day that are achieved *most* days.
- Nobody is working more than 50 hours per week on average.
- Work is organised and planned in advance and carried out with minimal stress for the farmer and animals.
- Administrative work like registering calves is completed during the day, not at night time after a full day's work when tired and more likely to make mistakes.

- The spring workload will be busy but manageable. Being prepared for the spring by planning and allowing for something that may go wrong (e.g., calf scour) so the farm team can still cope with the extra work.
- At least some rest time during calving (e.g. getting help with the milking for a day a week) and ideally every second weekend off outside of the calving and breeding season.
- Good retention of full and part time employees indicates that people enjoy working for you and working on the farm.
- Adequate time for professional development (i.e., discussion groups, open days, training courses, etc.).

How to achieve a sustainable workload

If some of the targets outlined above are not being achieved, then consider making changes to reduce workload.

There are a variety of options to consider that will reduce the workload on any given farm. These can be broken into the following categories:

Changing work practices

Making changes to how work is done on the farm can save large amounts of time without any reduction in farm performance, and often with very little cost. Work practices that have been done routinely for years may no longer be suitable on a farm given the increased workload with extra cows. Examples of changes which can save time include:

- Once a day calf feeding from three weeks of age.
- Vaccine use in cows/ calves to reduce animal health issues e.g. for scour or pneumonia.
- Night time feeding of dry cows during late pregnancy to increase the number calving during the day.
- Grazing cows in 36 hour blocks to avoid needing strip wires during the main grazing season.

Making the farm set-up more labour efficient

Facilities have a major influence on labour efficiency and should be considered during any aspect of farm development. As milking is the task that takes up most time during the year, the milking parlour set-up has a large influence on farm labour efficiency. Cow flow into and out of the parlour and the number of rows to be milked are key considerations. Calf rearing facilities tend to be the least modern on many farms, and increases the workload during the busiest time of the year. Having tractor access to clean out pens, not having to carry milk long distances and being able to rear calves in batches of 10+ are all essential on a modern dairy farm.

Out-sourcing work

Many of the most labour efficient farmers reduce the hours of work by out-sourcing work. On larger scale farms this can mean all machinery work being done by contractors (fertilizer, slurry, silage, winter feeding etc.) and on smaller scale farms this might involve using contractors at particularly busy times of the year (e.g. slurry and fertilizer spreading in spring). Many farmers rule out this option due to the cost of the service but fail to consider the huge potential gains e.g. your time as the manager of your business is extremely valuable, especially in the first half of the year during calving and breeding. Ensuring the job gets done on time is another important benefit e.g. a delay in getting fertilizer out in spring can be a huge cost in terms of lost grass growth. Savings on machinery running costs are another big positive; some farms using all contractors for machinery work have a lower contracting bill than the combined contracting and machinery running bills of farms with their own machinery.

There are also many other options to out-source work. An increasing number of farmers are now getting calves contract reared from two weeks of age to further reduce the workload during the spring. Contractors can be used for almost any job on the farm from fencing to power hosing sheds etc.

Hiring full or part time help

As dairy farms continue to increase in scale there will be a greater requirement for part time and full time help. While the workload on many farms was manageable for one person up to the recent post-quota expansion, increased scale and the seasonality of the workload means that extra help is needed. The key change when you become an employer is that your farm is now a place of work for another person. This is where the farm set-up health and safety becomes more important: the easier that jobs are to do, the better they are likely to be done.

How many cows can one person sustainably manage?

When discussing labour efficiency, a question is often asked: how many cows can one person manage? The first point to make is there should be no such thing as a one person farm. Every person needs a break from work and so every dairy farm business should have people available to offer the farmer time away from the farm, regardless of scale. This may be family members or paid relief help.

Cows per person is influenced by two things:

- How many hours of work does each cow require during the year?
- How many hours is the person willing to work?

Using data from previous Teagasc labour research, this relationship is illustrated in Figure 1. Based on the national average herd size (75 cows in 2016), average labour efficiency nationally is estimated to be 40 hours per cow per year. This includes the workload associated with rearing replacement heifers for the farm.

Farms operating very labour efficient systems (e.g. those with labour efficient set-ups, contract rearing heifers and contracting out machinery work etc.) are achieving efficiency levels of <20 hours per cow per year. As can be seen from Figure 1, this difference in labour efficiency could potentially allow one person manage another 60 cows.

The other key variable is how many hours is a person willing to work? Achieving high levels of labour efficiency by simply working longer hours is unsustainable. The farm will look impressive using the key performance indicator of cows per person, but chances are that profit is not being maximised as people are too busy working and management decisions suffer. Combining current national average levels of labour efficiency with maintaining a reasonable working week of 50 hours per week over 48 weeks would mean that one person can effectively manage 60 cows. While this analysis looks at annual labour efficiency, another key consideration is the workload at different times of the year, especially in the spring.

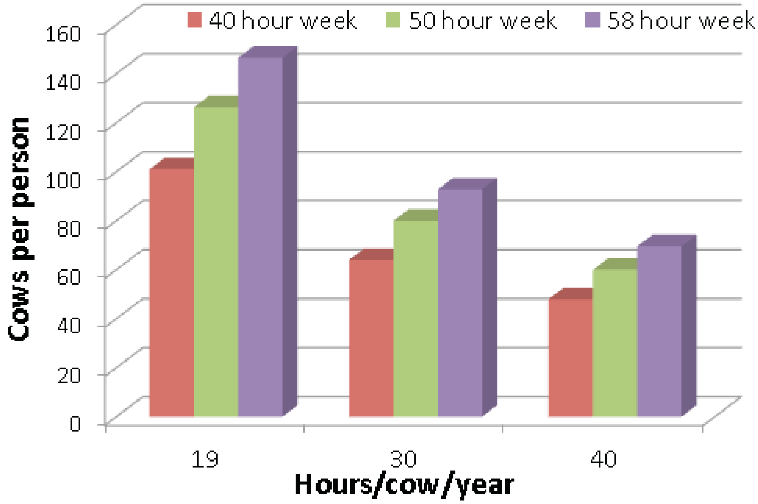

Figure 1. *The effect of labour efficiency (hours/cow/year) and the duration of the working week on the number of cows that one person can manage*

Features of labour efficient farms

- Simple farm system that can be easily communicated and operated by others.
- Minimum number of enterprises on the farm (e.g., sale of all surplus calves and contract rearing replacements).
- Suitable cow type that doesn't require individual attention.
- An appropriate calving date and stocking rate for the farm that minimises the need for supplementary feed (reducing both workload and farms costs).
- Good grazing infrastructure that facilitates easy movement of animals to and from grazing by a single operator.
- Adequate well organised farmyard infrastructure that facilitates the easy movement of stock, particularly at calving and calf rearing.

Case study – The Shinagh Demonstration Farm

Seasonal calving workload

A breakdown of the monthly workload to manage a 230 cow spring-calving herd measured on the Teagasc/Carbery Shinagh demonstration farm is illustrated in Figure 2. In total, approx. 4,300 hours are needed to run the farm per year as all of the main tractor operations including silage harvesting, slurry spreading and winter feeding are undertaken by contractors and heifer rearing from 12 weeks to 19 months is also contracted out. When the total figure is divided by 230 cows, the annual labour efficiency figure is 19 hours of work per cow per year.

Nearly 50% of the total hours on the farm are worked during February, March and April. With the use of pregnancy scanning data and fertility reports, this workload is now very predictable. Therefore, the spring workload can be planned well in advance to ensure that adequate facilities, equipment and help is available to cope with the demand. Having the herd of cows in the appropriate body condition score, adequate opening pasture cover to allow cows be turned out to grass as they calve and being personally in good mental and physical health at the start of calving are all very important to reduce the stress associated with compact spring calving. While the farm is run with one person for most of the year, three people work on the farm during February to March to cope with the workload. There are numerous labour reducing strategies that can be employed during this period such as once-a-day milking during the very busy first three weeks of calving, once a day calf feeding from three weeks of age, night time feeding of dry cows during late pregnancy to minimise night time calving etc.

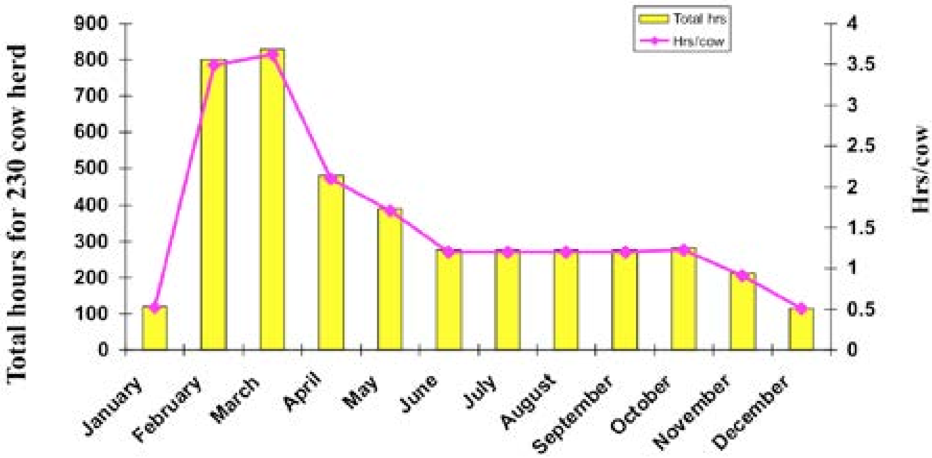

Figure 2. *Monthly labour requirement for a compact spring-calving 230 cow herd*

Being an employer of choice

Staffing has been problematic on some expanding farms, and recruitment and retention have been regularly highlighted as issues. Having a good working environment on the farm will result in improved work efficiency, increased employee satisfaction and will increase the overall operational efficiency of the farm business. There are a few simple things that can be done to gain a reputation as a good employer.

- Pay a fair wage that reflects staff members' responsibilities and pay on time without exception.
- Allow employees to have a good work life balance. This can be achieved by having regular start and finish times and by working to a roster that provides adequate days off and is organised well in advance.
- Give employees some responsibility and involvement in farm decisions and a degree of control in planning their own workload.
- Ensure a high safety standard on the farm.

Feeding the herd at grass – can we do better?

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Summary

- With higher stocking rates on Irish dairy farms, grass production and utilisation must be sustainably increased.
- Autumn closing management and targeting the correct closing cover are vital to ensure adequate spring grass availability.
- The importance of early turnout and spring grazing management is underestimated. For every one per cent of the grazing area grazed in February, an additional 14 kg DM/ha is grown by 10th April.
- The first rotation needs to be finished by early-April in order to achieve 2.5 grazing rotations by early May and 10 grazing rotations in the year.
- Post grazing sward height and pasture quality are key drivers of the feeding status of the herd during mid-season.
- Grazing management requires continuous improvement.

Introduction

There are major improvements needed in the areas of grazing management and the conversion of grass into milk. 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. Irish farms have expanded rapidly over the last number of years. Average herd size on specialist dairy farms is now 87 cows, which requires farms to increase the amount of grass grown to meet an increasing herd feed demand. Increasing stocking rates and more compact calving has resulted in increased spring feed demand on dairy farms. Extra grass must be grown and utilised in this period to avoid increases in supplementary feed use. It is clear from Profit Monitor results in the last two years that farms targeting high levels of grass utilisation are more profitable (+€261/ha higher net profit). Even the farms achieving the highest grass utilisation, however, are still only utilising 10 t DM/ha. This paper examines where Irish dairy farms can improve the feeding management of the dairy herd at grass, to further increase output and lower farm costs.

Current grass DM production performance

The optimum stocking rate for an individual farm is that which gives sustainable profitability, and is dependent on the individual farm's grass growth and utilisation capability. Many Irish farms are only producing 50-60% of their grass growth capability, and substantial increases in grass production need to be achieved. Other dairy nations that have expanded without growing and utilising more grass have lost their competitive advantage. Many farmers in Ireland will fall into the same trap if grass production isn't increased. Sustainable dairy expansion must come from utilising more grass, and not at the cost of importing supplementary feed. Improved feeding of the dairy herd will only come from better grazing management skills being employed. This means regularly measuring pasture cover, using specialized grassland management software to analyse grass production data, and making decisive grazing management decisions. These are the key drivers of increasing the grass growth capacity on the farm. A recent survey of high performing grassland farmers reported that all the farmers agreed that they were completing more farm walks, grazing their cows tighter and reseeding more than they were five years ago. This underlines the importance of continuous improvement in grassland management practices.

At present, Irish dairy farmers are utilising 7.8 t DM/ha at and 80% utilisation and growing on average 9.1 t DM/ha, which is utilised during a grazing season that averages 210 days. This poor performance is a result of inadequate (or zero) routine grassland measurements being completed on most farms. Across all the farms that are routinely recording farm cover in PastureBase Ireland (PBI), the bottom 20 farms, the average of all farms, and the top 20 farms are growing 11.0, 13.8 and 16.7 t DM/ha, respectively (Figure 1). Variation in the amount of grass grown in the top 20 versus the bottom 20 farms in PBI is evident across the seasons: 1,199 versus 816 kg DM/ha in spring; 4,932 versus 4,462 kg DM/ha during mid-season; and 6,442 versus 5,937 kg DM/ha in autumn. An extra grazing rotation is achieved on the top farms compared to the bottom farms (7.7 versus 6.8 grazings per paddock per year). This extra grazing results in a greater proportion of grazed grass in the cows' diet.

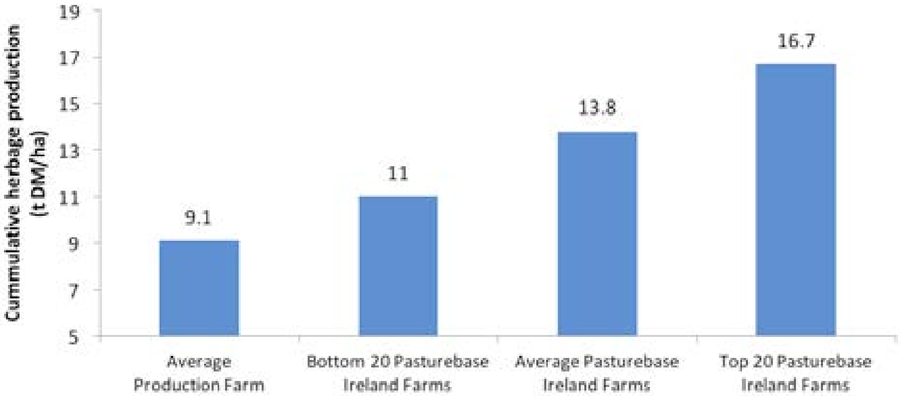

Figure 1. *Comparison of National average dairy farm DM production and that of farms participating in Pasturebase Ireland*

Grass allocation

On many farms, the grass grown on the milking platform is prioritised for the grazing cows, as it reduces the levels of imported supplementary feed required. Pasturebase Ireland now provides the tools to determine how much grass is grown and utilised for grazing on farms. Figure 2 shows the relationship between grazing DM production and total grass DM production on farms during 2016. On average, for every extra 1 t DM/ha grown, 0.88 t DM/ha was allocated to the grazing herd.

The relationship between grass allocation and stocking rate in grazing herds is summarized in Table 1. Farms that are not producing sufficient grass to meet the stocking rate requirement cannot allocate enough grazed grass to their herd and are forced to increase supplementation levels. Many farms in the country are facing this prospect if they don't improve grassland management to increase farm grass DM production across the year.

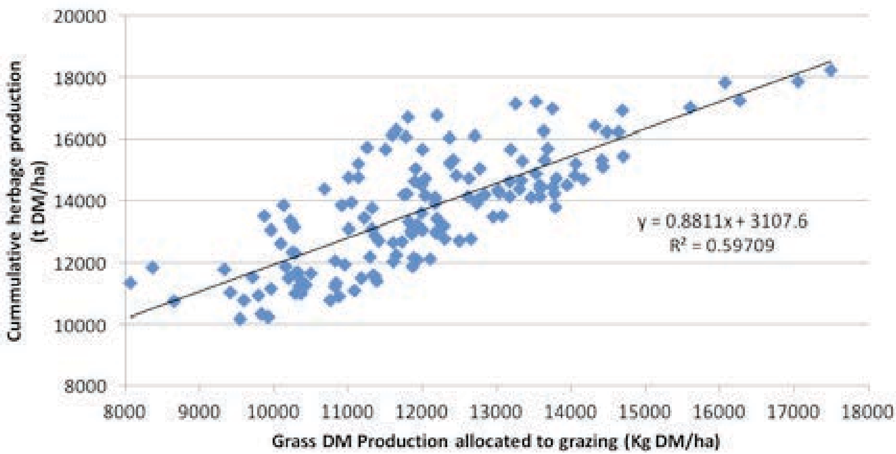

Figure 2. *The relationship between farm total grass DM production and the amount of grass allocated to grazing*

Table 1. Grass DM availability for the grazing herd a different levels of DM production

Grass DM Production	Grass availability @ 80% allocated to grazing	Appropriate farm stocking rate*
9	7.2	1.8
11	8.8	2.2
13	10.4	2.6
15	12.0	3.0
17	13.6	3.4

**Assumes 4 t DM grazed grass allowance per cow*

Spring grazing management

Grazing management in the first two months post-calving determines spring grass growth and cumulative growth for the remainder of the year. Data from PBI (n=65 farms) from 2015 and 2016 shows that, on average, 22% (range 0 to 52%) of the grazing platform was grazed in February. These figures are well below the target minimum of 30% grazed by March 1st. The same dataset showed that for every one per cent of the grazing area grazed in February, an additional 14 kg DM/ha was grown by April 10th. This equates to an additional 125 kg DM/ha grown on those farms. A target of 1,450 kg DM/ha must be grown from January 1st to April 10th to meet the majority of the cow requirements from grazed grass. The first rotation end date can have a large impact on spring DM production. For example, PBI data indicates mean spring grass production from January 1st to April 10th was 1,239 kg DM/ha on farms completing the first grazing rotation on or before April 10th compared to 994 kg DM/ha for farms completing the first grazing rotation after April 10th. This 20% difference clearly shows that some farms are finishing the first rotation too late.

Given that most farms are increasing both stocking rate and six-week calving rate, the opening farm cover has a large impact on spring grazing and herbage allocation. Opening with a low average farm cover means there is less available grass to graze. Targeting an opening farm cover of 900 kg DM/ha for highly stocked farms can be achieved to keep supplementation low. An experiment to establish the effect of opening farm cover commenced at Moorepark in spring 2017. This trial is investigating the effect of opening farm cover on animal performance and herbage production in an intensively stocked system (2.9 LU/ha). Preliminary results for animal performance during the first rotation (February 6th to April 8th 2017) is summarized in Table 2. Commencing grazing with a greater opening farm cover (1,040 versus 650 kg DM/ha) resulted in more grass available for lactating cows (12.9 versus 9.5 kg DM/cow per day) over that 60 day period. The higher grass allocation resulted in an additional (13 kg MS/cow), (38 kg MS/ha) produced by April 8th (9% increase in milk output per ha). Each additional 100 kg DM/ha increase in opening farm cover resulted in an additional 9 kg milk solids/ha.

Ensuring a high opening farm cover and maintaining it so it doesn't drop below 500 kg DM/ha in late March/early April is a crucial aspect of spring grazing. During the spring period the farm should be walked a minimum of four times during February and March to ensure adequate grass is available and regrowth's are recovering to target levels. If average farm cover drops, the level of grass available for grazing animals is reduced, and levels of supplementation will increase. It is important that adequate nitrogen is spread on the farm by April 1st to stimulate early grass growth (70 units/acre, 88 kg/ha).

Table 2. The effect of high and low opening farm covers on grazing and animal performance for the first rotation (February 6th to April 8th)

	High grass	Low grass	Difference
Opening farm cover (kg DM/ha)	1,040	650	+ 390
Grass allocation (kg DM/cow/day)	12.9	9.5	+ 3.4
Concentrate feed (kg DM/cow/day)	2.8	2.8	0
Pre-grazing herbage mass (kg DM/ha)	1,533	1,091	+ 442
Post-grazing sward height (cm)	3.7	3.3	+ 0.4
Cumulative milk solids (kg/cow)	151	138	+ 13

Mid-season management

The primary objective during the main grazing season is to maintain high animal performance from an all-grass diet, while at the same time maintaining pasture quality. In general, from late April onwards, grass supply exceeds demand. Pre-grazing herbage mass should be maintained at 1,300 to 1,600 kg DM/ha, with a grazing residual of 50 kg DM/ha (4 cm post-grazing height). One of the biggest issues in mid-season is not stocking the farm appropriately to match grass growth, resulting in large surpluses (understocked) or large deficits (overstocked). Farm cover should be maintained between 150 to 180 kg DM/cow from mid-April to mid-August with a rotation length of 18-21 days. In order to maintain this, average farm cover should be monitored weekly and three times every two weeks during peak grass growth. Paddocks with surplus grass should be removed as identified. Improving pasture quality offers the potential to achieve further increases in animal performance from pasture. Grass quality varies across the season; however, some of these changes can be negated by good management practices. The current measure of how well grass is utilised in the field is the post-grazing sward height. In 2016, 33 farms were monitored for post-grazing height from April to September. On average, the results achieved were reasonable, but still showed that grass is being underutilised on farms. For example, post-grazing sward height increased by close to 0.5 cm in May and stayed at >4.4 cm for the remainder of the year (Figure 3). This has adverse consequences for sward quality and regrowth capacity in subsequent rotations.

Maintaining high quality grazed grass has the ability to maintain milk production of 2 kg milk solids/cow per day. For each one-unit increase in organic matter digestibility (OMD), grass dry matter intake can be increased by 0.20 kg, which can result in an increase of 0.24 kg milk/cow per day. Well grazed swards (grazed to 4.0 cm) will contain a high (80% +) proportion of leaf in the mid-grazing horizon (4 to 10 cm). The proportion of leaf in the grazing horizon has a strong influence on the grass DM intake achieved by the dairy cow, so it is imperative that swards are leafy to the base. This can be achieved by good grazing management practices. Poorly managed swards (grazed >4.5 cm) can fall to 65% leaf during the reproductive period, resulting in more stem and reducing overall sward quality.

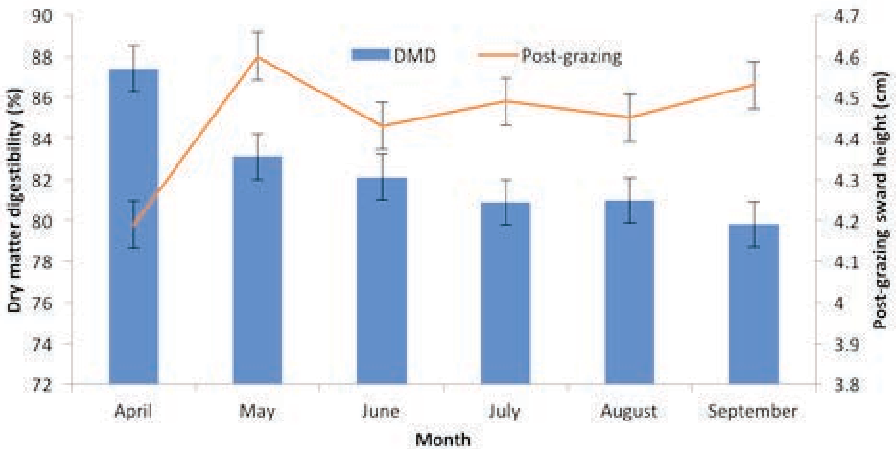

Figure 3. *Post grazing sward height (red line) and grass dry matter digestibility (blue bars) measured on 30 farms participating in Pasturebase Ireland in 2016*

The corresponding grass quality assessments (Figure 3) show a consistent decline in grass quality from April through to September, with no increase in any month. The big rise in the May post-grazing height was most likely due to the doubling of grass growth from the first week of May to the third week of May in 2016. The mean grass growth figures for May, June, July, and August in 2016 were 70, 76, 74 and 68 kg DM/ha/day, respectively. The increase in post-grazing sward height highlights the difficulty of managing grass quality when grass growth increases during mid-season.

Autumn grazing management

Autumn closing date is one of the most important management factors influencing the supply of grass in early spring. To ensure adequate quantities of grass are available at the start of calving in spring on highly stocked farms, farmers must ensure an average farm cover of ≥600 kg DM/ha is achieved at closing (December 1st). To achieve these targets, farmers should use the autumn planner, which allocates the area of ground to be closed from October to November. The closing of paddocks should start between 5th and 10th October, and 60% of the paddocks should be grazed by 7th November. In highly stocked farms, which have greater demand for early spring grass, this target should be 70% grazed by 7th November, with 100% grazed by the end of November. Farms with heavy soils or farms with low autumn growth rates should close approximately one week earlier. If average farm cover does drop due to poor autumn growth rates, farmers should house or increase silage supplementation to prioritise grass for early spring grazing.

Conclusion

All farms can grow more grass through improved grassland management. Managing a farm to produce more grass requires attention to detail and improved grazing management. The farms that are monitoring farm cover regularly are more likely to feed their cows better at grass, achieve more grazings per paddock, improve grass production and increase farm profit irrespective of milk price.

The perfect cow

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Summary

- A perfect cow is one that efficiently produces a large quantity of high value dairy products predominantly off grass, throughout her long lifetime with minimal intervention required.
- Breeding has proven itself to be an effective and efficient strategy to achieve rapid gains in a range of performance traits concurrently.
- Higher EBI animals are more profitable than their lower EBI counterparts.
- Research consistently highlights additional advantages in terms of performance and profit with Jersey crossbred cows in addition to that explained by EBI alone.
- A high EBI fertility sub-index will reduce the number of cows that require treatments for anoestrous and endometritis, as well as shorten the interval to pregnancy establishment after the start of the breeding period.

Introduction

Breeding was traditionally thought of as a slow process. Annual trends in performance of the national herd, coupled with the comparison of EBI strains in the *Next Generation Herd*, clearly demonstrates that the appropriate breeding strategies can, in fact, rapidly achieve high performance potential for a range of different traits. Analysis of the large e-Profit monitor database clearly shows that higher EBI herds are more profitable. The characteristics of the ideal cow have remained largely unchanged for almost two decades, but the technologies to accelerate gains in genetic potential and the management strategies to help realise this genetic potential, are improving year-on-year.

The Economic Breeding Index (EBI) – where has it come from and where is it going?

When launched in 2001, the EBI was comprised of only five traits: milk yield, fat yield, protein yield, calving interval and survival. The recognition that all traits affecting profitability should be included within breeding indexes led to the expansion of the EBI to its current format today, which now includes 18 traits. A similar trend has occurred globally, with some dairy cow indexes now containing >40 different traits. Widening the scope of breeding indexes does not, however, necessarily equate to a large reduction in performance gain in the other traits. For example, the annual rate of genetic gain in fat plus protein 305-day yield in the last 10 years in Ireland is 83% of the annual gain achieved in the 10 years before the introduction of the EBI (Figure 1). This increase in milk solids yield arose due to a combination of greater yield per se, and also due to greater composition (Figure 1). The mean genetic merit of Irish females born in the past 10 years is 0.1% greater in milk fat concentration and 0.1% greater in milk protein concentration than Irish females born in the 10 years before the EBI. In fact, the actual gains in cow lifetime yield are expected to be considerably greater in the modern-day dairy cow. This is attributable to 1) greater daily yields, 2) longer lactations, and 3) greater survival.

Genetic merit for calving interval was lengthening (i.e. getting worse) by 1.5 days per year before the introduction of the EBI (Figure 1). During the last decade, genetic merit for calving interval has been reducing, on average, by almost half a day per year. Shorter calving interval not only affects the costs of production, but also facilitates longer lactations through earlier calving.

The yield of a mature cow is 22% greater than that of a first lactation cow; hence, improving the herd age profile will help achieve the herd's genetic potential. Genetic merit for survival improved by almost 0.3% per annum in the past 10 years compared to a year-on-year disimprovement in survival before the introduction of the EBI. Based on an analysis of DairyMIS data between the years 1990 and 2001, the number of lactations achieved per cow declined by 0.1 per year (i.e. one less lactation per cow was achieved when comparing the year 2001 to the year 1990), while replacement rate increased by almost one per cent per year, equating to a 10% increase in replacement rate over the 10 year period.

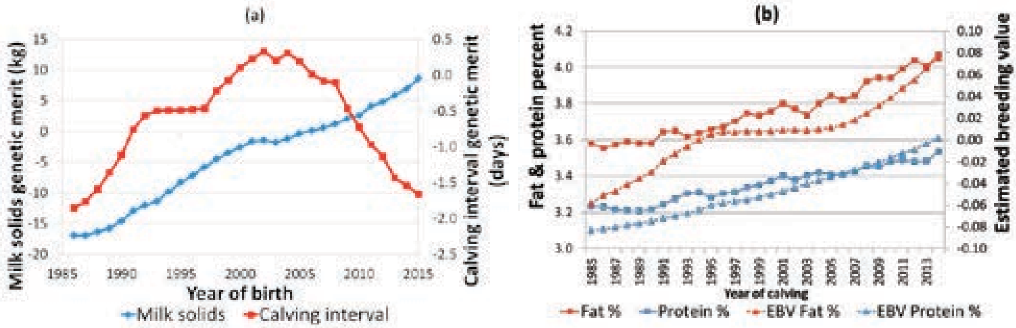

Figure 1. *a) Trend in genetic merit for milk solids yield and calving interval by year of birth in Ireland, and b) mean annual bulk tank fat and protein concentration (continuous line) and the genetic merit (i.e. EBV) of the contributing cows*

The EBI is, therefore, achieving gains in cow productivity by improving several different aspects of performance. Although the annual gains may seem small, the key point is that it is cumulative and permanent: the parents of each generation benefit from the gain of previous generations.

Further evidence that selection for EBI is delivering, is the findings from Teagasc's *Next Generation Herd*, which compares high EBI Holstein-Friesian cows against Holstein-Friesian cows representative of the national average. A detailed performance summary is provided later in this booklet. The results of the study are extremely encouraging. Cow performance, both in terms of productivity and fertility/longevity, and as a consequence predicted profitability, are consistent with expectations based on EBI and its sub-indices.

The EBI, like all national breeding indexes, is constantly being scrutinised to identify improvements. With the current traits in the EBI, simply maintaining fertility levels (i.e. no improvement) would allow the relative emphasis on calving interval to be reduced by only seven per cent. Therefore, it is unlikely that the economic weight on calving interval will change any time soon. Three suites of traits under active research for consideration in future versions of the EBI include feed efficiency, milk quality and more detailed health traits. Over 70% of feed efficiency is already implicitly assumed within the EBI through the simultaneous inclusion of both milk production and body weight. Even at the same milk energy output and body weight, however, differences in feed intake among progeny of sires exist. Given the importance of high value export markets, having consistently high quality and nutritious dairy products is vital to command a premium price. As fertility in the Irish dairy herd continues to improve year-on-year, animal health is likely to become the next biggest limiting factor to a cow achieving its genetic potential. This is especially true as the average cow age increases with improved survival. Animal health is poorly represented within the EBI, primarily due to a lack of routinely available data that can be used to derive genetic evaluations and identify genetically elite parents of the next generation.

Developments will also occur in the genetic evaluations themselves. Two large areas of research are the evaluation of alternative and more pertinent measures of fertility in the EBI as well as other approaches to modelling lactation yield. The Irish fertility genetic evaluations were last updated over 10 years ago, while the milk production evaluations were last updated 15 years ago. The current genetic evaluations for milk production are based on a standard milk lactation profile for a given lactation number by calving date; no consideration is given to variability in the shape of lactation profiles among cows. In fact, the actual shape of milk lactation profiles is under strong genetic control. This implies that the daughters of some bulls peak higher than the daughters from other bulls, but there are also differences in the persistency of daughter lactation profiles between bulls. Although computationally more demanding, such a development, termed a test-day model, will more accurately evaluate cows and bulls based on their true lactation profile.

Does crossbreeding still have a role?

Crossbreeding with high EBI Jersey offers a rapid approach to deliver a type of cow that is ideally suited to seasonal, pasture-based dairying: high yields of milk fat and protein, moderate size, excellent fertility, high intake capacity relative to their moderate size, and high productivity per unit area. The Jersey breed is highly complementary to our high EBI Holstein-Friesian. Because of the large genetic distance between the breeds, potential gains from hybrid vigour are maximised, in addition to breed complementarity. Research findings consistently identify advantages in terms of greater performance and greater profit with Jersey crossbred cows, typically in the order of an additional €100 to €150 per cow per lactation, over and above that explained by EBI (see more detail later in this booklet). Despite the modest gains in EBI with the currently available Jersey sires, crossbreeding with Jersey still offers advantages to the Irish dairy industry in the short to medium term, at least. Long term, the opportunity to exploit the Jersey breed and its proven synergy with our intensive seasonal pasture-based production system may require a proactive futuristic approach to deliver a continued supply of high EBI Jersey genetics. One such initiative is the recent establishment of an elite nucleus herd of Jersey cows by Teagasc (NextGen Jersey).

Fertility characteristics of the perfect cow

With growing herd sizes, and hence less time available per cow, inherently fertile cows are a valuable resource. A highly fertile cow goes in-calf early during the breeding period, and hence calves early during the calving period, year after year. These cows produce more milk, reflecting longer lactations (>280 days) and greater survival (>5.5 lactations). A cow has many hurdles to overcome after calving before she is capable getting pregnant again. All farmers are aware that anoestrous cows (i.e. non-cycling cows) and cows with endometritis (i.e. dirty cows) represent problem cows in a herd; they require treatment, which costs time and money, and they will have poorer fertility during the breeding season than the cows that do not have these problems. Will selecting heavily for EBI fertility sub-index reduce (and eventually eliminate) problem cows?

Taking advantage of the substantial genetic variation for fertility traits that existed in the early 2000's in Ireland, a study was initiated at Moorepark to identify fertility phenotypes under genetic control. Cows with similar genetic merit for milk production traits, but either very good (Fert+) or very poor (Fert-) genetic merit for fertility traits were identified and assembled as a single herd of animals. With a similar environment (nutritional management, health protocols, winter housing, etc.), the divergence in fertility phenotypes recorded in these two groups of animals was astounding. Despite calving at similar BCS and having approximately similar milk production, Fert+ cows had earlier resumption of cyclicity, more rapid recovery of uterine health after parturition, greater BCS during lactation, more favourable blood indicators of bioenergetic status, stronger oestrous expression, a larger ovulatory follicle (and greater circulating estradiol concentrations) that subsequently resulted in a larger corpus luteum (and greater circulating progesterone concentrations). In addition, Fert- cows were more likely to have either silent heats (i.e. ovulation occurred, but there were no behavioural signs of heat) or to have anovulatory heats (i.e. the cow did display signs of heat, but failed to ovulate). Obviously, there can be no pregnancy establishment while cows have either silent heats or anovulatory heats.

The key phenotypes that differ between Fert+ and Fert- cows during the early postpartum period and at the time of breeding are summarised in Table 1.

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

Early postpartum (parturition to Week 7)	At breeding (Weeks 8–16 postpartum)
Higher 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 circulating progesterone
More favourable metabolic status	More favourable uterine environment
	More favourable metabolic status

These detailed measurements collectively impacted the reproductive performance during the breeding period, with the Fert- cows failing to achieve fertility targets and survive in seasonal calving systems. The collective results from this investigation highlighted the importance of selecting for fertility traits, and for the first time identified the fertility phenotypes under genetic control in lactating dairy cows. It is interesting to note that all of these differences in fertility phenotypes were captured by selecting cows based on differences in calving interval. In the day to day management of a dairy herd, problem-free cows are good cows. For fertility management, having high fertility sub-index cows will allow a more compact calving pattern, reduced requirement for interventions, and a lower proportion of non-pregnant cows at the end of the breeding period. These are all key drivers of farm profitability.

Conclusions

The EBI has stood the test of time with overwhelming evidence that higher genetic merit animals, either on a trait-by-trait basis or on the EBI as a whole, translate to greater performance and profitability, respectively. In addition, research consistently highlights further advantages in terms of performance and profit with Jersey crossbred cows in addition to that explained by EBI alone. High fertility is a key driver of profit, suitable genetics is essential to optimise performance.

Teagasc grass and clover breeding programme

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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-seven perennial ryegrass and 11 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 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, showing 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 1960's at the Oak Park Research Centre, Carlow. To date, the programme has bred and commercialised 27 perennial ryegrass varieties and 11 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, a leafy, highly digestible sward is desirable. We also want varieties that produce 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 become more problematic in future.

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 recurrent phenotypic, genotypic and genomic selection. Phenotypic 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 full-sib family selection and half-sib progeny test selection. Genomic selection is selection based on the DNA of the plants. 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 Marine for independent testing under cutting and grazing. The variety is added to the Ireland 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 2017, farmers may choose among 10 perennial ryegrass and six 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 and Magician
- Late diploid: Glenroyal, Glenveagh, Majestic and KERRY
- Late tetraploid: Kintyre and Solas

White clover varieties:

- Medium leaf size: AVOCA, BUDDY, Chieftain and Iona
- Small leaf size: COOLFIN and Galway

Two new white clover varieties (COOLFIN and GALWAY) were released in 2017. Small leaf varieties are especially suited for tight grazing and tend to be less aggressive than larger leaf varieties. Traditionally, small leaf varieties were lower yielding than larger leaf varieties. However, modern bred varieties may buck this trend: COOLFIN out yields all medium leaf size varieties on the Ireland Recommended List. Forthcoming Teagasc varieties, currently undergoing seed increase and with predicted release dates of 2018-19, include the intermediate tetraploid perennial ryegrass variety ELYSIUM, the late diploid perennial ryegrass varieties OAKPARK and SMILE, and the large leaf white clover variety DUBLIN.

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 six white clover varieties bred by Teagasc for reseeding. A number of other new varieties are currently undergoing seed increase for future release.

Establishment of perennial ryegrass and perennial ryegrass-white clover pastures

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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 long term DM production.
- There is no loss in grass DM production in the establishment year with spring reseeding compared to permanent pasture.
- White clover can be established into existing swards by over sowing.
- Management after reseeding/over-sowing is just as important as decisions made at sowing.

Introduction – the need for more reseeding

Reseeding levels in Ireland are low. Less than two per cent of our national grassland area is reseeded annually. As grass is our dominant feed during the main grazing season, and the primary source of winter forage in the form of grass silage, the low level of reseeding must be addressed. Reseeding must be combined with the correction of soil fertility to successfully establish new swards. Data from PastureBase Ireland shows that there is huge capacity on Irish farms to grow more grass. Economically, pastures with a low proportion of perennial ryegrass are costing farmers up to €300/ha per year due to reduced DM production and nitrogen use efficiency. If the cost of reseeding is estimated at approximately €700/ha, the increased profitability of the reseeded pasture would cover the initial reseeding cost in just over two years. This means reseeding is one of the most cost effective on-farm investments.

Cultivation techniques

How paddocks are prepared for reseeding depends on soil type, the quantity of underlying stone, weather conditions and machine/contractor availability. While there are many cultivation and sowing methods available; once completed correctly all methods are equally effective. The do's and dont's of a number of cultivation techniques are outlined in Table 1.

Key points when seeding

- Soil test and use the results to fertilise the newly sown sward.
- Spray off old sward with glyphosate.
- Graze sward tightly or mow to minimise surface trash.
- Apply lime.
- Choose a cultivation method that suits your farm.
- Apply fertiliser.
- Firm fine seedbed with good seed/soil contact is essential.
- Roll after sowing.
- Spray for weeds at 4/5 weeks post emergence.

Table 1. The Do's and Don'ts of different cultivation techniques		
	Do's	Don'ts
Ploughing	Shallow plough. Develop a fine, firm and level seedbed	Plough too deep (> 15 cm) Cloddy, loose seedbed
Discing	Graze tight, apply lime. 3-4 runs in angled directions	Forward speed too fast - rough, uneven seedbed
One-pass	Graze tight, apply lime. Slow forward speed at cultivation	Forward speed too fast – rough, patchy seedbed
Direct drill	Graze tight, apply lime and slug pellets. Wait for moist ground conditions (slight cut in ground)	'Trashy' seedbed - no seed/soil contact. Use when ground is dry and hard

Timing of reseeding

Timing of reseeding depends very much on weather conditions, grass supply and whether the farmer has planned for reseeding or not. Previous survey information suggests that grassland farmers focus their reseeding towards the autumn. This may make sense from a feed budget perspective but it does have some negative consequences. Soil conditions deteriorate as autumn progresses – lower soil temperatures can reduce seed germination, and variable weather conditions reduce the chances of grazing the new sward. The opportunity to apply a post-emergence spray in autumn is also reduced as ground conditions are often unsuitable for machinery.

Spring reseeding offers more flexibility. One of the most important aspects of spring reseeding is that the total grass production from a spring reseed is as much, if not more than, old permanent pasture. Establishing clover in a spring reseed is more reliable than autumn due to the stability of soil temperatures in late spring. Post-emergence spraying for weed control is usually very successful with spring reseeding due to favourable weather conditions in summer. Whether reseeding in spring or autumn, it generally takes a sward around 11 months to fully establish and settle down, so good grazing management in that early growth phase is very important.

Cultivar choice

Grass cultivars should be selected from the Irish (Republic or Northern) Recommended Lists. These varieties have been tested under Irish conditions. The Teagasc Pasture Profit Index is also a valuable tool to select the most suitable grass cultivars for your farm. Teagasc recommendations are to sow 35 kg seed/ha (14 kg/ac) to ensure good establishment of the sward. It is also advised to sow a minimum of 3 kg of each cultivar within a mixture, and no more than three or four cultivars per mix.

How to establish a white clover sward on your farm

Clover can be established on your farm using direct reseeding or over-sowing.

Direct Reseeding

Follow the key points for establishing a reseed as outlined above with the addition of 1 to 2 kg/ha of white clover seed to the mixture.

Over-sowing

Over-sowing is a simple and low cost method of introducing white clover onto your farm. Success is very much dependent on weather conditions around sowing; therefore there is a certain amount of risk associated with this approach.

Key steps involved with over-sowing white clover

- The clover seed can be broadcast onto the sward or stitched in using a suitable machine (e.g. Einbock pneumatic seeder).
- It is best to over-sow directly after grazing (≤ 4 cm post-grazing sward height) or after cutting the paddock for surplus bales. It is not recommended to over-sow clover into dedicated silage paddocks.
- A slightly higher clover seeding rate (3.5 to 5 kg/ha) is recommended for over-sowing compared with a full reseed to overcome the issues with slugs and a lower germination rate
    - » Sow with a fertilizer that contains P, particularly if soil fertility is poor, e.g. one bag of 0-7-30 or 0-10-20 per acre.
    - » If possible reduce nitrogen fertiliser post over-sowing.
- Roll or spread 2,000 gallons/acre of watery slurry on paddocks post-sowing to ensure good seed-soil contact.
- Ideally over-sow on well managed grassland. If the sward is old with a low content of perennial ryegrass and a dense 'butt' a full reseed is best practice.

Management of reseeds

Weed control is an essential element in both direct reseeding and over-sowing. Weeds in new reseeds are best controlled when grass is at the 2-3 leaf stage. Docks and chickweed are two of the most critical weeds to control in new reseeds; it is important to control these at the seedling stage by applying the herbicide before the first grazing. When clover is included in the sward a clover safe herbicide must be used. When over-sowing clover into existing grass swards, it may be better to control established weeds before over-sowing. If you are considering this, it is important to consider the residue time from application of the spray to over-sowing the clover, as it can vary from one month to four months. It is important to contact your local advisor or merchant if doing this. All pesticides users should comply with the regulations as outlined in the Sustainable Use Directive (SUD).

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 and, where relevant, clover establishment. Grazing by lighter 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 approximately 700 – 1,000 kg DM/ha. Frequent grazing of the reseeds at light pre-grazing yields (<1,400 kg DM/ha or less than 8 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 and clover establishment resulting in an open sward which is liable to weed ingression.

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. White clover can be established in swards at reseeding or can be successfully incorporated into existing swards by over-sowing. Whether it is a full reseed or over–sowing, management after sowing has the biggest impact on the successful establishment and production potential of swards.

Clonakilty update: The effect of tetraploid and diploid swards sown with and without white clover on the productivity of spring milk production systems

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Summary

- White clover inclusion can increase milk (+ 728 kg milk and + 58 kg milk solids per cow) and grass dry matter (DM) production (+ 1.5 t DM/ha) in intensive grass-based dairy production systems.
- Perennial ryegrass ploidy does not affect milk or grass DM production.

Introduction

The focus of this paper will be on the results of the first three years of the Clonakilty Agricultural College research experiment. The experiment was established in Clonakilty Agricultural College in 2012 and 2013. Seventy five percent of the experimental area was reseeded in 2012 and 25% in 2013. Four separate grazing treatments were sown on the experimental area; a tetraploid only sward (TO), a diploid only sward (DO), a tetraploid plus clover sward (TC) and a diploid plus clover sward (DC). Four diploid (Tyrella, Aberchoice, Glenveagh and Drumbo) and four tetraploid (Aston Energy, Kintyre, Twymax and Dunluce) perennial ryegrass cultivars were sown as monocultures with and without white clover around the farm, thus creating a separate farmlet of 20 paddocks for each treatment. In the clover paddocks, a 50:50 mix of chieftain and crusader white clover was sown at a rate of 5 kg/ha. There are 30 cows in each treatment group and treatments are stocked at 2.75 cows/ha, receive 250 kg of nitrogen (N) fertiliser/ha and target concentrate supplementation is 300 kg/cow for each treatment. Each farmlet is walked weekly to monitor average farm cover (using PastureBase Ireland) and when surpluses are identified, they are removed in the form of baled silage. The objective of the experiment is to compare milk and grass production from tetraploid and diploid swards sown with and without clover. When discussing the effect of grass-only (the mean effect of T and D; GO) versus grass-clover (the mean effect of TC and DC; GC) swards the terms GO and GC are used.

Grass production

There was no difference between TC and DC in terms of the proportion of clover in each sward and the profile of clover in both swards was consistent with the expected pattern of clover growth i.e. the proportion of clover in the sward is low in the spring and then increases to a peak in August and September. The average clover proportion was 24% and 26% for TC and DC swards, respectively during the three years of the experiment. The effect of clover inclusion in the sward on daily grass growth during the three years of the experiment is illustrated in Figure 1. Daily grass growth rates for GO and GC swards were similar from January to May. However, from June to September GC swards had a 12 kg DM/ha per day greater mean daily grass growth rate compared with GO swards. In October and November, there was no difference in mean daily grass growth rate between the GO and GC swards. As a result, grass DM production was 15.5 t DM/ha on the GO swards and 17.0

t DM/ha on the GC swards over the three years.

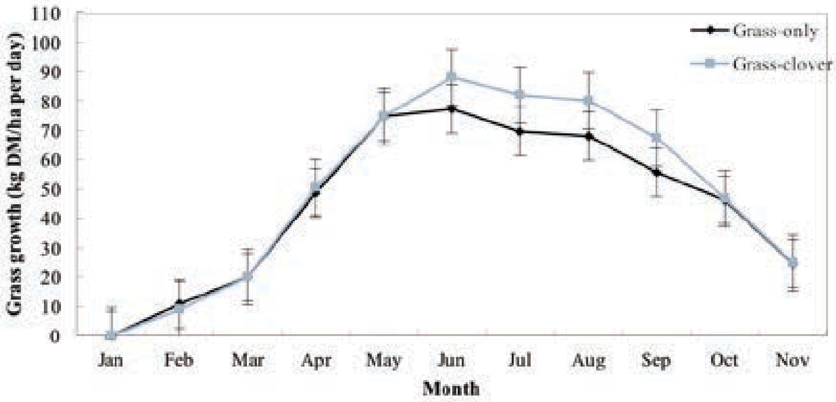

Figure 1. *The effect sward type (grass-only and grass-clover) on mean daily grass growth rates for each month over three years (2014 – 2016)*

Milk production

Average annual concentrate supplementation across all treatments was 321 kg DM/cow during the three years of the experiment. Average annual silage supplementation during lactation to the GC cows was significantly greater (431 kg DM/cow) compared with the GO cows (328 kg DM/cow). The effect of treatment on milk production during the three years is presented in Table 1. Ploidy had no effect on any of the milk production variables. Clover inclusion had a significant effect on all milk production variables with the exception of fat and protein content. Both milk and milk solids yield per cow and per ha were greater for cows on GC treatments compared with GO treatments. Cows on GC treatments produced 728 kg more milk and 58 kg more milk solids than cows on the GO treatments, which resulted in an extra 2,001 kg and 160 kg of milk and milk solids per ha, respectively. Neither ploidy nor clover inclusion had an effect on body weight or body condition score.

Table 1. The effect of treatment[1] on milk production variables over three years (2014 – 2016)

	TO	DO	TC	DC
Milk yield (kg/cow)	5,086	5,110	5,842	5,809
Fat (%)	4.65	4.64	4.62	4.63
Protein (%)	3.79	3.73	3.73	3.73
Milk solids yield (kg/cow)	429	426	487	484
Milk yield (kg/ha)	13,987	14,053	16,066	15,975
Milk solids yield (kg/ha)	1,180	1,172	1,339	1,331

[1]*TO = tetraploid only; DO = diploid only; TC = tetraploid + clover; DC = diploid + clover*

Conclusion

Perennial ryegrass ploidy did not affect milk or grass DM production. However, white clover inclusion had a significant effect on both. Both milk (per cow and per ha) and grass DM production were greater on the GC swards compared with the GO swards. The experiment demonstrates the potential of white clover to improve the productivity of grass-based production systems in Ireland.

Moorepark update: Herbage production and milk production from grass only and grass clover swards

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Summary

- Sward clover content varies across the year; it is least in winter and early spring and greatest in late summer/early autumn.
- Annual milk solids (MS) production can be increased by up to 34 kg/cow when average annual sward clover content is 23%.
- Annual herbage production was similar in a grass-clover sward receiving 150 kg N/ha to that of both a grass only and grass-clover sward receiving 250 kg N/ha.
- Over four years of evaluation, average sward clover content was 23% and 27% on grass-clover swards receiving 250 and 150 kg N/ha, respectively.

Introduction

Nitrogen (N) fertiliser is used in Irish grass based milk production systems to ensure an adequate supply of high quality herbage is available to feed dairy cows over a prolonged grazing season (270+ days). Nitrogen fertiliser use is limited under the Nitrates Directive. However, farms with high stocking rates (>2.5 LU/ha) have a high feed demand, and N fixed from the atmosphere by white clover can supply extra N for herbage growth. Previous Moorepark research has shown that including clover in grazed swards, even at N application levels above 150 kg N/ha can increase herbage production. Clover grows well with perennial ryegrass and is suitable for grazing systems. Grass growth peaks in May/June, while clover growth peaks in August. Clover growth is slower than grass over winter and in early spring because clover requires soil temperatures of approximately 8^{0}C for growth while grass grows at soil temperatures of 5 to 6^{0}C. Applying N fertiliser to grass-clover swards can compensate for low clover growth rates in spring. Incorporating clover in to grass swards has the potential to increase milk production, particularly in the second half of the year (June onwards).

Grazing experiment

A farm systems experiment was undertaken at Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork from 2013 to 2016. The experiment compared herbage and milk production from a grass-only sward receiving 250 kg N/ha per year (Grass250) and grass-clover swards receiving 250 or 150 kg N/ha per year (Clover250 and Clover150, respectively). Each treatment was stocked at 2.74 cows/ha. All swards received similar N fertiliser until May, after which N fertiliser application was reduced on the Clover150 treatment. All treatments had a similar rotation length, target pre-grazing herbage mass (1,300 to 1,500 kg DM/ha in mid-season), and target post-grazing sward height (4 cm).

Results

Annual herbage production was similar on all treatments (14.6 t DM/ha) across the four years of the experiment (Table 1). Average annual sward clover content was greater on Clover150 (27%) compared with Clover250 (23%). Although milk fat and protein percentages were similar across treatments, milk solids yield was greater on the Clover250 and Clover150 treatments (496 and 493 kg MS/cow) respectively compared with Grass250 (460 kg MS/cow) due to increased milk yield (Table 1). Based on the results of this experiment there is potential to reduce N fertiliser application to grass clover swards from May onwards in milk production systems with stocking rates up to 2.74 cows/ha. This offers a considerable potential saving to the farmer in terms of reduced N fertiliser application.

Table 1. Average daily milk and milk solids yield, annual milk solids yield and annual herbage production on grass only swards receiving 250 kg N/ha (Grass250) and grass-clover swards receiving 150 and 250 kg N/ha (Clover150 and Clover250, respectively) and average annual sward clover content during the experimental period (2013 - 2016).

	Grass 250	Clover 250	Clover 150
Milk yield (kg/cow/d)	21.47	23.05	22.57
Milk solids (kg/cow/d)	1.73	1.83	1.81
Cumulative milk solids (kg/cow/year)	460	496	493
Cumulative milk solids (kg/ha/year)	1,261	1,361	1,353
Annual herbage production (kg DM/ha)	14,544	14,479	14,350
Sward clover content (%)	-	23	27

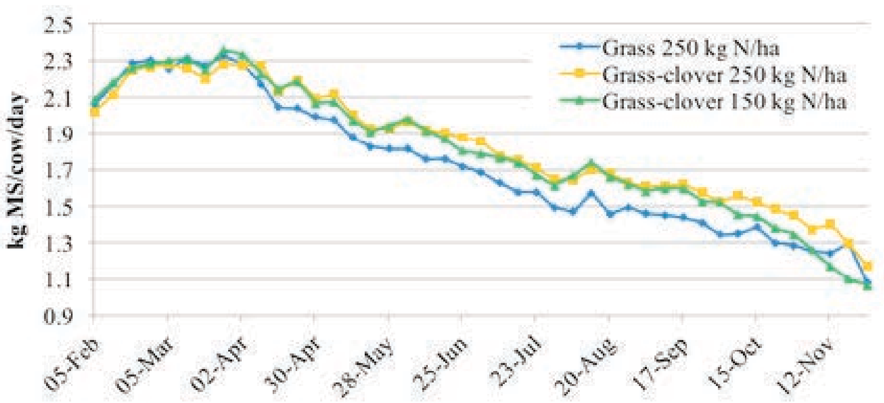

Figure 1. *Average daily milk solids production (kg MS/cow/day) from a grass only sward receiving 250 kg N/ha, and grass-clover swards receiving 250 kg N/ha or 150 kg N/ha*

As herbage production was similar on all three treatments in the four year period, the three treatments in this grazing experiment in 2017 are Grass250, Clover150 and Clover100 at a stocking rate of 2.74 cows/ha to investigate if N fertiliser application to grass-clover swards can be reduced below 150 kg N/ha without negatively impacting on herbage and milk solids production at this stocking rate.

Conclusions

Milk solids production was greater on the grass-clover treatments compared to the Grass250. Reducing N fertiliser application on the Clover150 treatment from May onwards resulted in greater sward clover content compared to Clover250. Herbage production was similar on all three treatments.

Acknowledgements

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On-farm evaluation of grass and clover variety performance

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Summary

- On farm grass evaluation shows large differences (1.7 t DM/ha) in dry matter (DM) production between varieties.
- Differences have also emerged between the number of grazing's achieved between varieties.
- Grazing utilisation differences have been established with some varieties showing very consistent post-grazing residual heights.
- Clover variety evaluations have now started on farms since 2016.

Introduction

The Irish grass evaluation programme (Department of Agriculture, Food and Marine Recommended List) is capable of identifying varieties with superior performance within grazing systems and is essential to the success of ruminant production in Ireland. The question remains whether current evaluation criteria provide breeders with adequate information to develop new grass varieties that align to the needs of modern grassland farmers. In order to supplement existing evaluation protocols and identify better grass genotypes suited to grazing systems, it is necessary to establish trials that reflect "real" farm conditions over longer time periods. On-farm grass evaluations have been undertaken previously but across a small number of farms with multiple varieties sown in strips within the same paddocks, however the approach taken in this project is very different. On-farm evaluation has the ability to influence and direct the breeding of the next generation of grass varieties suited to intensive grazing regimes. The objective of this work is to evaluate grass variety performance on commercial farms within intensive grazing regimes.

Project setup

Sixty six regionally dispersed dairy farms across a range of soil types and management systems were identified and enrolled into the program. The farm locations are as follows; Cavan (1), Cork (28), Donegal (2), Galway (4), Kerry (2), Kildare (2), Kilkenny (2), Laois (1), Limerick (8), Longford (2), Roscommon (1), Tipperary (7), Waterford (1), Westmeath (2), and Wexford (3).

A prerequisite for the selection of farms was the availability of historical grassland management information, based on records from PastureBase Ireland (PBI), which indicates the level and quality of data recorded. This is an important factor as it is necessary to encourage varieties to express their potential under grazing in the respective environments. All participating farmers were provided with grassland management training to ensure data was recorded correctly and coherently and that management practices were adhered to in order to sufficiently test varieties and to disseminate new information. Varieties were evaluated on-farm for the years 2013 to 2016 inclusive, based on swards sown as monocultures in individual paddocks from 2011 to 2014. PastureBase Ireland is a web based grassland database that has a dual function of providing real time decision support for farmers while acting as a national grassland database, capturing information for benchmarking and research purposes. The system operates with the individual farm paddock as the basic unit of measurement. All grassland information is recorded by the farmer through the web interface. Grass cover estimations are entered on a weekly basis during the main growing season. Estimations are taken by using either a plate meter or by visual assessment.

Variety choice

Perennial ryegrass varieties were selected from the Irish Recommended List for Grass and White Clover Varieties in each of the years 2012, 2013 and 2014 (Department of Agriculture 2017). Diploid (D) and tetraploid (T) varieties with similar heading dates ranging from May 30th to June 10th were selected for use. Tyrella (late heading D) was the most widely used variety in commercial farm mixtures for the previous three years in Ireland, and was used as a control variety sown on each participating farm. The varieties sown (along with the associated ploidy and heading date in parenthesis) were: AberChoice (D; June 10th), AberGain (T; June 5th), AberMagic (D; May 30th), Astonenergy (T; June 2nd), Drumbo (D; June 7th), Dunluce (T; May 30th), Glenveagh (D; June 3rd), Kintyre (T; June 8th), Majestic (D; June 2nd), Twymax (T; June 7th) and Tyrella (D; June 4th).

Grass DM production

A 1.7 t DM/ha difference in grass DM production was measured between the highest and lowest yielding variety on farms. This is illustrated in Figure 1, where Abermagic yielded 13.7 t DM/ha compared with 12.0 t DM/ha for Glenveagh and Majestic. A number of other agronomic measurements taken from the study show differences in the number of grazings achieved on farms with both Astonenergy and Drumbo achieving 7.4 grazings per year, a 0.5 grazing increase on Twymax and Majestic. There was no evidence of seasonal productivity differences between varieties despite breeder's particular efforts to increase spring and autumn herbage production, however this may manifest itself in the future. Differences in grass quality and grazing utilisation have also been recorded between varieties. On-farm varieties were shown to form swards of differing densities. In general, the varieties which formed more dense swards had the greatest reductions in density over the evaluation period.

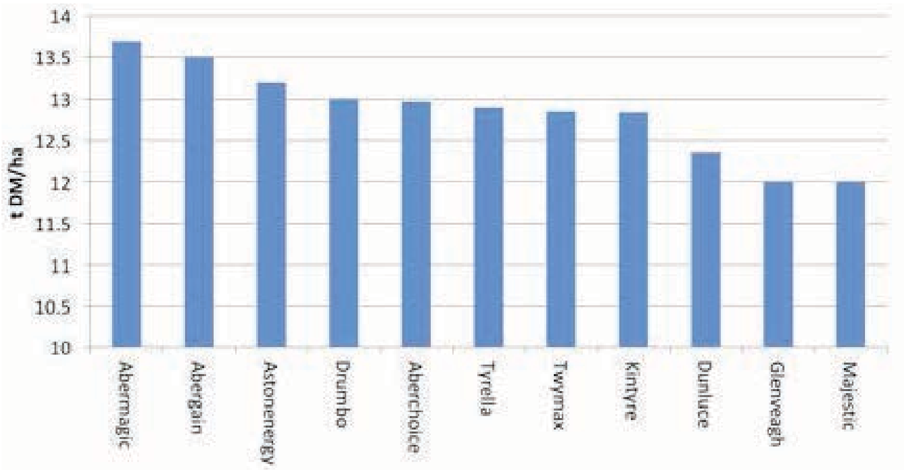

Figure 1. *Total DM Production (t DM/ha) of various varieties on 66 commercial farms from 2013-2016*

Conclusions

The current project demonstrates that perennial ryegrass varieties can be evaluated on commercial farms when a large number of farm covers are completed during the grazing season. Overall, variety was found to affect total herbage DM production on-farm. On-farm evaluation proved to be a suitable environment to assess sward quality as varieties were shown to contain differing concentrations of DMD. The number of grazing's recorded by variety was different and this new concept is a worthwhile parameter due to its positive effect on herbage production and as an indication of suitability to grazing. This work will establish the commercial performance of varieties and will further direct progress in delivering improved varieties suited to intensive grazing environments.

Acknowledgement

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Grazed grass quality – impact of fibre digestibility

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Summary

- Grass quality influences dairy cow intake and production performance.
- Grass quality is indicated by grass organic matter digestibility (OMD).
- High OMD 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.
  - » Low to medium pre-grazing herbage mass (1,300-1,600 kg DM/ha; PGHM).
- Grass digestibility is influenced by indigestible neutral detergent fibre.

Introduction

Grass-based dairy cow production is based on the efficient production and utilisation of high quality grazed grass. Performance of cows in these systems can be optimised when a high dry matter intake (DMI) of high quality grass is achieved. Maintaining high quality grass is one of the key steps to achieving high DMI and ultimately milk solids production from grazed grass.

Importance of grazed grass

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. Typically, digestibility is reported as OMD. The more nutrients cows can extract from feed, the greater the OMD. High OMD grass is characterised by its chemical composition - high protein concentration and medium fibre concentration. High OMD grass is also characterised by its physical structure - high leaf and pseudostem content and low true stem and dead content. Grass OMD is heavily influenced by grazing management. High OMD grass comes from implementing a short to medium regrowth interval and grazing grass with a low to medium pre-grazing herbage mass (PGHM) to a post-grazing residual of 4 cm. Having swards with high leaf content and that are grazed at the target PGHM (1,300-1,600 kg DM/ha) will allow cows to graze to 4 cm, which will ensure grass quality is maintained throughout the year.

Importance of grass quality

Low OMD grass has a higher neutral detergent fibre (NDF) concentration than high OMD grass. This means that low OMD grass is bulkier which can limit DMI. This low intake potential energy content of low OMD grass is undesirable in a grass-based milk production system which relies on cows consuming large quantities of high energy feed. 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 daily energy intake of approximately six per cent, equivalent to a reduction of 0.2 kg milk solids per cow per day.

Fibre – Digestible or not?

The changes in grass OMD through the growing season are strongly associated with changes in the fibre fractions in grass. In grass, NDF can be separated into potentially digestible NDF (pdNDF) and indigestible NDF (iNDF). Potentially digestible NDF is the amount of fibre available to cows for digestion. Indigestible NDF is fibre that is locked within lignin and is indigestible and provides no nutritional value to cows. Recent studies in Teagasc Moorepark investigating fibre digestion have shown that an increasing iNDF concentration in grass is highly correlated to a reduction in grass OMD. In Figure 1, the relationship between iNDF and OMD is reported. In this instance, every one per cent increase in iNDF decreased OMD by 1.3 %. The larger reduction in OMD can be attributed to the increase in iNDF and also to a reduction in digestibility of pdNDF that is trapped within the iNDF fraction. This relationship helps to further explain why grass OMD varies by season and pre-grazing herbage mass. Indigestible NDF has no nutritional value for cows. Future research will look to investigate the potential application of using iNDF as a parameter for predicting grass quality.

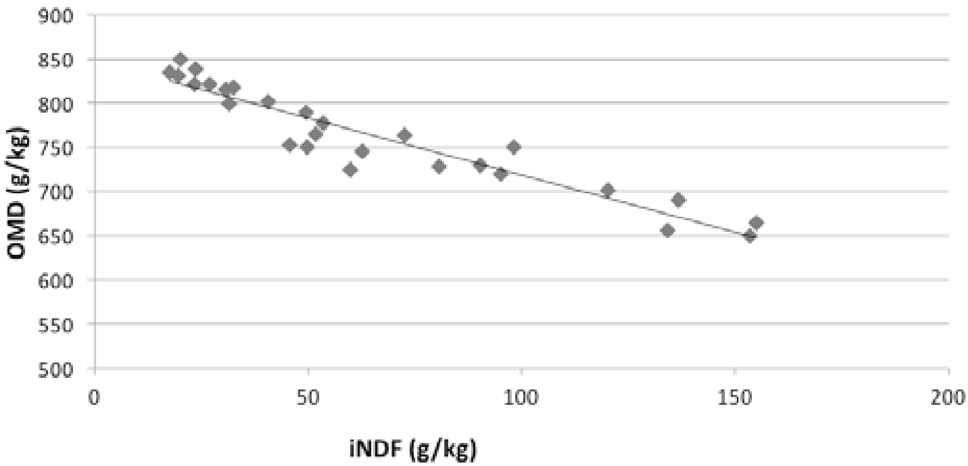

Figure 1. *Relationship between organic matter digestibility (OMD) and indigestible neutral detergent fibre (iNDF)*

Conclusion

Grass quality, measured by OMD, has important implications for dairy cow intake and milk production performance. Grass quality should therefore be maximised by following recommendations on target PGHM. Grass iNDF concentration is a good predictor of OMD and helps explain variation in OMD caused by seasonal and PGHM effects.

Nutritional modelling – the next frontier for Irish pasture-based systems

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Summary

- More accurately understanding the detailed nutritive characteristics of pasture has the potential to increase animal performance in grazing systems.
- Incorporating a nutritional model such as the Cornell Net Carbohydrate and Protein System (CNCPS) has the potential to understand the variables first limiting milk solids (MS) production in pasture-based systems.

Introduction

Currently, the supply of nutrients to grazing animals is insufficient to maintain milk production above 2.2 kg milk solids (MS)/ cow per day. Metabolisable energy is thought to limit milk production from forage diets, but the supply of protein to the duodenum has also been proposed to limit milk production from high quality pasture. In order to consistently and predictably increase MS production from pasture, an understanding of the energy and post-ruminal amino acids supply to the cow and their subsequent metabolism is required.

Cornell Net Carbohydrate and Protein System (CNCPS)

In 2015, an exciting collaboration project was established between Teagasc Moorepark and Cornell University under the direction of Prof. Michael Van Amburgh, one of the world's leading dairy cow nutrition scientists. The main aim of this collaboration was to evaluate the CNCPS model for Irish dairy cows in pasture-based systems. The CNCPS is a nutrition model, which was developed to serve as a decision support tool for both research development and feed formulation for cattle. The model is continuously evolving by incorporating new research data and descriptions of rumen function and metabolism into mathematical equations and quantitative representations. Currently, the CNCPS is used to feed millions of dairy cows worldwide.

Dairy cow nutrition research programme

The objective of this research programme is to develop and implement a dairy cow nutrition programme with a view to increasing the competitiveness of the Irish dairy industry. In order to achieve this, a solid foundation comprising of three main pillars in dairy cow nutrition is required. The vision for these three pillars are; 1) the feed: implementing new feed chemistry analysis to accurately describe nutrient supply, 2) the cow: investigating variables such as passage rates and rumen degradative ability to mechanistically describe her biology, and 3) the model: incorporating this new knowledge into a functional model to predict animal requirements and performance potential at pasture.

Preliminary data

Research efforts are underway on all three pillars. Currently, Neutral Detergent Fiber (NDF) is reported on feed analysis output as an indicator of feed quality and plant maturity. However, NDF is not a uniform fraction and requires further analysis to understand its nutrient supply to the animal. For clarification purposes, NDF is now referred to as aNDFom, which corrects the fraction for contaminations such as starch and ash. Output from novel feed chemistry on Irish pastures, undertaken at Cornell University, is shown in Figure 1, which shows the relationship between the proportion of aNDFom fermented and a number of time series for both Spring and Autumn pasture. Using mathematical modelling and time course analysis, it is possible to define the rate (kD) and extent (undigested (uNDFom)) to which the aNDFom of a particular grass is digested in the rumen of a cow. Figure 1 shows that the rate (17.6%/ h versus 12.8%/ h kD) and extent (9.3% versus 15.3% uNDFom) of aNDFom digestion, which was greater for Spring compared with Autumn pasture. These variables have large implications for both the energy supply and intake potential of pasture swards.

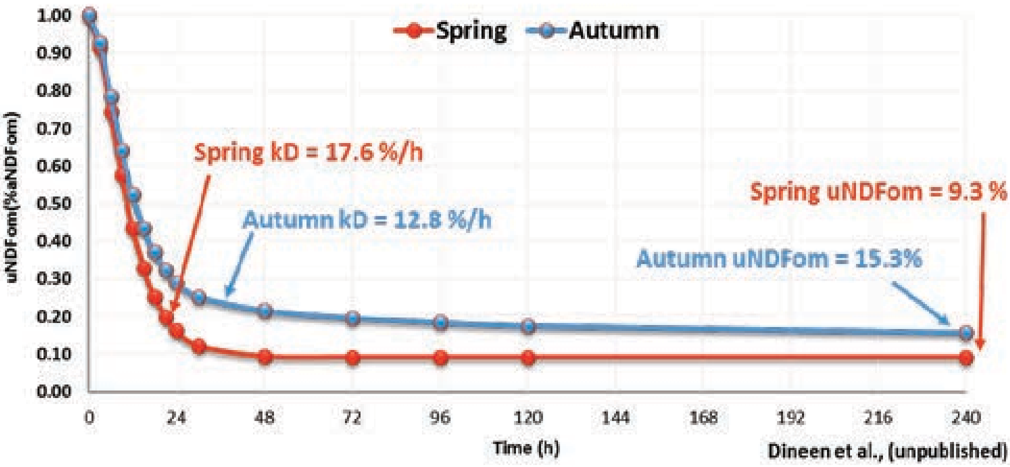

Figure 1. *In-vitro aNDFom fermentation of Irish Spring and Autumn pasture*

Omasal sampling study

Work has commenced this summer to describe pillar two, the cow. An omasal sampling study is underway where digesta leaving the rumen is sampled across the 24-hour profile with cows fed fresh pasture or pasture plus 3 kg DM of a starch supplement. To complement this procedure, rumen evacuations and faecal sampling are being undertaken to quantify variables such as amino acids flows and total tract digestibility. The results of this study will give a greater understanding of rumen dynamics, passage rates, microbial populations and how these variables effect intake, digestibility and MS production from grazed pasture.

Conclusions

Although the nutritional constraints of pasture have been examined, there are a large number of possible interactions between the supply of dietary nutrients and the animal requirement for these nutrients. By combining new feed chemistry analysis, the omasal sampling procedure and the predication capability of a complex model such as the CNCPS, a more accurate quantification of the nutrients limiting MS production at pasture can be defined.

Autumn and spring grazing management

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Summary

- Careful planning and decision rules must be put in place and targets adhered to for autumn and spring grazing management.
- Target an opening farm cover of 900 kg DM/ha in spring.
- Average farm cover must not drop below 500 kg DM/ha in March or April.

Introduction

Grass growth in Ireland is highly seasonal with little growth from November to February. Irish dairy farmers must make careful decisions on grass allocation in autumn and spring to optimise the quantity of grazed grass in the herd's diet. Increasing stocking rates together with increasingly compact calving has increased spring feed demand on dairy farms. Extra grass must be grown and utilised in this period to avoid unnecessary supplementary feed use. These changes in feed demand necessitate careful planning of autumn and spring grazing management practices to guide farmers in achieving sufficient grass to feed the herd.

Autumn closing date is one of the most important management factors influencing the supply of grass in early spring. To ensure adequate quantities of grass are available at the start of calving on highly stocked farms, farmers must ensure that an average farm cover (AFC) of in excess of 600 kg DM/ha is achieved at closing. To achieve this target, farmers should use the autumn planner, which allocates an area of ground to be closed from October to November. It is recommended that the first paddocks should be closed between October 5th and 10th, and 60% of the area should be grazed by November 7th, with 100% grazed by the end of November. Heavier farms or ones with low autumn growth rates should close approximately one week earlier. The aim in spring is to gradually increase the proportion of grazed grass in the diet of the grazing animal, while at the same time budgeting so that there is enough grass until the start of the second grazing rotation. A low AFC at turnout in spring will result in increased levels of supplement being fed to freshly calved cows. Farmers should target an opening AFC of 900 kg DM/ha in early February to ensure that supplementation is kept to a minimum. The spring rotation planner (SRP) should be used to manage grazing in the first rotation. The first rotation should start in early February and continue until early April. Thirty percent of the farm should be grazed by March 1st and 66% by March 17th. Average farm cover should not be allowed to drop below 500 kg DM/ha in March or early April. It is important to monitor AFC in conjunction with the autumn planner and SRP to ensure that AFC does not drop below target levels.

New autumn and spring grazing research at Teagasc Moorepark

In September 2016, a grazing experiment was established at Teagasc Moorepark examining autumn and spring grazing management. The objectives of this project are to evaluate the potential of alternative autumn and spring grazing practices to increase grass supply and quality, and utilisation efficiency to increase herd feed supply from grazed grass. To determine the effects of autumn closing date on spring grass availability, three autumn grazing managements were imposed; early closing (Sept 25th – Nov 9th), normal closing (Oct 10th – Nov 24th) and late closing (Oct 25th – Dec 9th), (Table 1).

Table 1. Three autumn closing managements: early (Sept 25th – Nov 9th), normal (10th Oct – 24th Nov) and late closing (25th Oct – 9th Dec)					
Autumn closing	Start closing	60% closed	Housed	Rotation length	Turnout date
Early	25-Sept	17-Oct	9-Nov	46	6-Feb
Normal	10-Oct	1-Nov	24-Nov	46	6-Feb
Late	25-Oct	17-Nov	9-Dec	46	6-Feb

The three autumn closing managements are combined with two spring grazing rotations, fast (Feb 6th – Apr 1st) and slow (Feb 6th – Apr 8th) (Figure 1). All six treatments are stocked at 2.9 cows/ha, and all swards receive similar nitrogen fertiliser application.

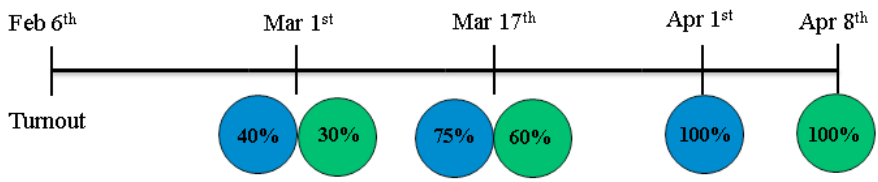

Figure 1. *Spring grazing management from turnout (February 6th) until the end of the first rotation: Blue – fast rotation – 40% grazed by March 1st, 75% grazed by March 17th and 100% grazed by April 1st; Green – slow rotation – 30% grazed by March 1st, 60% grazed by March 17th and 100% grazed by April 8th)*

Update on autumn and spring grazing experiment at Moorepark

Results are available for the over winter period from closing in December 2016 until opening in February 2017. Average farm covers on the early, normal and late closing treatments were 720, 590 and 420 kg DM/ha, respectively on December 9th 2016. This equated to opening AFC on January 30th 2017 of 1040, 840 and 650 kg DM/ha for the early, normal and late treatments, respectively. Overwinter growth rates were 9, 8 and 6.5 kg DM/day for the early, normal and late treatments, respectively. This experiment will continue for three years to establish the effects of altering autumn and spring grazing management.

Conclusion

Management decision rules must be put in place for autumn and spring grazing management, using the autumn and spring rotation planners. Intensively stocked farms should achieve an opening farm cover of 900 kg DM/ha in spring and must not allow AFC in March and April to drop below 500 kg DM/ha.

Optimum stocking rate

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Summary

- Within grazing systems, optimum stocking rate (SR) balances the competing objectives of adequate grass intake to optimise milk production per cow while also maximising grass utilisation and milk production per ha.
- Increasing SR is akin to increases in grazing intensity and grass utilisation resulting in higher grass growth and improved sward quality.
- Each additional grazing day results in an increase of 11 kg DM/ha grass utilised and 1.7 kg milk solids (MS)/ha.

Introduction

There is an increasing awareness of the multifunctional benefits of grass-based 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 forage or concentrate feeds, grazed grass provides a relatively inexpensive and uniquely nutritious feed source that can support high levels of milk production. Stocking rate (cows/ha) is widely acknowledged as the primary driver to systematically improve grass production, grazed grass utilisation, and milk production per ha in grazing systems.

Identifying the optimum stocking rate

Within grazing systems, the optimum SR achieves a balance between the competing objectives of high grass allowance and intake to maximise milk production per cow, and increased grazing intensity to maximise grass utilisation and milk production per ha. In Table 1, the optimum SR for farms that produce different quantities of grass and feed different levels of supplement are defined. For example, if a farm can grow 10 t DM/ha of grass and the system involves feeding 0.5 t DM concentrate/cow, the overall farm SR should be 1.8 cows/ha. In comparison, a farm capable of growing 16 t DM/ha of grass and feeding 0.5 t concentrate/cow, SR should be 3.0 cows/ha.

Table 1. SR (cows/ha) guideline to optimise farm profitability growing different quantities of grass and feeding different levels of supplement/cow

	Grass grown, t DM/ha			
t concentrate 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

Highly productive grazing systems

Highly productive grazing systems are characterised by high MS output per ha fuelled by increased grazing intensity and grass utilisation achieved through higher SR and extended grazing season lengths. There is a strong association between the number of grazing days per ha (grazing season length x SR) and grass utilisation and MS production per ha (Figure 1). Each additional grazing day per ha corresponds to an increase in grass utilisation of 11 kg DM/ha and additional MS production of 1.7 kg/ha.

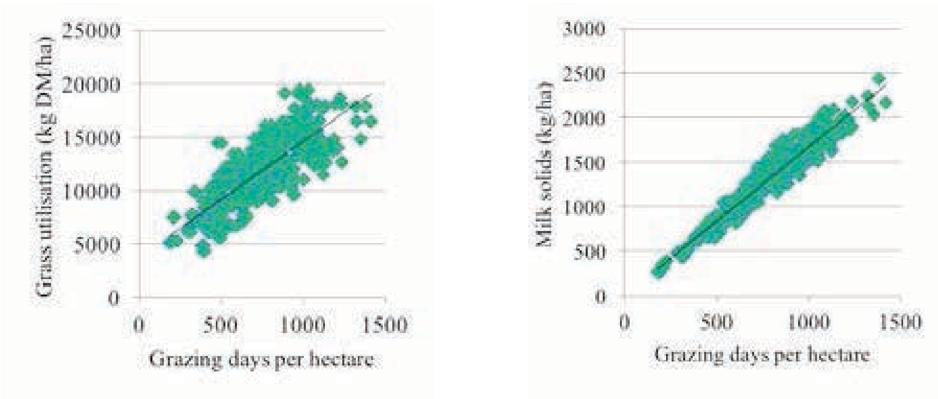

Figure 1. *The relationship between grazing days per hectare and (a) grass utilisation (kg DM/ha) and (b) milk solids (kg/ha) recorded at Curtin's Farm*

Curtin's farm stocking rate experiment

Recent research at Curtin's farm has investigated a range of SR (Low: 2.5 cows/ha, Medium SR: 2.9 cows/ha, and High SR: 3.3 cows/ha). Such SRs are high compared with the national average dairy farm SR (2.0 cows/ha). As SR increased, grazing days per ha, grazed grass utilisation, and concentrate fed increased (Table 2). Additionally, increased SR resulted in an increase in MS production per ha while MS production per cow decreased. Table 2 demonstrates the considerable potential for increased grass utilisation and MS production on commercial dairy farms through improved grazing management.

Table 2. Grass and milk production in Curtin's research farm and the national average dairy farm

	Low	Medium	High	Nat. Avg.
Stocking rate (cows/ha)	2.5	2.9	3.3	2.0
Grazing days per hectare	658	756	863	446
Grazed grass utilisation (kg DM/ha)	10,237	11,016	11,809	7,100
Concentrate fed/ha (t DM)	1,263	1,328	1,468	2,016
Milk solids (kg/cow)	456	432	414	333
(kg/ha)	1,140	1,253	1,366	665

Conclusions

To fully exploit the competitive advantage of grazed grass, grazing management practices must improve to maximise grass production and utilisation. Furthermore, the biological impact of intensification demonstrated at higher SR at Curtin's farm is indicative of the potential for increased grass and milk productivity attainable on commercial dairy farms in the future.

Using the Pasture Profit Index

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Summary

- The Pasture Profit Index (PPI) is a total merit economic index which ranks grass varieties on their economic value to a grassland farm.
- The relative emphasis on each trait is as follows; grass DM yield (31%), grass quality (20%), silage yield (15%) and sward persistency (34%).
- There is a large range in PPI values (€/ha/year) between the highest (€206) and lowest (€23) varieties.
- Farmers will need to carefully choose varieties for their purpose when using the PPI.

Introduction

Food Wise 2025 has set a target to increase grass utilisation nationally by 2 t DM/ha by 2025. This target will be difficult to achieve without an increase in reseeding to generate new high productivity ryegrass white clover swards. The Pasture Profit Index (PPI) was introduced to the Irish grassland industry in 2013, after many years of focussed research work and refinements to Department of Agriculture, Food and the Marine evaluation protocols. The PPI sets out in economic terms, the agronomic differences between grass varieties, to allow farmers to select the most appropriate varieties for their chosen purposes. It is critical that the industry has direct feedback on the relative performance of varieties on commercial farms, as the recommended list ensures that varieties are appropriate for use in Ireland. It is also critically important that farmers and the industry only use or retail recommended listed material as this is the most reliable quality control for grass varieties.

Approach used

The use of the PPI enables the identification of varieties which will provide the greatest economic contribution to a ruminant grazing system. The sub-indices identify the relative strengths and weaknesses of individual varieties. The index ranks varieties based on their economic benefits and will ultimately result in an increase in the use of superior varieties which results in higher profitability for the industry as a whole. All varieties on the PPI now have a minimum of two years agronomic data generated before the PPI is calculated. The range in PPI in 2017 is from €23 to €206/ha/year, this is the economic ranking difference between the highest and lowest ranked variety and on investigation of the PPI/Recommended list, this difference is easily recognised. Many of the lower ranked varieties have deficiencies in seasonal grass production and grass quality.

The data generated in the PPI is from the Department of Agriculture, Food and Marine evaluation protocols. The relative emphasis on each trait is as follows: grass dry matter (DM) yield (31%), grass quality (20%), silage yield (15%) and sward persistency (34%). The base values that are used are spring DM yield = 1.01 t DM/ha, mid-season DM yield = 6.1 t DM/ha and autumn DM yield = 1.9 t DM/ha. Base values for grass quality (in terms of dry matter digestibility) are 853 g/kg (April), 856 g/kg (May), 826 g/kg (June), 816 g/kg DM (July), respectively. The base value for first cut silage is 4.5 t DM/ha and 3.5 t DM/ha for second cut silage. Persistency is based on ground score change (GSΔ), the economic merit for persistency was determined by dividing the reseeding cost of €672/ha by the number of years a variety persists with varieties surviving the yield threshold of 12 years or longer getting a value of zero and less persistent varieties having a negative economic value. In so doing, the PPI rewards varieties with a low GSΔ and consistently high levels of DM production.

The sub-indices present the opportunity to select varieties for specific purposes. For example, if selecting a variety for intensive grazing, particular emphasis should be placed on quality plus seasonal DM yield with less importance on silage performance. Inversely, if selecting a variety specifically for silage production, particular emphasis should be placed on the silage sub-index and persistency. The PPI will continue to develop and new traits such as a new grazing utilisation trait will be included in the future.

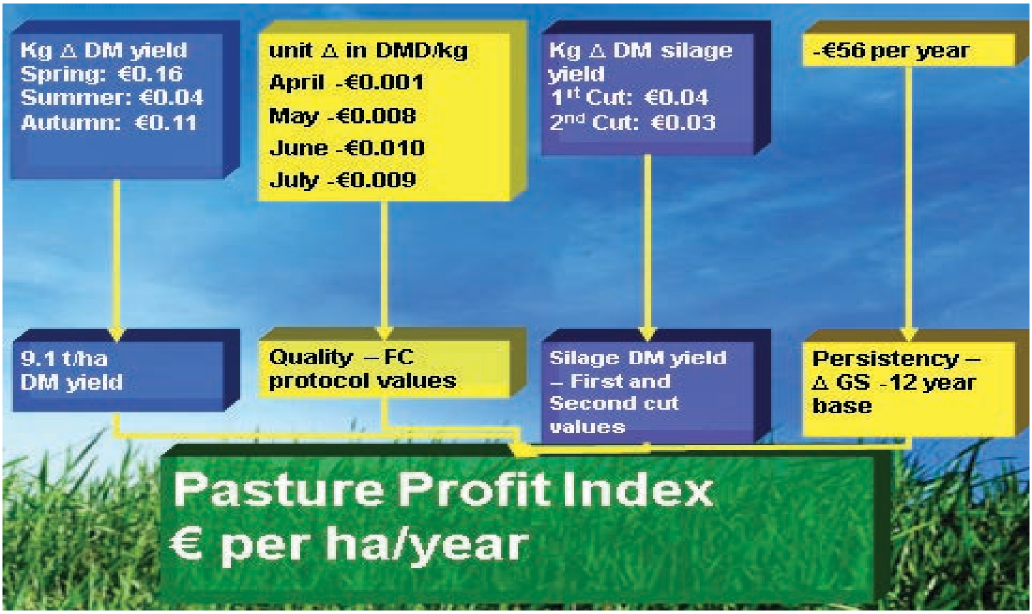

Figure 1. *Economic Values as assigned to base values of Pasture Profit Index 2017*

Table 1. Recommended Intermediate & Late Perennial Ryegrass Varieties 2017

			Pasture Profit Index Values € / Ha / Year							Spring	Summer	Autumn	Total Yield	Mean DMD	1st Cut Silage	2nd Cut Silage	Ground Cover
			Total	Sub-Indices						(t DM/ha)	(t DM/ha)	(t DM/ha)	(t DM/ha)	(g/kg)	(t DM/ha)	(t DM/ha)	Score
Variety Name	Ploidy	Heading Date	PPI	Spring	Summer	Autumn	Quality	Silage	Persist.								
Aberclyde	T	26-May	206	44	49	34	59	19	0	1.27	7.39	2.22	10.88	857.0	4.71	3.85	5.6
Abermagic	D	31-May	199	36	51	68	33	11	0	1.22	7.43	2.53	11.19	849.6	4.46	3.94	6.3
Nifty	D	27-May	191	70	53	57	-7	16	0	1.43	7.50	2.43	11.37	838.6	4.74	3.71	6.4
Fintona	T	22-May	178	58	39	50	11	21	0	1.36	7.12	2.36	10.84	842.0	4.97	3.55	5.8
Aberchoice	D	09-Jun	175	11	49	47	63	6	0	1.07	7.40	2.33	10.80	855.4	3.98	4.40	6.3
Aberwolf	D	31-May	171	58	39	34	29	12	0	1.36	7.11	2.22	10.69	846.9	4.54	3.86	7.0
Rosetta	D	24-May	170	89	29	40	2	11	0	1.55	6.86	2.27	10.68	838.7	4.68	3.60	6.4
Abergain	T	05-Jun	169	17	44	42	64	20	-19	1.10	7.26	2.29	10.66	858.0	4.49	4.19	5.9
Aberplentiful	T	09-Jun	167	39	50	40	29	9	0	1.24	7.42	2.28	10.94	847.5	4.11	4.34	5.7
Seagoe	T	28-May	167	33	40	43	19	33	0	1.20	7.15	2.30	10.66	845.5	4.94	3.98	6.1
Dunluce	T	30-May	165	17	44	46	41	17	0	1.11	7.25	2.33	10.68	849.8	4.23	4.45	5.6
Meiduno	T	06-Jun	163	43	45	41	32	12	-11	1.27	7.29	2.29	10.84	848.7	4.34	4.12	5.2
Solas	T	10-Jun	151	8	43	55	30	15	0	1.05	7.23	2.41	10.69	846.0	3.92	4.78	6.0
Magician	T	22-May	141	46	33	33	6	23	0	1.29	6.96	2.21	10.46	841.0	4.73	3.94	5.7
Astonenergy	T	02-Jun	131	-9	36	38	61	5	0	0.95	7.06	2.26	10.26	857.2	4.38	3.85	5.3
Xenon	T	11-Jun	130	7	37	30	45	10	0	1.04	7.08	2.19	10.31	852.1	3.90	4.66	6.4
Kintyre	T	07-Jun	126	10	37	53	32	6	-11	1.06	7.06	2.39	10.51	846.0	4.03	4.36	6.0
Solomon	D	21-May	125	65	30	31	-24	22	0	1.40	6.89	2.19	10.48	834.2	4.98	3.58	6.5
Alfonso	T	04-Jun	113	-5	36	34	50	-2	0	0.97	7.06	2.22	10.24	853.8	4.28	3.73	6.0
Aspect	T	06-Jun	110	6	40	24	37	5	0	1.04	7.14	2.13	10.30	851.8	4.05	4.27	6.3
Boyne	D	22-May	107	55	31	26	-39	34	0	1.34	6.92	2.15	10.41	828.9	4.99	3.97	6.5
Carraig	T	24-May	105	37	39	32	-12	9	0	1.23	7.13	2.20	10.56	838.8	4.81	3.38	6.1
Navan	T	06-Jun	98	-6	38	48	20	3	-5	0.96	7.09	2.35	10.40	844.9	3.99	4.31	5.8
Drumbo	D	07-Jun	96	13	33	32	43	-6	-19	1.08	6.96	2.20	10.24	847.7	4.02	3.94	6.5
Kerry	D	01-Jun	93	19	40	39	-1	2	-5	1.11	7.15	2.26	10.52	837.8	4.04	4.20	6.2
Glenroyal	D	05-Jun	92	11	39	39	2	2	0	1.07	7.11	2.26	10.45	838.2	4.05	4.18	6.9
Delphin	T	02-Jun	91	2	39	25	16	15	-5	1.01	7.12	2.14	10.27	844.6	4.43	4.10	5.3
Clanrye	D	06-Jun	76	21	39	15	-10	11	0	1.13	7.13	2.05	10.31	834.9	4.08	4.44	7.0
Majestic	D	02-Jun	65	22	30	37	-16	-8	0	1.14	6.89	2.25	10.27	833.0	4.20	3.64	6.9
Glenveagh	D	02-Jun	51	8	32	20	-12	3	0	1.05	6.95	2.10	10.09	835.3	4.26	3.94	6.9
Stefani	D	02-Jun	50	4	25	21	-3	3	0	1.03	6.76	2.10	9.89	837.4	4.29	3.88	6.5
Piccadilly	D	03-Jun	46	10	29	16	-24	15	0	1.06	6.86	2.06	9.98	831.1	4.65	3.79	6.7
Tyrella	D	04-Jun	23	24	17	14	2	-7	-28	1.15	6.55	2.04	9.74	839.9	4.26	3.61	6.4

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

PastureBase Ireland – Increasing grass utilisation on Irish dairy farms

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Summary

- Dairy farms recording farm cover regularly on PastureBase Ireland have grown between 12 and 14 t DM/ha per year over the past four years (2013-2016).
- There was large variation between dairy farms for grass DM production ranging from 18.8 t DM/ha to 7.3 t DM/ha.
- The Spring Rotation Planner targets have not been achieved on farms; in spring 2015 and 2016 dairy farms were 10% behind target.
- Spring DM production is variable on dairy farms. Top producing farms are achieving 1.8 t DM/ha.
- Autumn closing date has a very significant impact on what level of grass is available for the following spring. Each week delay in closing in autumn, reduces spring grass availability by 77 kg DM/ha.

Introduction

PastureBase Ireland is an internet-based grassland management tool. In operation since 2013, it offers farmers 'grassland decision support' and stores a vast quantity of grassland data from dairy, beef and sheep farmers in a central national database. At the moment the vast majority of farms recording grass measurements on PBI are dairy farms, currently there are 3,000 farmers using the system.

The database stores all grassland measurements within a common structure. This will allow the quantification of grass growth and DM production (total and seasonal) across different enterprises, grassland management systems, regions, and soil types using a common measurement protocol and methodology. The background data such as paddock soil fertility, grass/clover variety, aspect, altitude, reseeding history, soil type, drainage characteristics and fertiliser applications are also recorded.

Grass DM production on dairy farms - PastureBase Ireland data (2013-2016)

It is obvious that there is significant variation in grass DM production on and between farms. High grass DM 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 over the past four years (2013-2016). There are many reasons for this, including differences in stocking rate, soil fertility and grazing management practices. If soil fertility and grazing management can be improved, many farms are capable of increasing their DM production substantially.

Figure 1 shows the annual DM production data from farms across the country in 2016. These farms have in excess of 30 weekly farm walks completed during the grazing season. In 2013, these farms produced an average of 12.2 t DM/ha, increasing to 13.5 t DM/ha in 2014 and 14.1 t DM/ha in 2015. The variation between farms is large (+9.4 t DM/ha) while year also has a significant effect on grass DM production. The highest producing farms are growing more than 16.0 t DM/ha with little variation between paddocks whereas lower producing farms have much greater variation between individual paddocks.

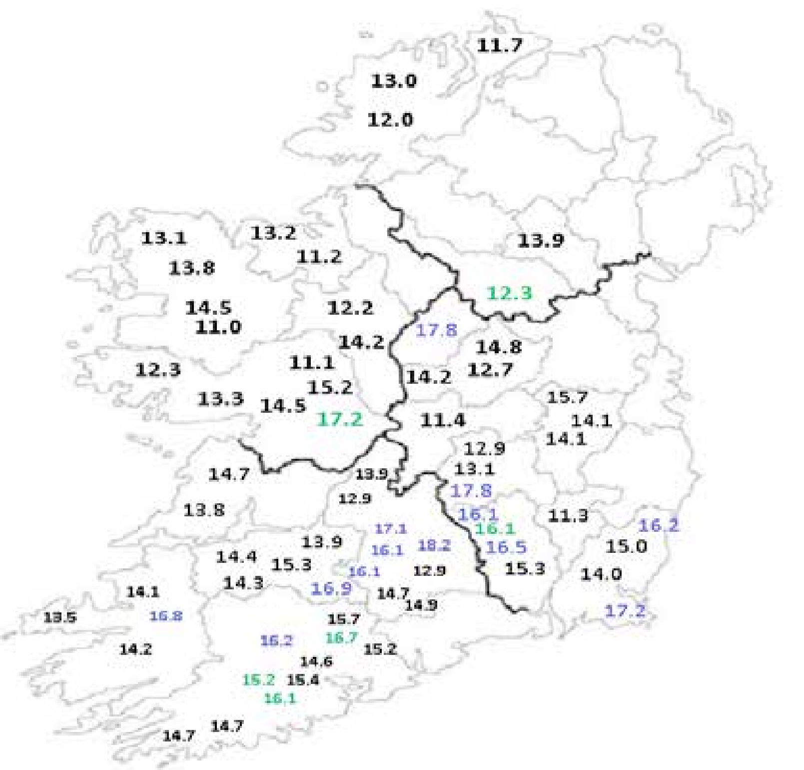

Figure 1. *Grass dry matter production (t DM/ha) from PastureBase Ireland dairy farms across the country in 2016*

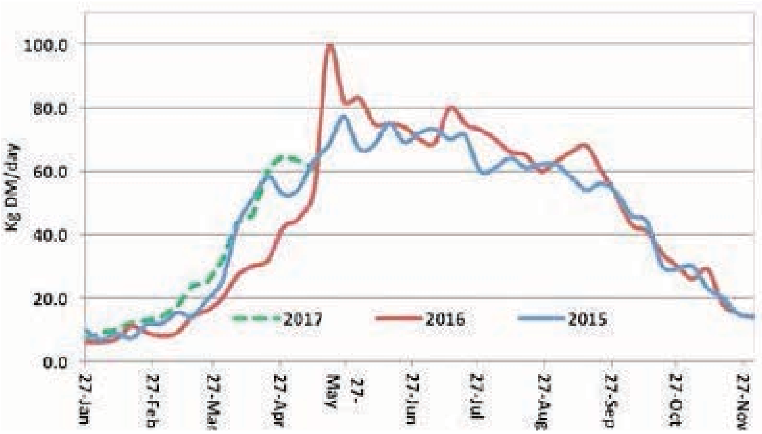

Figure 2. *Mean daily growth rates (kg DM/ha per day) for PastureBase Ireland farms for 2015, 2016 and to date in 2017.*

Future plans

Since early 2016, PBI and AgriNet Grass have merged to form one grassland management decision support tool for farmers. This venture is a great asset for Irish farmers as it will offer world leading grassland software to aid decision making on farm. Large quantities of data will now be stored in one database for dissemination and for the benefit of Irish farmers. Over the past 12 months, PBI has undergone considerable redevelopment with the addition of new management tools and a more user friendly interface.

Conclusions

It is clear that Ireland has huge potential to increase annual DM production with a better focus on grazing management. PastureBase Ireland, the national database, will allow the industry to move forward with a better understanding of the performance of grassland farms. PastureBase Ireland has highlighted that all dairy farms can increase DM production and as a consequence increase milk solids output and overall farm profitability.

Sign up

If you wish to join PBI and start managing your grass better, contact your local Teagasc adviser or support@pbi.ie.

New developments in nitrogen fertilisers

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Summary

- Fertiliser nitrogen (N), optimal overall soil fertility and vigorous swards will drive grass production; the most cost-effective feed on farms.
- Fertiliser N, a critical farm input, is a source of two important N gases, the greenhouse gas nitrous oxide (N2O) and the air pollutant ammonia (NH3).
- Calcium ammonium nitrate (CAN) has relatively high N2O losses and urea has relatively high NH3 losses. National commitments to cut both these gases must be met.
- New N fertiliser, Protected Urea (urea+NBPT), has reduced losses of both NH3 and N_2O compared to conventional N fertilisers while consistently yielding as well as CAN and at similar cost. Other options for farmers to reduce these gases on-farm are costly and/or impact production.

Introduction

Ireland's growing agriculture industry is utilising our national soil and climate resources to produce high quality foods. The sustainability of our production systems is important to differentiate our exports from competitors. Fertiliser N is a cornerstone input of many of our production systems but its application is associated with emissions of the greenhouse gas nitrous oxide (N_2O) and the air pollutant ammonia (NH_3). Ireland has committed to reducing losses of both gases while expanding production. As agriculture accounts for ~33% of GHG emissions and ~98% of ammonia emissions it must play a role in meeting reduction targets. Recent research from Johnstown Castle shows that the formulation of N fertiliser used on our farms has potential to decrease emissions without reducing the fertiliser rates or dry matter (DM) production which underpin productivity.

Grass DM yield

When applied throughout the year, CAN, urea and urea protected with the urease inhibitor *N*-(*n*-**butyl**) **thiophosphoric triamide** (NBPT) gave comparable annual grass DM yields. On average, urea (unprotected) was a little better yielding than CAN in spring with 103.5% of the yield of CAN. In contrast, summer applied urea was a little poorer yielding 98.9% of the yield of CAN.

Fertiliser N recovery efficiency

CAN and protected urea had the highest N recovery efficiency (Figure 2b). As the N rate increased, the efficiency gap between urea and the other two products widened (Figure 2b). Protected urea is consistently as efficient as CAN. Urea (unprotected) is less efficient during the summer or at higher N rates, e.g. in silage.

The greenhouse gas nitrous oxide

Nitrous oxide is c. 300 times as damaging as CO_2 emitted from your car and c. 12 times more damaging than the methane emitted by dairy cows. Recent research has shown that, of the three fertiliser N options, CAN has the highest and most variable GHG loss in Irish grassland conditions. In comparison, protected urea reduced losses of the potent GHG nitrous oxide by ~70% compared to CAN.

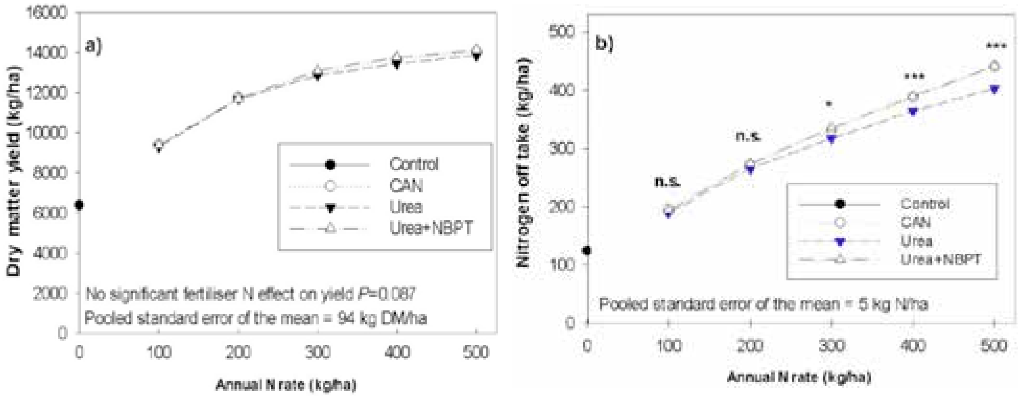

Figure 1. *The effect of fertiliser formulation on a) grass yield, and b) nitrogen off-take efficiency based on data from six site-years and 30 individual applications*

Ammonia gas

Ireland has committed to reduce ammonia gas emissions by five per cent by 2030. This is a significant challenge for a growing agricultural sector which produces ~98% of national ammonia emissions. Urea protected with NBPT has been show to cut ammonia loss by 79% on average compared with untreated urea under Irish conditions. The results show that ammonia loss from protected urea was not significantly different to CAN which has minimal ammonia gas loss.

	CAN	Urea	Urea + NBPT
Cost of N	★★★½	★★★★★	★★★★
Yield	★★★★★	★★★★½	★★★★★
N recovery efficiency	★★★★★	★★★½	★★★★★
Greenhouse gas	★★	★★★★★	★★★★★
Ammonia gas	★★★★★	★★	★★★★½

Figure 2. *Relative strengths of CAN, Urea and protected urea (Urea + NBPT)*

Conclusion

Each fertiliser N option has strengths (see above). Based on research in Irish grassland conditions, protected urea fertiliser (urea + NBPT) is a very promising option for an agriculture industry seeking to grow sustainably. Protected urea can be used as a substitute for CAN or for unprotected urea.

Acknowledgements

Funding support is gratefully acknowledged from the Department of Agriculture Food and the Marine Research Stimulus Fund, the Department of Agriculture and Rural Development for Northern Ireland and the Teagasc Walsh Fellowship Scheme.

Planning for high quality silage

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Summary

- Quality grass silage is the main winter feed on most dairy farms. Increasing stocking rates on farm will require more high quality silage to be produced.
- Good digestibility and preservation are key silage quality targets.
- Feed budgeting will ensure adequate amounts of high quality silage are available.

Grass silage quality

Grass silage feed quality can vary from that of highly digestible grazed grass to feed of comparable nutritive value to straw. High quality silage has the potential to support up to 23 kg milk/cow/day in lactating cows while poor quality silage has to be supplemented to meet cow maintenance requirements. Nationally in 2016, silage quality had an average dry matter digestibility (DMD) of 650 g/kg, but a large variation was recorded with DMD ranging from 520 to 820 g/kg. Silage makes up a considerable part of the annual feed budget on-farm so every effort should be made to ensure silage of adequate quality is produced. Silage quality targets depend on the nutrient requirements of the animals being fed.

Planning for silage production

Silage accounts for a significant proportion of a grass-based dairy herd's annual feed budget, from approximately 20% for extended grazing systems, to > 30% for highly stocked grazing platforms and/or heavy soil type farms. Changes to silage budgets are often a hidden cost where grazing stocking rates rise due to dairy herd expansion, particularly in the absence of improved annual grass growth per hectare. In such cases, the amount of grass silage conserved from grazing platforms declines sharply simultaneously with an increasing demand for conserved forage. The result is increased reliance on forage sources from external land blocks which often have lower growth capacity and poorer quality swards. It is important therefore, that silage areas are managed correctly to maximize utilisation of forage per whole farm hectare. Planning for high quality silage should be incorporated into the grazing management of the farm. Plan for how much high quality silage and dry cow silage is required on farm. In a spring calving herd, a dairy cow will consume 1.5 t DM of 680 g/kg DMD silage over a 140 day winter but an additional 400 kg DM of silage at 740+ g/kg DM should also be available to feed lactating cows. This is very important where stocking rates have increased and grass supplies are under greater pressure during periods of poor growth. Replacement heifers should also have access to high quality silage, with 850 kg DM silage allowed for each replacement heifer for a 150 day winter. Silage analysis is imperative to ensure correct concentrate supplementation rates.

Growing high quality silage

High quality silage can only occur where careful planning is implemented. In the long term, silage swards should be reseeded as necessary, to maintain a high perennial ryegrass content in swards. Perennial ryegrass contains high sugar concentrations which helps ensiling and preservation of silage. Soil fertility can be a major limiting factor to silage yield and quality on-farm. Deficiencies in lime, phosphorus or potassium along with inadequate nitrogen application cause reductions in both quantity and quality of silage produced. Fields intended to be cut for silage should be grazed tightly (4 cm) in late 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. Table 1 highlights the causes of reductions in DMD and the typical reduction in silage quality.

Table 1. Causes of changes in digestibility in silage crops

Causes of drop in DMD	Size of drop in DMD %
1 week delay in harvesting	2.5-3.0
Old pasture (No/little ryegrass)	5-6
Lodging	7-9
Not grazed (dead butt)	6-7
Bad preservation	2-3
Heating at feed out	2-3

Silage Preservation

Harvesting high DMD grass for silage production requires careful management of the ensiling and preservation process to ensure silage will be of high quality at feeding. Firstly, cutting grass in afternoon or evening is advisable as sugar content is greatest at these times. A 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. Grass should be spread to facilitate a wilt and attempting to wilt in merged windrows or in damp/wet weather is likely to have negative effects on both silage digestibility and preservation. Grass does not require an additive to be applied at harvesting if it is well wilted or has adequate sugar content (> 3%). For walled pits or clamp silage, grass should be filled quickly, evenly and rolled thoroughly. Adequate rolling is very important in drier silage, and pits should be sealed to remove air. At least two sheets of 0.125 mm plastic should be used as a cover and care should be taken to ensure airtightness at the edges of silage covers. As silage settles in pit, some sinking will occur and it is necessary to retighten silage cover. This is a vital step as it will help ensure anaerobic conditions and prevent dry matter losses and secondary fermentation. Effluent should be collected and disposed of safely. Baled silage should be wrapped with at least four layers of plastic stretch film and if bales are very wet, intended for long-term storage, or will be handled multiple times, six layers can help reduce losses.

Conclusion

With increasing stocking rates, feed budgeting will become increasingly important on farm. Silage accounts for a considerable proportion of the feed requirement on farm. Sufficient quantities of quality silage should be harvested to ensure adequate feed supply and reduce concentrate requirements. Careful management of silage pits and bales can prevent losses at feed out.

More information is available on making good quality silage at www.teagasc.ie/media/website/publications/2016/Teagasc-Quality-Grass-Silage-Guide.pdf

Don't let soil fertility curtail your business

David Wall, Mark Plunkett and Patrick Forrestal

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Summary

- Lime and fertiliser phosphorus (P) and potassium (K) use on Irish farms has been low over the past decades.
- Currently over 55% of soils on dairy farms have below target soil pH and regular lime applications are required.
- 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 €275 /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 a valuable resource and should be targeted at soils with the highest requirement for P & K to help offset fertiliser costs.

Introduction

Soil fertility levels have declined on dairy farms coinciding with a reduction in fertiliser usage in the last decade (Figure 1). Of the dairy farm soil samples analysed by Teagasc in 2016, only 10% had optimal soil fertility levels as indicated by soil pH, P and K. Forty four percent of soils sampled had soil pH at the optimal level > pH 6.2.

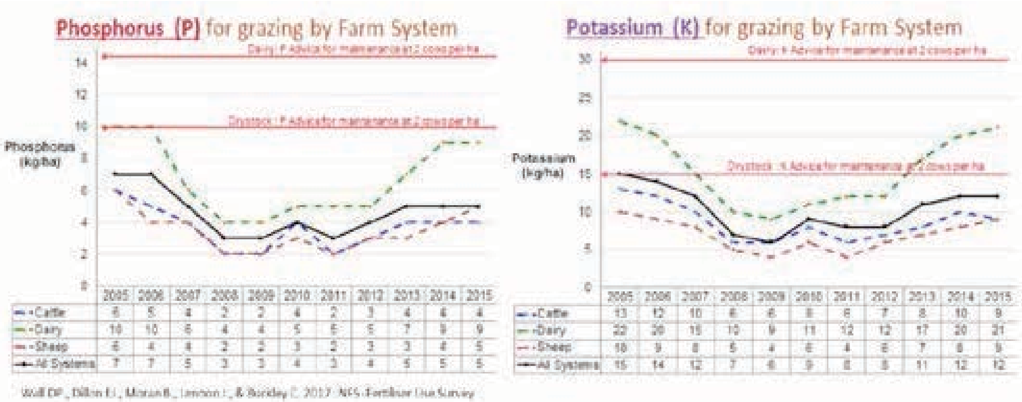

Figure 1. *Phosphorus (P) and Potassium (K) use on cattle, dairy and sheep farms, surveyed by Teagasc National Farm Survey. Typical P and K maintenance fertiliser rates for dairy and drystock are shown by the red lines*

With up to 90% of soils currently deficient in at least one of these critical elements, poor soil fertility poses a significant threat to productivity and profitability improvement 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), Phosphorus (P), Potassium (K) and Sulphur (S) (Table 1). However, only a fraction of these nutrient requirements are provided as fertiliser inputs due to the continuous recycling of nutrients within the soil. These high rates of nutrient uptake by grassland shows the importance of good soil fertility.

Table 1. Typical concentrations of N, P, K and S in 1 tonne of grass DM, and the total uptake of each nutrient required in one 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/ha (kg)
N	34.9	558
P	4.1	67
K	29.7	475
S	2.9	46

Lime and 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 advice for both P and K applications shown includes 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 as concentrate.

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 K 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	+180	+260
2	55	60	65	70	+155	+230
3	25	30	35	40	+125	+200
4	0	0	0	0	0	0

Typically no more than 90kg/ha K should be applied at closing for silage

Conclusion

Trying to plan fertiliser application without information on soil fertility levels is impossible and 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, animal health and ultimately farm profitability.

ICT technologies to increase precision and efficiency in grassland systems

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Summary

- Grass measurement tools that capture geo-tagged grass measurement data and can use developed algorithms to calculate parameters such as grazing area allocation bring a new level of precision to grazing management.
- Technologies that can monitor cow behaviour and location at grazing have potential to positively influence grazing management based on real time cow information.
- Increased and advanced measurement through the use of ICT-led recording at farm level has the potential to improve grassland management in Ireland.

Introduction

Profitability within grass-based production systems is driven by the degree of grass utilisation achieved. This is influenced by grass growth and optimum usage of available grass supply. Frequent measurement of grass parameters facilitates optimum herbage production and utilisation. The potential to use ICT for grass measurement is dramatic but ICT has not been commonly used in grassland management to-date. There is potential to up-scale grassland management at farm level by integrating ICT tools, new technologies and decision supports with grass measurements.

The Grasshopper tool for grass height measurement

A rising plate meter known as the *Grasshopper* device has been developed in conjunction with an Irish company (TrueNorth Technologies). This tool is basically a plate-meter that uses an ultra-sonic sensor to accurately and precisely measure compressed grass height, with recorded GPS coordinates. It also has the capacity to transfer the generated data automatically to a SMART device via Bluetooth and then onto an online database. This data can then be used to automatically define the appropriate area to be allocated daily to the grazing herd. The *Grasshopper* is calibrated and validated for measurement of grass height against the New Zealand plate meter, the *Jenquip,* and shows a very high level of accuracy and precision. The technology has the ability to upload the data to the decision support tool (DST) *Pasturebase Ireland* and can reduce the labour requirement associated with grass measurement significantly.

The grass Q tool for grass quality measurement

An on-going project (in conjunction with research organizations in Denmark, Finland and Switzerland and TrueNorth Technologies) is investigating the development of an automated tool to measure 'real-time' grass quality in the paddock. The allocation of grass to a cow herd is a function of herbage yield, grass quality and herbage allowance. To allow precise allocation, it is necessary to have an accurate 'real-time' measure of grass height and quality. The automated and geo-tagged grass height measurement may be obtained using the *Grasshopper*. The quality of the herbage on offer remains an estimated value. The proposed research focuses on development of a near infrared spectroscopic sensor (NIRS) to record grass quality and herbage mass data at geo-referenced locations in the paddock. The recorded data will be instantaneously uploaded to a cloud based DST that will present farmers with 'real time' data analysis via a Smartphone App through a user friendly interface. The quality data will be defined as percent dry matter (DM) and percent crude protein (CP) initially and percent organic matter digestibility (OMD) at a later point. The CP will be determined as a factor of the N content of grass, and as the data is geo-specific, it can also be utilised for targeted fertiliser application and yield mapping. The proposed work will enhance both grass utilisation efficiency and targeted fertiliser application.

Cow behaviour monitoring

Currently, most commercially available sensors for monitoring feeding behaviour are calibrated for indoor systems and are not validated in a grazing environment. However, grazing behaviour sensors can aid successful grazing management of cows in both conventional and automatic milking systems. Two grazing behaviour sensors were validated against visual observation at Moorepark; (i) 'RumiWatch' halter, which measures grazing behaviour by recording jaw movements using a noseband pressure sensor, and is designed for research use; and (ii) 'MooMonitor+' collar, which measures grazing behaviour by an accelerometer placed on the neck and is developed for commercial use on farms. The RumiWatch halter showed a correlation of r = 0.96 and r = 0.98 for grazing and ruminating behaviour, respectively, when compared with the 'gold standard' of visual observation. The MooMonitor+ had corresponding r values of r = 0.94 and r = 0.98. Thus, both devices showed a high degree of accuracy and demonstrated a high feasibility for monitoring accurate feeding behaviour.

Smartbow equipment for continuous 'real time' monitoring of cow location

The daily schedule of cows, their presence and grazing patterns at different locations in a grass-based system can have an impact on grass intake and thus, profitability. Technology to monitor 'real time' cow location is installed at a dairy farm at Moorepark. The technology under study is a product of Smartbow (Austria). Its component parts include (i) an ear-tag attached to each animal's ear, (ii) 37 aerials distributed at various locations over the grazing paddocks (27 ha), (iii) four transmitters to receive communication from the aerials, and (iv) the data server located in the farm office. Position of the ear-tag (and thus the cow) is determined by radio signals between the aerials. The values are passed by radio on the 2.4 GHz ISM band via the wall points to the data station. The system is currently under test. Knowledge of cow location is very important to inform grazing management decisions, as well as providing key information in automatic milking systems, where milking frequency is dependent on voluntary movement of the cow.

On-going virtual fence (VF) research

The ability for cattle producers to move and monitor animals by drawing a fence on an electronic map of the farm, on a smart phone or tablet may become reality, due to technological advances and reduced equipment costs. The VF is a device capable of containing animals within a defined area, with the use of warning stimuli through the medium of a collar. Commercialisation of these collars and the associated management system is progressing in Australia (eShepherd). However, in intensive grazing systems as commonly operated on dairy farms in Ireland, the feasibility of VF technology will depend on the ability to successfully train the cows. Training and learning of the cows is crucial for operating VF in a welfare friendly manner in intensively grazed systems. This area of work is currently being monitored.

Conclusions

The long term potential from increased ICT-led recording at farm level will increase ICT uptake in the farming community. ICT use around grass quality parameters, animal grazing behaviour, cow location and virtual fencing will consequently improve grassland management in Ireland.

Using a grass growth model to answer the question: Is the variability in grass growth between two parts of Ireland due to weather or soil type?

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Summary

- The MoSt Grass Growth model was developed at Teagasc Moorepark to predict grass growth in grazing systems.
- A grass growth model allows the prediction of the impact of management on grass growth on the farm as well as the environmental impact in terms of nitrogen leaching.
- A grass growth model must be able to adapt to different management strategies depending on soil type and weather.
- The MoSt model showed that the difference in grass growth between locations is due mainly to soil type and weather conditions.
- The model is currently being tested on a weekly basis at three locations using weather forecasts and the long term aim is to incorporate the model within PastureBase Ireland.

Introduction

In Ireland, 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. Since the removal of the EU milk quotas, new dairy enterprises are developing outside of the existing traditional milk production regions on more marginal soil types. However, even though the Irish temperate climate allows grass growth throughout the year, grass growth is highly seasonal and depends heavily on climate conditions and soil type. Management of pasture (such as fertiliser application, silage harvesting and grazing management) also influence grass growth. There is increased interest in the potential to increase grass growth and utilisation through more precise grassland management, including the utilisation of predictive models.

Description of the grass growth model

The MoSt Grass Growth model was developed at Moorepark for Irish grazing systems and meteorological conditions. The model predicts daily grass growth (kg DM/ha) depending on weather conditions and management. Farmer decisions which can impact on grass growth within the model are nitrogen (N) fertiliser application as well as the pre- and post-grazing sward height, or the pre- and post-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 the water in the soil, this will allow the prediction of total N leached during the year as well as the N emissions in the form of dinitrogen (N_2), nitrous oxide (N_2O) and ammonia (NH_3) due to different weather or farm management. Consequently, the model can also be used to predict the environmental impact of different farm management strategies.

Example of the use of the MoSt Grass Growth model

The MoSt Grass Growth model was used to compare the impact of the climate and soil type at two contrasting sites in Ireland: a free draining soil type - Moorepark and a heavy soil type – Athea, Co. Limerick. Heavy soils can retain three to five times more water than well drained soils. However, heavy soils have a low capacity to absorb rainfall due to poor soil structure and low porosity. In the scenarios examined, N fertiliser application was 240 kg/ha^{-1} and 2015 weather conditions (rainfall, temperature and solar radiation) for each site were used. A grazing event occurred as soon as sward height reached 9 cm. The post-grazing sward height was 3.5 cm for the first grazing event of the year and 4 cm thereafter. Residency time for each grazing event was two days. To further understand the impact of weather and soil type, the Moorepark weather was applied to both the Moorepark and Athea soil types, and the Athea weather data was also applied to both soil types.

Results of the simulations

Results are presented in Table 1 and Figure 1. Grass growth was on average, 2,873 kg DM/ha greater on the Moorepark soil type than the Athea soil type. Similarly, grass growth was, on average, 1,360 kg DM/ha greater with the Moorepark weather than with the Athea weather. Nitrogen leaching was greater on the Moorepark soil type than the Athea soil type (average increase of 47 kg N/ha), and the Athea weather induced a slightly greater leaching than the Moorepark weather (average increase of 12 kg N/ha).

Table 1. Impact of soil and weather on the number of grazing events, grass growth, and annual N leaching

Soil type	Weather source	No. of grazing events	Grass growth (kg DM/ha/day)	Nitrogen leaching (kg N/ha)
Moorepark	Moorepark	8	12,635	131
	Athea	7	11,207	143
Athea	Moorepark	6	9,694	84
	Athea	5	8,402	96

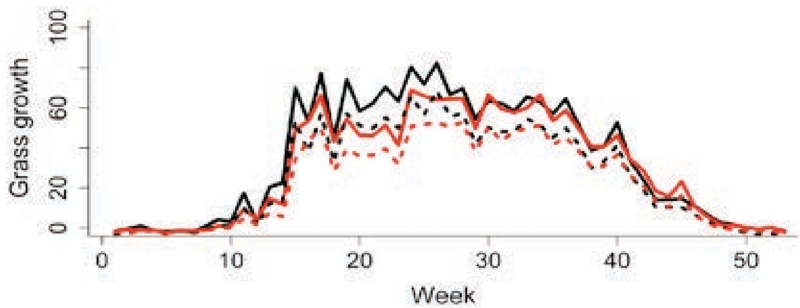

Figure 1. *Representation of grass growth using the Moorepark (black) and Athea (green) weather on either the Moorepark (plain line) or Athea (dotted line) soil*

Conclusions and future utilisation of the model

The heavy soil site was less favourable for grass growth and grazing due to its high clay level and low soil organic matter. However, even if less important, the weather in that area was also a limitation to grass growth. The model is currently being tested for its ability to predict grass growth on a weekly basis using weather forecasts at three sites.

Using a whole farm model to answer questions: What combination of stocking rate and concentrate level results in the best on farm benefit?

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Summary

- Modelling permits the simulation of the impact of a farmers' decision on the short and long term performance of a dairy farm.
- Models can be used to highlight the challenges faced by farmers such as milk price and weather variability.
- Models can also help to predict which combinations of management strategies leads to the best on-farm profit. In this example it is a stocking rate of 2.6 cows/ha and a concentrate supplementation of 600 kg/cow.

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 by facilitating, in general, lower costs of production. Now that milk quotas have been removed, dairy farmers question the optimum systems and need extensive advice and support to ensure they remain viable and profitable. Decision support tools (DST) can help farmers' in their management decisions and in the prediction of the long term impact of changes on-farm. Those DST need to be developed specifically for the Irish system in order to predict the actual impact of on-farm changes on grass growth and animal performance.

Description of the PastureBase Herd Dynamic Milk (PBHDM) Model

The PBHDM Model was developed for Irish grazing systems to predict the impact of different management strategies and decisions on-farm. Within this model, every animal and paddock are described individually to permit the model to recreate the on-farm heterogeneity that is evident on every farm in the country. The model can take into account the impact of pre- and post-grazing sward height, stocking rate, quality of grass, and quantity and quality of supplementary feed, as well daily dry matter (DM) intake of the cow at grass. The model simulates individual animal characteristics at grazing. The prediction of daily milk production of the animal is based on the daily energy intake and the partitioning of this energy between milk production and body condition score change. Grassland management based decision rules are also included in the model. The PBHDM Model was combined with the Moorepark Dairy System Model to explore the financially optimum strategy for Irish farms. Three stocking rates (2.3, 2.6 and 2.9 cows/ha) and five concentrate levels (0, 180, 360, 600 and 900 kg DM/cow) were examined. Simulations were run using 10 year weather conditions from Moorepark (2004 to 2013). The average outputs from the 10 years were examined to predict the best management strategy at three milk prices: 24.5, 29.5 and 34.5 c/l.

Results of the simulations

Results of the economic analyses are presented in Table 1. Milk price had the greatest impact on farm profit. At 24.5 c/l, within each stocking rate, 900 kg concentrate/cow resulted in a greater deficit in profitability than all other concentrate levels. At 2.6 and 2.9 cows/ha, the deficit in profitability was reduced by feeding 360 or 600 kg concentrate/cow, and at 2.3 cows/ha it was best to feed no concentrate. At an average milk price (29.5 c/l), a stocking rate of 2.3 cows/ha combined with 900 kg concentrate/cow had the lowest profitability and combined with 360 kg concentrate/cow had the greatest profitability. For the other two stocking rates, the 0 kg concentrate/cow had the lowest profitability and the 600 kg concentrate/cow was best. At all concentrate supplementation levels, 2.6 cows/ha achieved the greatest profitability. At a high milk price (34.5 c/l), 0 kg concentrate /cow had the lowest profitability, except for 2.3 cows/ha where the 900 kg concentrate/cow was least profitable. At all stocking rates, the 600 kg concentrate/cow was most profitable. From this analysis, the optimum management strategy is 2.6 cows/ha and 600 kg concentrate /cow.

Table 1. Impact of milk price, stocking rate (SR) and concentrate (C) supplementation on farm profit (average of 10 year simulation 2004 to 2013).

	Low milk price 24.5 c/l			Average milk price 29.5 c/l			High milk price 34.5 c/l		
C\SR	2.3	2.6	2.9	2.3	2.6	2.9	2.3	2.6	2.9
0	-10,805	-12,726	-18,493	9,888	10,503	7,156	30,581	33,732	32,804
180	-11,320	-12,308	-18,165	10,320	11,926	8,652	31,960	36,161	35,471
360	-12,184	-11,417	-16,739	10,388	13,898	11,296	32,961	39,213	39,332
600	-14,246	-11,202	-16,790	9,381	15,332	12,628	33,007	41,865	42,045
900	-20,987	-15,266	-20,648	3,661	12,491	10,141	28,309	40,248	40,929

Figure 1 shows the variation in grass growth, grass intake, silage fed and milk production per ha predicted by the model for the different years of the simulation for 2.6 cows/ha and 600 kg concentrate/cow. This highlights the impact of weather on farm profitability.

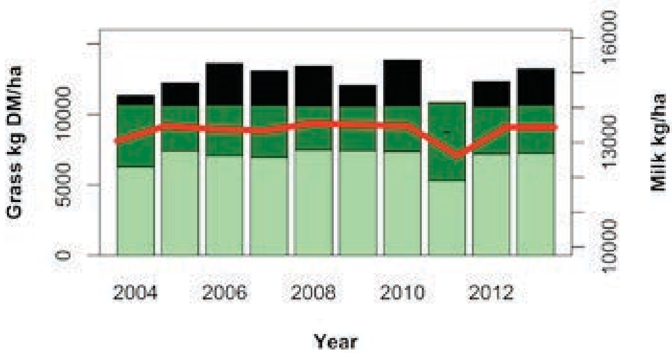

Figure 1. *Proportion of the total grass grown (kg DM/ha; black), grazed (kg DM/ha; white), and fed as silage (kg DM/ha; grey), and milk yield (kg/ha; blue line) depending on the year*

Conclusions

The PBHDM model can be used to answer very specific questions regarding farm management strategies. In our example, the model has been used to highlight the high variability of different systems that may be operated at farm level in terms of output and farm profit. It shows that with fluctuating milk prices and varying weather conditions, the optimum strategy is to have a medium stocking rate and concentrate feeding level.

ADVANCING GENETIC GAIN

Breeding your way to a healthy herd

Alan Twomey[1], Siobhán Ring[1], Ross Evans[2], David Graham[3], Rebecca Carroll[3], Astrid Blom[2] and Donagh Berry[1]

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Summary

- The advances in milk production and fertility achieved through breeding can also be realised for animal health – however, recording of animal level disease is essential to make progress.
- Research has demonstrated the ability of genetic evaluations for tuberculosis (TB) and liver fluke to predict the susceptibility of an animal succumbing to these diseases.
- Breeding for animal health will be a useful complementary strategy to current control and eradication strategies at both herd- and national-level.

Introduction

Did you ever wonder why not all animals in an infected herd succumb to a disease like TB? One likely reason is that genetic differences among animals have a large bearing on whether or not an animal becomes infected. In fact, we now know that there is as much variability in susceptibility to diseases as there is in milk production. Therefore, rapid genetic gain in animal health is achievable if the necessary data-recording infrastructure is developed and farmers are willing to populate the ICBF database with health data.

Bacterial diseases

Research at the Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, has clearly shown that diseases like TB and Johne's disease are under strong genetic control; between 9% and 12% of the inter-animal variability in susceptibility is due to genetic differences. To test the hypothesis that it is possible to breed for more resistant cows, a genetic evaluation was carried out for susceptibility to TB. The selection of cows included in the study was based solely on TB data from their ancestors. Using their estimated genetic merit for susceptibility to TB, cows in the worst 10% for genetic merit for TB, deemed to be 'high risk', were compared to cows in the best 10% for genetic merit for TB, deemed to be 'low risk'. When followed throughout their lifetime, 31% of the high risk animals became TB reactors while only five per cent of the low risk animals became TB reactors (Table 1). Using only data from ancestors, the genetic evaluation was able to identify animals with a higher likelihood of becoming infected with TB. Therefore, breeding animals with greater resistance to TB is possible and can be a useful complementary strategy to the national testing and eradication scheme. Similar research is now underway for Johne's disease.

Table 1. Incidence of TB in cows deemed high risk or low risk of succumbing to TB based on a genetic evaluation for TB using ancestry information only

Genetic evaluation prediction	Cow incidence	Herd incidence
High risk of TB	31%	13%
Low risk of TB	5%	8%

Viral diseases

Respiratory diseases are the biggest contributors to mortality in young animals. Recent research undertaken as part of the HealthyGenes study on 68 commercial dairy farms revealed large variability in the prevalence of positive blood tests for IBR among progeny of different sires. The progeny of some sires only had a five per cent prevalence of positive tests while the progeny of other sires had a 90% prevalence of positive tests, despite animals residing in common herds (Figure 1).

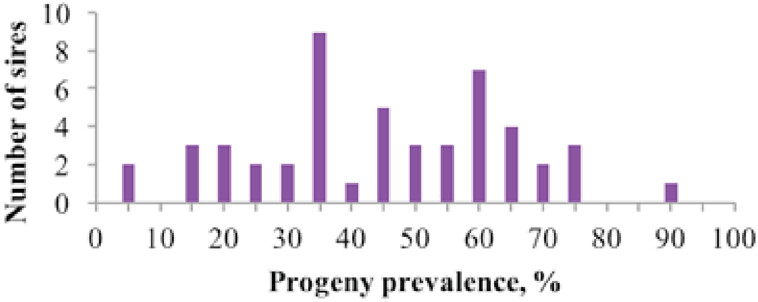

Figure 1. *Prevalence of positive blood tests for IBR in progeny of sires with ≥25 daughters in ≥5 herds*

Parasitic diseases

Parasitic diseases, such as liver fluke and stomach worms, are common in Irish cattle because of our reliance on grazed pasture. Both resistance to anthelmintics, and their restrictions in lactating cows, pose challenges for parasitic control. Genetic selection is an ideal tool to assist current parasitic control strategies. As part of the Beef HealthCheck programme implemented by Animal Health Ireland, the livers of all slaughtered animals are inspected for liver fluke. Using this information, significant genetic variation between dairy cows for infected livers was detected. Although liver fluke infection was only two per cent heritable, this heritability estimate is similar to calving interval in Ireland, a trait where significant progress has been achieved through genetic selection. A genetic evaluation for liver fluke was undertaken to test its usefulness in identifying animals that differ in their susceptibility to liver fluke. Cows with the poorest genetic evaluations had a higher incidence of liver fluke compared to their genetically superior contemporaries (Table 2). Neospora is also under genetic control, where eight per cent of the variation in cow susceptibility to Neospora is due to exploitable genetics.

Table 2. Incidence of liver fluke in cows differing in estimated genetic merit for susceptibility to liver fluke

Genetic evaluation prediction	Cow incidence (%)	Herd incidence (%)
High susceptibility of liver fluke	47	48
Low susceptibility of liver fluke	41	45

Requirement for data

As with all genetic evaluations, accurate data on a very large population of animals is required to generate reliable genetic evaluations. Farmer recorded health information on individual animals is essential to complement the data available from national health recording programmes.

Conclusions

Animal health traits have been proven to be under partial genetic control and will soon be the next addition to the ever-evolving EBI. This addition will ensure the EBI is selecting a more profitable cow for the future.

Improving udder health and lameness through breeding

Siobhán Ring[1], Alan Twomey[1], Noel Byrne[1], Thierry Pabiou[2], John McCarthy[2] and Donagh Berry[1]

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Summary

- Animal health is influenced by both management and genetics.
- The benefit of breeding is that it accumulates over time, with the parents of each generation benefiting from the gain of previous generations; therefore, breeding is a sustainable strategy to improve health.
- Genetic evaluations for health traits suffer from a lack of farm records, which contributes to low reliability of the genetic evaluations and slow genetic gain.

Introduction

Unhealthy cows have reduced milk production, compromised fertility performance, and are more likely to be culled; unhealthy cows also impose undue hardship on farmers. With restricted land bases and growing herd-size, Irish cows are required to walk long distances, thus enforcing the necessity for durable, healthy cows. The contribution of breeding for increased milk solids output and improved fertility are well established; the same improvements can be achieved for health traits.

Genetic trend

Between 1990 and 2005, year-on-year improvements in genetic susceptibility to lameness and udder health were observed in Holstein-Friesian cattle (Figure 1). Since 2005, however, there has been no improvement in genetic merit for mastitis and lameness; genetic improvement in somatic cell count (SCC), however, continues.

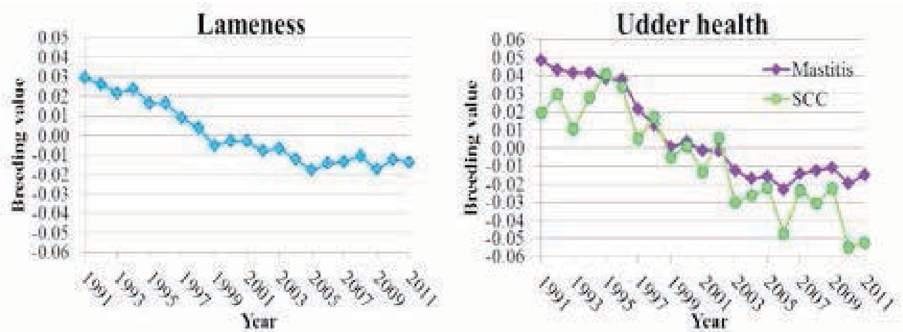

Figure 1. *Genetic trend for health traits by year of birth for Holstein-Friesian AI sires*

Obtaining reliable breeding values – the importance of data recording

How well an animal's estimated breeding value represents its true breeding value is dependent on both the heritability (i.e. how much of the observed disease on-farm is due to genetics) and availability of on-farm records. High heritability traits yield more reliable breeding values with fewer records compared with low heritability traits (Figure 2). Just like fertility, both mastitis and lameness are lowly heritable; this means that approximately three per cent of mastitis and lameness observed on-farm is due to genetic differences between animals. As experienced with fertility, however, it is possible to breed for low heritability traits. Therefore, to generate reliable breeding values for udder health and lameness, which is necessary to achieve genetic gain, a large quantity of farmer recorded data are required; once high reliability is achieved, genetic progress in low heritability traits (e.g. health and fertility) can be as rapid as that achieved in high heritability traits (e.g. milk). Therefore, genetic merit for SCC is improving but mastitis and lameness is not; this is partly due to less data recorded for lameness and mastitis while ample data exists for SCC.

Table 1. Prevalence (%) and heritability (h^2) of hoof lesions, linear scores and farmer-recorded lameness

Trait	%	h^2
Overgrown hoof	52	8%
Sole bruising	53	24%
White line disease	49	12%
Rear legs (side view)	-	10%
Foot angle	-	7%
Legs composite	-	12%
Locomotion score	-	10%
Farmer recorded lameness	10	3%

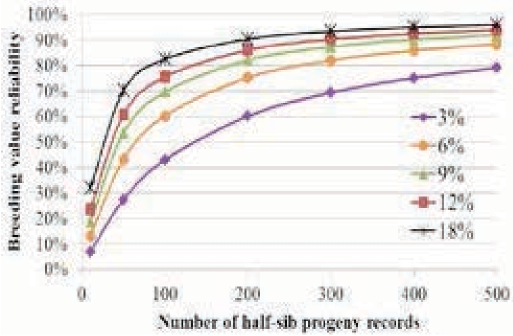

Figure 2. *Comparing the reliability of breeding values for different heritability estimates as the number of records increase*

HealthyGenes project

When genetic progress for a trait is limited by data availability, records from other traits that are genetically similar to the trait we want to breed for can be used. Teagasc Moorepark is investigating the genetic relationship between lameness and both hoof lesions and linear classification traits. During autumn 2015, hoof trimming was undertaken by professional trimmers on 7,533 dairy cows in 51 herds; the presence and intensity of hoof lesions were recorded for both back feet of all lactating cows. Linear classification traits were also available on 60,000 first lactation Holstein-Friesian cows. Early results indicate that the heritability for hoof lesions and linear classification traits are far greater than for farmer-scored lameness (Table 1). Thus, high reliabilities for these traits would be achieved faster than farmer recorded lameness with fewer records. That said, hoof lesion data are not routinely recorded and they are expensive to measure.

Health emphasis in the EBI – is it sufficient?

The economic weight on a trait in the EBI is the impact of a unit change in that trait on profit, holding all other traits constant. For example, increasing fat yield will also increase protein yield, but the economic weight on fat yield just relates to the value of an extra kg of fat, not protein. Health traits explicitly represent three per cent of the EBI. Animals with a poor breeding value for health traits receive a direct financial penalty for treatment costs and time incurred by the farmer; it does not include costs associated with reduced milk yield, compromised fertility or a greater risk of culling or death. This is because animals that have a poorer genetic merit for health will, on average, also be genetically inferior for production traits (i.e. milk production, fertility, carcass value) and survival and therefore, animals will be penalised for these traits in the EBI. As a result, the actual emphasis on health traits in the EBI is far greater than perceived.

Conclusions

Accurate genetic evaluations require data on a large population of animals; in the absence of farmers inputting such data into the ICBF database, the genetic evaluations for mastitis and lameness will remain relatively poor.

The EBI and its component traits translate into improved performance

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Summary

- Each unit increase in herd EBI translates to €1.96 more profit per lactation in Holstein-Friesian dairy cows, which is as expected.
- Progeny from sires of higher genetic merit for milk production and composition produce more milk of greater composition.
- Animals of higher maintenance sub-index (i.e. genetically lighter) are indeed lighter animals.

Introduction

Two strategies exist to validate breeding indexes and their component traits. One strategy is to compare animals divergent for genetic merit within the confines of a controlled experiment, like as undertaken in the *Next Generation Herd*. The second approach is to compare the performance of a large database of herds or animals differing in genetic merit. The *Next Generation Herd* and the High-Low Cow Fertility study have clearly documented the divergence in performance that can be achieved in animals divergent for EBI and fertility, respectively. Evaluated here, using herd data, is the concordance between herd EBI and performance; also evaluated, using cow data, is the concordance between genetic merit for milk production with actual cow milk performance, as well as between the maintenance subindex and cow live-weight.

EBI and profit

Access to e-Profit monitor data provides a globally unique opportunity to validate if herd EBI translates into more profit per cow. A €1 difference in herd EBI is expected to translate to an extra €2 profit per lactation. Using data from >1,300 e-Profit monitor herds between the years 2008 and 2011, a €1 difference in herd EBI was associated with a €1.94 extra net profit per lactation in spring calving Holstein-Friesian herds. The analysis was recently re-run using data from the years 2012 to 2016 in spring-calving herds where EBI data were available on >70% of cows; >90% of the genetics of each herd had to be Holstein-Friesian to remove any confounding of heterosis which is not captured in the EBI. Based on these most recent years, a €1 change in herd EBI was associated with €1.96 net profit per cow; account was taken of the year, herd mean stocking rate and the level of concentrates fed per cow as well as using a standard A+B-C milk pricing system across the whole country. This new and more recent-based analysis further supports the results from the *Next Generation Herd* that higher EBI equates to more profit.

Milk production

Although research studies from Moorepark have clearly shown that animals genetically divergent for calving interval subsequently have dramatically different fertility performance, no study has attempted to validate if genetic merit for milk production translates into difference in milk production. Data on >200,000 lactations from >3,000 Irish dairy herds were collated over the years 2012 to 2014 (i.e. pre-quota) and the lactation yields and composition of each cow was compared to the respective genetic merit of the sire. We expect a one unit difference in sire genetic merit to translate to a one unit difference in cow performance in an unrestricted environment. The results of the analysis are in Table 1.

Table 1. Mean increase (standard error) in performance per cow per one unit respective increase in sire genetic merit

	Milk (kg)	Fat (kg)	Protein (kg)	Fat (%)	Protein (%)
Average	0.59(0.01)	0.61(0.01)	0.48(0.01)	0.79(0.01)	0.73(0.01)
Parity 1	0.48(0.01)	0.45(0.01)	0.39(0.01)	0.73(0.01)	0.66(0.01)
Parity 2	0.67(0.01)	0.73(0.01)	0.56(0.01)	0.84(0.01)	0.80(0.01)
Parity 3	0.87(0.02)	0.98(0.02)	0.73(0.02)	0.89(0.01)	0.88(0.01)

Table 1 signifies that a one unit increase in sire genetic merit for milk yield translated to just a 0.59 kg increase in daughter milk yield across all parities; the associated increase was less in first parity animals. The change in daughter performance for milk composition per respective change in sire genetic merit for milk composition was greater. These results are not unexpected. Milk quota restricted the yields that could be achieved, and thus the benefit of genetic improvement in milk production was not being fully realised on the average Irish farm – hence, this implies that there was (and probably still is) ample genetic merit for milk production in Irish dairy cows. The lesser response in first parity cows relative to older cows is simply and artefact of their respective stage of maturity. Mature cows yield 22% more than first parity cows and thus genetic improvement is more fully realised in older cows signifying the importance of survival in realising genetic gain. This is substantiated by a lesser parity difference in milk composition.

Maintenance

The maintenance subindex within the EBI is calculated from the carcass weight of slaughtered cull cows multiplied by an economic value of -€1.65. A question that is often asked is how differences in maintenance subindex translate to differences in cow live-weight. To answer this, 22,705 live-weight records from cows sold singly in livestock marts in the year 2016 were used. Adjustments were made for the herd the cow originated from, as well as the parity of the cow, days since last calving, and the calendar month of the year. The mean live-weight of cows within €10 brackets of maintenance sub-index is in Figure 1.

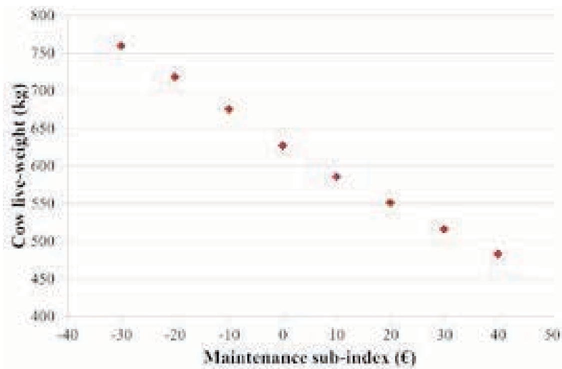

Figure 1. *Mean cow-liveweight across different maintenance subindex values*

Each €10 increase in cow maintenance sub-index was associated with 41.6 kg lighter cow live-weight; similarly each unit increase in cull cow weight genetic merit was associated with 3.4 kg increase in live-weight. Assuming a kill out of 45%, one would expect the latter value to be 2.2 kg.

Conclusions

Results provide further evidence substantiating previous research from both the national database and experimental studies that higher EBI equates to higher farm profit but also differences in genetic merit for milk production and maintenance values translate to differences on-farm.

Genomic evaluations – Maximising genetic gain

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Summary

- Genomic selection has resulted in a large increase in the rate of genetic gain for the Irish dairy industry.
- Like all technologies, improvements take place periodically and this can lead to changes in the EBIs of animals, as occurred in spring 2017.
- Genotyping females will facilitate parentage verification and aid in identifying the best herd replacements; moreover, genotyped females will improve the accuracy and stability of genomic evaluations for all animals.

Introduction

The performance of an animal is determined by its genes and how these are influenced by the management the animal is exposed to (i.e. its environment). Genes are composed of DNA, they remain the same throughout an animal's life, and are identical in every cell in the body. Therefore, knowing the genes of a calf at birth and how these genes affect performance, facilitates the prediction of how that animal, and its progeny, will perform. This process is called genomic selection and the process was implemented nationally in Ireland in February 2009.

Advancements in genomic evaluations

Traditional genetic evaluations based on pedigree have been constantly improved since their introduction in the 1950's. DNA-based evaluations, known as genomic evaluations, also periodically undergo such improvements as knowledge of the technology and statistical algorithms improve. Of course, the accumulation of additional performance records on daughters in traditional genetic evaluations has realigned bull proofs for decades; this will continue to happen with genomics although the extent of the realignment is typically less. One such realignment occurred in spring 2017, and led to the re-ranking of individual animals with a few individual bulls experiencing a large shift in their EBI. One of the reasons for this realignment was simply the inclusion of more genotyped bulls in the reference population; this is analogous to more daughter performance records being included into national genetic evaluations. One of the prerequisites for an accurate genomic selection system is the availability of DNA information on a large number of highly proven bulls; this allows the effect of DNA profile on performance (like milk yield or fertility) to be estimated. When genomic selection was launched in Ireland in February 2009, the number of animals in the training population was less than 1,000; since then, more proven sires have been added to the training population which now consists of 6,000 animals. In 2017, an additional several hundred bulls were added, representing a large increase in the training population from 2016 to 2017; this impacted the proofs of all genotyped animals. Continuing to increase the size of the training population is critical to ensure the most accurate genomic predictions are being published. The average reliability of the genomic proofs of young bulls on the active bull list increased from 60% for spring 2016 to 63% for spring 2017.

Selecting genomically selected bulls

Despite the increase in reliability of proofs with the introduction of genomic evaluations, it is nonetheless still important to acknowledge that the EBI value of an individual animal can change over time as more information accumulates, both on the animal itself, and also on the population as a whole. Figure 1 illustrates the interval within which the EBI of an individual can vary across different reliability values; for example, the true EBI of a bull with a published EBI value of €200, and associated reliability of 63%, could be anywhere between €163 to €247. To mitigate against uncertainty with lower reliability bulls, it is recommended to use a team of least five to six bulls with no more than 20% of inseminations from any single bull. Although individual bull EBI may move as data accumulates, the mean EBI of the bull team will remain very high. For example, using a team of five genomically selected bulls each with a reliability of 63% will result in the reliability of 93% for the bull team. When selecting bulls for use on heifers, only use bulls with a calving difficulty proof that originated from actual progeny data. This will ensure relatively high reliability and confidence that they will be easy calving sires; the direct calving difficulty value should be <1.8 for heifers.

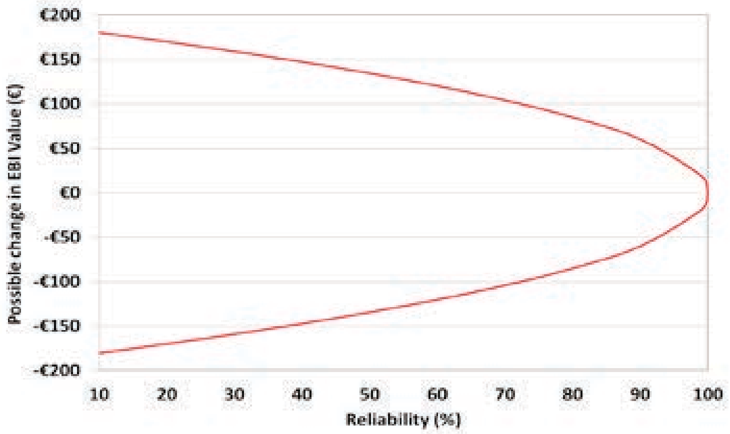

Figure 1. *Interval within which the true EBI of an individual may lie relative to its published EBI for varying levels of reliability*

Cost-benefit of genotyping

Genomic selection is not only useful for accelerating EBI gain in AI sires through screening of more individuals, but genomic selection can also be used to more accurately identify genetically elite replacement heifers. The current cost of genotyping all female calves in a herd is €22/head (incl. VAT). Although the value of genotyping is a function of the proportion of replacement heifers retained, this represents an excellent return on investment for Irish dairy farmers. There are also additional benefits of genotyping females: 1) parentage verification and assignment, which is crucial to avoiding inbreeding at mating time, 2) more accurate COW evaluations to identify females for culling, 3) detection of carriers of unfavourable mutations, 4) identification of animals with chromosomal abnormalities that make the female sterile, 5) identification of animals carrying DNA variants conferring different types of milk, 6) estimation of animal breed composition (under development), 7) estimation of the inbreeding level of the individual (under development), and 8) providing superior sire advice to better exploit genomic information (under development).

Conclusions

Genomic technology is the technology of choice in most developed international dairy cow populations. Although reliability figures are lower for genomically selected bulls compared to daughter proven bulls, genomic selection has resulted in a rapid acceleration in the rate of genetic gain in EBI.

Genomics – The hidden benefits

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Summary

- DNA information can provide additional benefits over and above more accurate evaluations.
- Parentage and breed verification can be carried out to maximise genetic gain, and also maximise hybrid vigour in crossbreeding programs.
- Karyotyping is the examination of the chromosomes for abnormalities, which can adversely affect animal growth, development and reproduction.

Introduction

DNA information has been incorporated into the Irish national genetic evaluations since spring 2009. This has contributed to an increase in the reliability of the genetic evaluations for young animals and an acceleration of genetic gain. As well as increasing the rate of genetic gain through more accurate genetic evaluations, there are a number of additional benefits that can be extracted from DNA information, all of which have the possibility to further increase profitability.

Parentage

Accurate parentage is essential for genetic gain and optimal mating programs to avoid inbreeding. The impact of parentage errors on genetic gain depends on the trait (heritability) and the number of progeny per sire. For fertility, assuming 100 recorded daughters per sire, a 10% pedigree error can reduce genetic gain by five per cent. Parentage errors in Ireland are estimated to be 8.5%. DNA information can identify parentage errors, and, if DNA information is already available in the ICBF database on the actual parent, then the true parent can be assigned.

Breed verification

The actual breed composition of the progeny from a mating of at least one crossbred parent cannot be determined based solely on pedigree information. Put another way, the mating of two first cross Jersey-Holstein parents can result in a calf anywhere on the spectrum from 100% Jersey to 100% Holstein. DNA information, however, can be used to accurately quantify the breed composition of an animal. Knowledge of breed composition might be of interest in crossbreeding strategies to maximise the benefit of heterosis (i.e. improvement in performance of a crossbred animal over that of its purebred parents) by availing of information on the actual breed composition of the cow. For example, if an F1 Holstein-Friesian X Jersey cow is back-crossed to a Holstein-Friesian bull, the expected proportion of Jersey in the offspring is 25%. However, when DNA information is used to determine the breed composition of such offspring in the ICBF database, the proportion Jersey in some animals was as low as five per cent. This variation in breed composition will affect the extent of heterosis expressed in these animals.

Traceability

Consumers are becoming increasingly conscious of purchasing traceable food produce. With beef from the dairy herd expanding, being able to unequivocally trace all products is growing in importance. DNA information is used in forensic sciences to identify perpetrators in the court of law. This technology can therefore also be used in cattle. Such a DNA-based traceability system could aid in securing higher value markets (for higher value products). DNA-traceability can also deter the theft of cattle as, unlike re-tagging of animals, the DNA of an animal cannot be altered.

Karyotyping

Abnormalities in the number of chromosomes an individual possesses or where two chromosomes actually unite, can compromise animal performance. Karyotyping, which involves looking specifically at the chromosomes, costs approximately €80; Teagasc, Moorepark were the first in the world to develop the algorithms to generate this information from the currently used genotyping tools. This therefore facilitates a karyotype analysis without the associated cost. Normal females, including humans, should have two X chromosomes. To test the algorithm, an Irish Holstein-Friesian was identified from its DNA profile as a female who potentially had only one X chromosome (i.e. Turner syndrome). When karyotype analysis was undertaken, the prediction was verified as being true (Figure 1). The heifer herself (Figure 2) had no observable external physical abnormalities; she had been inseminated several times and, at almost three years of age, was still not in calf. A post-mortem examination revealed that the heifer had only one ovary and underdeveloped uterine horns and oviducts, resulting in the animal being sterile. The normal external appearance of the heifer highlighted that karyotype abnormalities can largely go undetected on farm, and that DNA information can be applied to identify them thus saving on time and effort of trying to get her in calf.

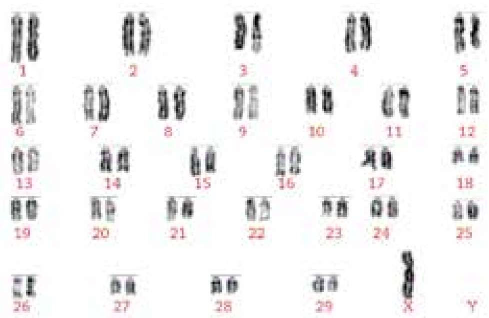

Figure 1. *Karyotype of the Holstein-Friesian heifer showing only one X chromosome*

Figure 2. *The Holstein-Friesian heifer appeared to have no physical abnormalities*

Conclusion

Considerable added benefit can be derived from developing DNA technologies. Much of this potential will be realised as more females are genotyped, especially in the role of precision DNA-based matings. DNA technology to-date focuses almost exclusively on tiny DNA changes, called SNPs (single nucleotide polymorphisms). Research is currently underway looking at other larger DNA changes (e.g., copy number variants, deletions or insertions of whole chunks of DNA) and how they affect performance.

Sire advice exploiting DNA information

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Summary

- Exploiting DNA information can help improve sire mating advice.
- The risk of progeny inbreeding can be more accurately determined by exploiting DNA information.
- Sire and dam DNA information can be used to avoid matings leading to progeny carrying two copies of lethal genetic mutations.

Introduction

The choice of which bull to mate to a given female must consider factors such as the EBI and component traits of each candidate parent, the degree of relationship between the candidate parents, and whether or not the candidate parents are carriers of known damaging mutations. The more accurately each measure can be derived, the more exact the advice will be.

Sire advice

The Irish Cattle Breeding Federation (ICBF) currently offers a sire advice decision support tool to help assign chosen sires to their mates. The matings are chosen using a process that maximises the average genetic merit of the resulting progeny taking into consideration the expected level of inbreeding in those progeny, while avoiding extreme progeny for either the milk or the fertility sub-indexes. All matings are assigned within the confines of the maximum number of possible inseminations allocated by the farmer to each bull. Such constraints imply that the best sires are not necessarily mated to the best females.

The sire advice algorithm is currently run based only on pedigree information, similar to most other countries. Exploitation of DNA information has the potential to improve every aspect of sire advice as well as add new opportunities to optimise the matings. The usefulness of DNA information to increase the reliability of genetic evaluations is well known. The same information can be used in a precision mating context to select parents that are complementary in different traits. However, other uses of DNA information are also possible to further improve sire advice.

Use of genomics in developing mating programs

Avoiding inbreeding

Inbreeding arises from the mating of two closely related individuals who inherit the same "chunk" of DNA from a common ancestor. Inbreeding, especially between closely related animals, can cause what is termed inbreeding depression. Inbreeding depression is the opposite of heterosis (i.e. hybrid vigour). Therefore, inbreeding depression tends to compromise performance, especially in traits associated with health, fertility and survival. The expected inbreeding in a progeny is half the relationship between both parents. Relationships among dairy cattle in most countries, including Ireland, are estimated based solely on pedigree information. It is impossible to know the true relationship among individuals based solely on pedigree. Furthermore, estimates of the relationships among individuals is a function of the depth of pedigree known – for example the assumed relationship between two individuals is zero if none of their ancestors are known. The true relationship between individuals can only be accurately determined when DNA information of both individuals are available.

Figure 1 illustrates the relationship between pedigree-based and DNA-based estimates of genetic relationships among 397 Holstein-Friesian animals with at least five recorded generations of pedigree. Although a strong relationship between the two measures exists, differences are still evident; this results in imprecise prediction of progeny inbreeding. Due to the impact of inbreeding on performance, sire advice currently penalises matings that would produce progeny with high levels of inbreeding. Updating sire advice to replace the currently used pedigree-based estimates with DNA-based estimates will therefore more accurately account for the potential risk of inbreeding in progeny while still maximising genetic improvement.

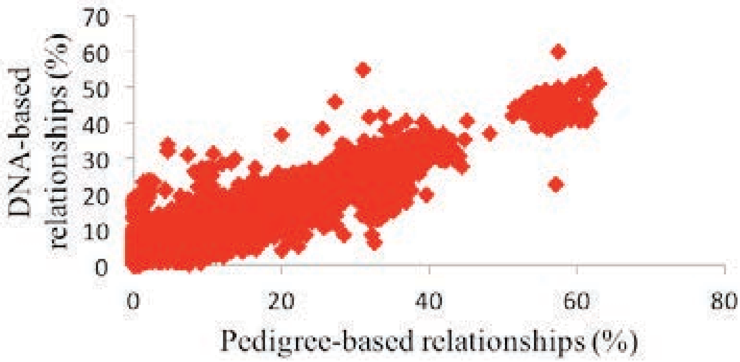

Figure 1. *Relationship between pedigree-based and DNA-based estimates of relationship between individuals*

Avoiding lethal genetic disease

Lethal genetic mutations are generally only expressed when an individual has inherited two copies of the bad variant; in most instances there is minimal or no observable effect in an individual carrying just one copy of the mutation. Examples of known lethal genetic mutations in Holsteins include Brachyspina, CVM, BLAD, and DUMPs; all AI sires in Ireland are screened for these mutations and no carriers enter AI. If two copies of the deleterious genetic mutation are inherited (i.e., one from each parent) then the resulting offspring will die, either in utero or shortly after birth. When two carriers are mated, there is a 25% chance of pregnancy failure or a stillbirth. Other potential defects are currently unknown, and can therefore contribute to pregnancy losses and cows returning to heat several weeks after being deemed to be pregnant (i.e. embryo loss).

A carrier animal was traditionally identified through analysis of the frequency of embryo loss/stillbirths in their progeny. However, routine genotyping currently undertaken in Ireland screens for carriers of known mutations; the number of tests on the panel will increase as new lethal mutations are discovered. When both the sire and dam are genotyped, avoiding carrier mating is therefore possible. The extent of genotyping in females is, however, currently low. Research is underway to predict the likelihood that a non-genotyped dam is a carrier and results to date are promising. This information can then be included in the sire advice program which can be further improved as new discoveries of defects are made.

Conclusions

DNA has the potential to improve the precision of sire mating advice. Accurate sire mating advice is crucial to maximise the performance and homogeneity of offspring, taking into account the expected inbreeding of the progeny and the potential for pregnancy failure due to lethal mutations.

Futuristic traits for inclusion in the EBI

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Summary

- The economic breeding index (EBI) is a tool to aid in identifying the most profitable animals; therefore all traits impacting profit should be considered within the EBI. Two poorly represented economically important traits in the EBI are feed efficiency and animal health.
- Although the EBI already considers gross efficiency and life-time efficiency, there is a small quantity of exploitable variability among cows in net feed efficiency not currently considered. Capturing this variability requires measurement of individual cow feed intake or a proxy trait.
- Genetic evaluations for animal health can be improved through better recording; thermal imaging has the potential to aid in this.

Introduction

The economic breeding index (EBI) is a selection index tool that aims to identify the most profitable dairy animals based on their genetic merit. All traits affecting profit should therefore be incorporated within the EBI. Analyses of both national data and experimental studies over the past 10 years have clearly shown a benefit from selection on EBI. Like all national breeding indexes, however, the EBI should be constantly examined and improved. Once a trait 1) is important, 2) exhibits genetic variation and 3) is measureable itself or through predictor traits, it should be considered within the EBI. Two traits that are either not represented or are poorly represented in the EBI include net feed efficiency and health and disease.

Feed efficiency

Gross efficiency of converting feed to milk has more than doubled over the past century, largely as the indirect consequence of increased milk output per cow. Reducing feed intake, without repercussions for the other performance traits, is important to maintain dairy sector competitiveness. Improving feed efficiency is also desirable because of its potential benefits towards reducing both nutrient and greenhouse gas emissions. 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. Research at Moorepark with Holstein-Friesian cows has clearly demonstrated that considerable differences in feed intake exist among cows, even at the same milk solids yield and live-weight.

A genetic evaluation for feed efficiency was undertaken on Holstein-Friesian cows from the Moorepark feed intake database, with the purpose of characterising animals divergent in genetic merit for feed efficiency. Animals were broken down into two groups (i.e. high or low feed efficiency) based solely on their genetic evaluation for feed efficiency. The performance of the highest (i.e. most efficient) and lowest (i.e. least efficient) ranked cows is illustrated in Table 1. The mean live-weight (511 kg v 514 kg) and body condition score (2.95 v 2.93 units) of the two groups was almost identical, but the cows genetically predisposed to have lower intake consumed less (16.79 UFL/day) than their less efficient counterparts (17.38 UFL/day). Both groups produced similar milk energy yield (9.48 v 9.46 UFL/d). The difference in feed intake between the cows ranked highest (i.e. more efficient) and lowest (i.e. less efficient) in genetic merit for feed efficiency was 0.59 UFL/d; this is the equivalent to ~½ kg concentrates/high nutritive grass daily, or in other words ~150 kg/lactation. Therefore, assuming a cow remains in the herd for, on average, 5.5 lactations, this translates to an estimated saving of €92.38. A greater number of feed intake records and screening a larger population could further increase these differences. A cost-benefit analysis is underway on the benefit of recording feed intake.

Table 1. Performance of the highest (i.e., more efficient) and lowest (i.e., less efficient) ranked animals divergent in genetic merit for feed efficiency

Trait	Low	High
Breeding value (UFL/d)	0.16	-0.10
Net energy intake (UFL/d)	17.38	16.79
Net energy of lactation (UFL/d)	9.48	9.46
Body-weight (kg)	511	514
Body condition score (scale 1 to 5)	2.95	2.93

Animal health

Lameness can have a large impact on farm profitability, and while this trait is included in the EBI, a larger dataset would increase the accuracy of selection for this trait. Routine recording of lameness is inconvenient, so investigation into new sensor technologies to detect infection is underway. Thermal imaging is a quick and non-invasive camera-based technology that can be used to measure the heat radiating from an object. Thermal imaging has been shown to detect many forms of infection. Figure 1 illustrates a thermal image, with cold temperatures depicted by black/blue and hot temperatures depicted by white/yellow. Figure 1 shows the difference between a healthy and an infected hoof; the infected hoof (left) is hotter (large white region visible) whereas the non-infected hoof (right) is colder (blue to yellow colours visible).

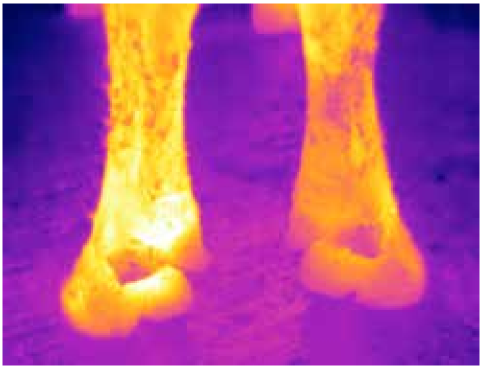

Figure 1. *Thermal image of an infected hoof (left) and a healthy hoof (right) (white=hot black=cold)*

Conclusion

The EBI identifies profitable dairy females to be selected as future replacements in the herd. It must therefore evolve both in terms of the traits included in the EBI and the relative emphasis placed on each trait.

Cow's Own Worth (COW) identifies culling candidates for a more profitable dairy herd

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Summary

- The Cow's Own Worth (COW) predicts the profit potential of a dairy female's remaining lifetime and is designed to aid farmers in identifying animals for culling.
- A pilot study of the COW was undertaken with 83 herds; each female in the herd received a COW value. Results from the survey indicated that 95% of participants were in favour of the roll-out of the COW nationally.
- Recording of additional data (such as inseminations, pregnancy diagnosis, health events, and genotyping) improves the accuracy of the COW.

Introduction

The ability to identify cows with the greatest predicted future profit potential will have a substantial impact on herd profitability and efficiency. Farmers make significant investments in data recording (e.g. milk recording, pregnancy diagnosis and genotyping) but collating all these data sources into one value per animal is key to aid decision making. The Cow's Own Worth (COW), developed by Teagasc in conjunction with ICBF, combines multiple sources of information to identify the expected profit potential for the remainder of every dairy female's life. The COW ranks females using genetic merit (estimated breeding values and hybrid vigour), cow-centric performance measures (e.g. milk recording yields) and current states (i.e. lactation number, calving date, and predicted calving date from available inseminations or pregnancy diagnosis). Farmers can quickly identify under-performing females to cull thereby retaining only the most profitable females. Other benefits of this management tool is that the COW reduces the time, effort and resources farmers spend on culling and retention decisions while getting more value from their data recording strategies.

Fundamentals of COW

The COW can be generated for milk recorded spring-calving herds. The profit potential per female considers: 1) profit within the current lactation, 2) expected profit from future lactations, and 3) net profit from culling (including the replacement cost).

Current lactation

Includes the expected profit of a cow until the end of the current lactation based on the cow's expected 305-day milk production (under the prevailing A+B-C milk pricing system) and live-weight as a proxy for feed intake. Expected profit is also dictated by the most recent calving month, where cows are penalised for later calving dates. Expected milk production is based on both additive and non-additive (e.g. heterosis) genetic merit, as well as cow-centric effects (e.g. cow's own milk yields from milk recording).

Future lactations

Considers the expected profit generated by a cow during future lactations if retained within the herd. This component includes the same animal attributes as the current lactation component, as well as udder health, calving and progeny beef performance. Also included is an expectation of future number of lactations, and the calendar month for next calving event.

Net profit from culling

Deducts the cost of a replacement heifer from the expected cull cow value based on genetic merit for carcass weight of the cow. This component of COW also accounts for the fact that fewer replacements are required in the long-term when an older cow is culled.

Teagasc research results

Based on an analysis of the national database, dairy females that ranked higher on the COW yielded more milk and milk solids and calved earlier in the calving season than their lower ranking contemporaries. The average difference in revenue between the top and bottom 25% of cows ranked on COW was €360 per lactation.

Theory into practice: ICBF's on-farm pilot study 2016

A pilot study was carried out on 83 herds to trial the performance of the COW. Each herd-owner received an email that contained key pieces of information: 1) a COW information leaflet, 2) a COW report, and 3) on-farm performance results (milk records, fertility records, etc.). A survey was conducted to gauge farmer impressions on the usefulness of the COW as an aid in decision making. Results were overwhelmingly positive, with 95% of farmers recommending a national rollout of the COW (Figure 1).

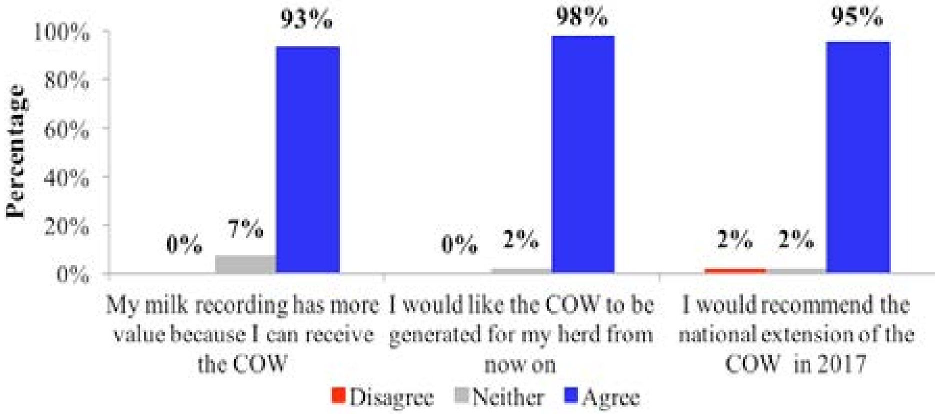

Figure 1. *Survey responses to Cow's Own Worth pilot study conducted in 2016*

How to make the most out of your COW?

Milk recording

Milk recording is an essential component of the COW. Milk recording provides the COW with the necessary information to adjust an animal up or down (i.e. permanent environment effects) relative to her pedigree (i.e. some daughters are better and some are worse than their parental average).

Fertility recording

The current calving date or predicted calving date accounts for 18% of the inter-animal variability in COW. Data from calving dates, inseminations, and pregnancy diagnosis are used to rank cows accordingly. Cows calving early will be rewarded, while late calving cows will be penalised.

Health recording

The COW receives somatic cell count information from the milk recording reports, but currently other health trait events are not readily available. Recording mastitis, lameness or other treatment events will markedly improve the accuracy and relevance of the COW for that farm.

Genotyping

Genotyped females will have a more accurate COW due to better predictions of the true genetic merit of the animal. It also provides certainty of parentage and correction of potential pedigree errors.

Conclusions

The COW is currently under development in ICBF as a profile page for HerdPlus members. A pilot scheme for the profile has been scheduled to take place in July 2017. The availability of COW will be known pending results of this pilot.

Teagasc's Next Generation dairy herd – proofing the EBI

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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.
- Results are extremely promising. Performance differences are in line with expectation based on EBI. Thus, 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. An analysis of commercial farm data indicated that each €1 increase in herd EBI results in a €2 increase in profit/cow per lactation. The incorporation of Genomic Selection into the national breeding programme since 2009 has accelerated the theoretical rate of increase in EBI. The *Next Generation Herd* was established as a strategic resource to validate that genetic selection using the EBI will deliver greater productivity and profitability under intensive grass based systems. It will also enhance the future development of the EBI, and provide a potential nucleus herd to supply genomically selected 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 herd is situated at the Dairygold Research Farm in Kilworth. There are two distinct EBI groups; 90 ELITE (extremely high EBI; €154 (ICBF, May 2017)) and 45 national average EBI (NA; €51 EBI) females (Table 1). The herd is exclusively Holstein-Friesian and genetic diversity (sire lines) has been maximised. For example, of the 90 ELITE heifers assembled for the trial in 2012, 40 sires, 83 grandsires and 27 maternal-grandsires were represented. The ELITE females are firmly inside the top one per cent in the country based on EBI. The first animals (all parity 1) calved in the spring of 2013. In 2016, the herd represented a mature herd profile, comprising parities one to four.

Table 1. Summary statistics for the Next Generation Herd

	EBI	Sub-Indices (€)						
		Milk	Fertility	Calving	Beef	Maintenance	Health	Management
ELITE	154	37	80	33	-12	13	1	2
NA	51	17	13	26	-8	2	1	0

	Milk kg	Fat kg	Protein kg	Calving interval	Survival
ELITE	-18	+7.2	+4.2	-4.2	+2.3
NA	+46	+4.1	+2.5	-0.9	+0.2

During the first four years the EBI groups were evaluated across three contrasting seasonal pasture-based feeding treatments: 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.

Results

The NA cows consistently out yielded the ELITE cows in terms of milk volume. The ELITE cows, however, had a higher milk solids yield due to higher milk fat and protein content (Table 2). Somatic cell count (116,000 cells/ml and 130,000 cells/ml), incidence of mastitis (9% and 14% annually, or 20% and 27% on an individual cow basis), and incidence of lameness (9% and 11% annually, or 19% and 21% on an individual cow basis) did not differ significantly between the ELITE and NA genotypes, respectively. Over the full lactation, the ELITE cows were slightly lighter but had significantly greater body condition score. Feed intake did not differ. Large differences in fertility performance were observed.

Preliminary economic analysis (at a milk price of 29 c/l) based on the biological data generated in the *Next Generation Study* was extrapolated to simulate a 40 ha unit. The profit differences are in line with expectation based on EBI (over €200 per cow and over €600/ha in favour of the ELITE cows). It is also apparent that the ELITE cows are more profitable regardless of feeding treatment.

Table 2. EBI group effect on lactation performance

	ELITE	NA
Milk yield (kg/cow)	5,413	5,612
Fat (%)	4.47	4.19
Fat (kg)	241	235
Protein (%)	3.72	3.55
Protein (kg)	202	199
Average body condition score (1-5)	2.92	2.74
Average weight (kg)	500	506
6 week in-calf rate (%)	73	58
12 week in-calf rate (%)	92	81
Net Profit per cow (€)	844	622
Net Profit per ha (€)	2,322	1,709

The ELITE cows had greater longevity, with 60% and 40% of the ELITE and NA cows surviving to the end of 4th lactation, respectively

NEXTGEN AI sires

A secondary objective of the *Next Generation Herd* is to make available the very highest EBI bull calves born in the herd to the Irish AI industry, and by virtue of this to Irish Dairy farmers. Three bulls recruited by Irish AI companies that are leading GS sires on the ICBF Active Bull List include 'NEXTGEN YKG Candy' (AI code FR2385), 'NEXTGEN PHC Emer' (AI code FR2460) and 'NEXTGEN BRIGADE' (AI code FR2007).

Conclusion

The results provide confidence that the EBI is working to identify more profitable dairy genetics. Irish dairy farmers must continue to genetically improve their herds, thus improving milk solids production, fertility and longevity.

Next Generation Jersey

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Summary

- Crossbreeding with Jersey has the potential to markedly increase milk solids output and herd productivity on Irish dairy farms.
- A Nucleus Jersey herd of elite Jersey genetics has been established at Moorepark to evaluate/validate 'high EBI' Jersey genetics on an on-going basis. It is also anticipated that this herd will also generate a supply of high EBI Jersey sires for the Irish dairy industry.

Introduction

A considerable body of research has been conducted at Teagasc Moorepark and internationally evaluating the performance benefits from crossbreeding in the dairy herd. The results consistently demonstrate that high EBI crossbred dairy cattle outperform high EBI purebred contemporaries, both within research studies and on commercial dairy farms. The economic advantage is €100-€150/cow per lactation in addition to that explained by EBI. This is a consequence of more favourable fertility/longevity as well as greater herd productivity compared to the mean performance of the parental pure breeds.

The Jersey breed offers particular advantages for crossbreeding in Ireland due to many innate favourable characteristics: small size, moderate yield coupled with high milk fat and protein content, high intake capacity, superior feed efficiency and compatibility with a pasture based system. These characteristics complement the higher yielding Holstein-Friesian breed. The genetic distance between the Holstein-Friesian and Jersey implies a greater expression of hybrid vigour, compared to crosses of more closely related breeds.

Crossbreeding research at Moorepark

During 2006 to 2010, a study including Jersey, Holstein-Friesian and Jersey Holstein-Friesian crossbred cows identified clear benefits from crossbreeding: the proportion of cows pregnant to first service (+ 21%), in-calf after six weeks breeding (+19%) and in-calf after 13 weeks breeding (+8%) were considerably higher for the Jersey × Holstein-Friesian compared with Holstein-Friesian (and pure Jersey cows). The economic analyses [incorporating differences in cull cow and male calf value] showed that a herd of Jersey × Holstein-Friesian cows was 48% more profitable than a herd of either of the parent breeds. On a per cow basis, the improved profit equated to over €180 per cow per lactation.

More recently (2013 to 2016), crossbred cows have been incorporated into a comparative stocking rate study at Teagasc's Curtins Research Farm. The EBI value of both the Holstein-Friesian and crossbred cows was similar at ~€130 (ICBF, May 2017). The Jersey crossbred cows delivered an additional 70 kg/ha annually. Economic analysis has not been completed, but a clear advantage in favour of the Jersey crossbred cows is evident.

At Clonakilty Agricultural College, the research being conducted is primarily concerned with evaluating the benefits of incorporating clover in the grazing sward but does include a comparison between Jersey × Holstein-Friesian and straight Holstein-Friesians. The EBI of both groups of cows is similar (€120 and €105). The Jersey crossbred cows are delivering more milk solids per cow per lactation (466 kg vs 455 kg). They are 10% lighter (-51 kg), had 15 percentage units higher pregnancy rate to first service, and 5 percentage units higher 6-week in-calf rate. An economic analysis has indicated a €100/ha advantage to the Jersey crossbred cows.

Our most recent research, an analysis of 40 commercial dairy herds with data from 2010 to 2012, represents the first evaluation of crossbred and straight bred cattle within commercial high EBI dairy herds. The results are in line with the research findings from Teagasc research herds: high EBI Jersey × Holstein-Friesian cows produced 25 kg more milk solids per cow per year than the mean of high EBI purebred Holstein-Friesian and Jersey purebred equivalents. The crossbred cattle also achieved a 7.5 day shorter calving interval within these herds.

A similar piece of research conducted during development of the 'Culling' or 'COW' index found that crossbred cows had a nine day shorter calving interval, a six per cent greater pregnancy rate in the first six weeks of the breeding season, and a three per cent greater survival rate to the next lactation. Lifetime financial heterosis was estimated to be just under €550 per cow.

Jersey intake capacity

Jersey cows consume approximately four per cent of their bodyweight in grass DM daily compared to 3.4% for the Holstein-Friesian and 3.65% for the Jersey crossbred cows. The implication of this is that Jersey and Jersey crossbred cows produce higher yields of milk solids relative to their body weight. This facilitates the higher productivity per ha achieved with the Jersey and Jersey crossbred cows in the studies outlined above. Detailed anatomical investigations conducted on animals post-slaughter revealed the physiological mechanisms underpinning the differences in intake capacity observed, which tended to be more physical than metabolic in nature.

Next Generation jersey herd

In Ireland, the Holstein-Friesian breeding programme continues to increase the rate of genetic gain (increasing EBI) due to our national breeding programme and the application of genomic technology. The rate of gain in Jersey genetics is lower, raising questions about the relevance of crossbreeding in Ireland. A Nucleus Jersey herd of elite Jersey cows has been established at Moorepark. This initiative has been driven by:

- The opportunity to exploit the Jersey breed, and its proven synergy with our intensive seasonal pasture based production and dairy product portfolio.
- The extra performance and profit to be gained from capitalising on hybrid vigour in addition to genetic improvement via EBI.
- The current absence of an Irish Jersey breeding programme, and consequent reliance on imported Jersey genetics.
- The long term requirement to continually evaluate 'high EBI' Jersey genetics in Ireland.
- The requirement to generate high EBI Jersey sires to complement our successful 'black and white' selection programme.

The herd has been established with genetics sourced from different breeding programmes around the world (primarily NZ and Denmark). The herd is currently comprised of 100 lactating cows, and there are plans to expand the resource.

Ultimately, the success of this initiative will depend on the level of demand for Jersey genetics at commercial farm level. Irish dairy farmers must be willing to embrace the programme by progeny testing the best young test sires that will emerge. This is a vital step to further advance genetic progress within crossbred dairy herds.

Body condition score, resumption of cyclicity and uterine health status in dairy cows

Eber Rojas Canadas, Mary Herlihy, Jonathon Kenneally and Stephen Butler

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Summary

- Body condition score (BCS) can be quickly measured to assess the nutritional status of individual cows at strategic time points during the year.
- It is well established that BCS, uterine health status and the postpartum anoestrous interval have important effects on cow fertility performance.
- A large field survey of postpartum fertility phenotypes revealed important relationships between these measures.
- It is important to manage BCS to avoid under- and over-conditioned cows at calving, as thin and fat cows have greater incidence of reproductive problems.

Introduction

During early lactation, the energetic cost of milk production can exceed energy consumed, resulting in a prolonged period of negative energy balance (NEB) and consequent mobilization of body tissue reserves. This information can be captured by monitoring body condition score (BCS) change over time. The objective of the current project was to examine associations between BCS and postpartum resumption of cyclicity and uterine health status.

Fertile dairy study

First and second lactation dairy cows (n=2858) from 35 dairy farms located in Munster were enrolled in the study. All cows were spring-calving (February to April) in either 2015 (n = 23 herds) or 2016 (n = 12 herds). All farms were visited every two weeks, and at each visit animals that were at Week 3 (range 14 to 27 days in milk) and Week 7 (range 42 to 55 days in milk) post-calving were examined. Transrectal ultrasound examinations were conducted at each visit to determine both ovarian cyclicity and uterine health status. Cows were categorized as cycling or not depending on the presence or absence of corpus luteum on either ovary. Uterine health status was recorded on a one to four scale based on the visualization of material within the lumen of the uterus, with scores of one, two/three and four indicating no infection, mild infection or severe infection, respectively. Cows were classified as thin if BCS was ≤2.50, on target if BCS was between 2.75 and 3.25 and fat if BCS was ≥3.50 at both the Week 3 and Week 7 visits.

At both the Week 3 and Week 7 visits, BCS affected the likelihood of having resumed cyclicity. Cows that were thin or fat were less likely to have resumed cyclicity compared with cows that had the target BCS at both Week 3 and Week 7 (Figure 1). In addition, the likelihood of cows having resumed oestrous cyclicity was greater if they were diagnosed as not having uterine infection compared with cows diagnosed with either mild or severe uterine infection at both Week 3 and Week 7 postpartum (Figure 2, top panel). Of the cows that were diagnosed as having severe uterine infection at Week 3 and Week 7, the greatest incidence was recorded for cows with BCS ≥3.50 (Figure 2, bottom panel).

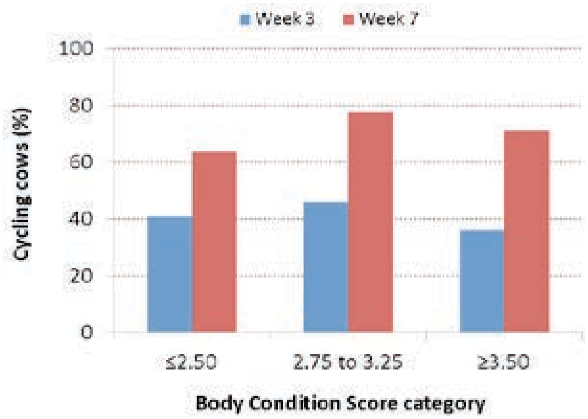

Figure 1. *The proportion of cows that had resumed oestrous cyclicity at Week 3 and Week 7 post-calving was greater in cows that were at the target BCS of 2.75 to 3.25*

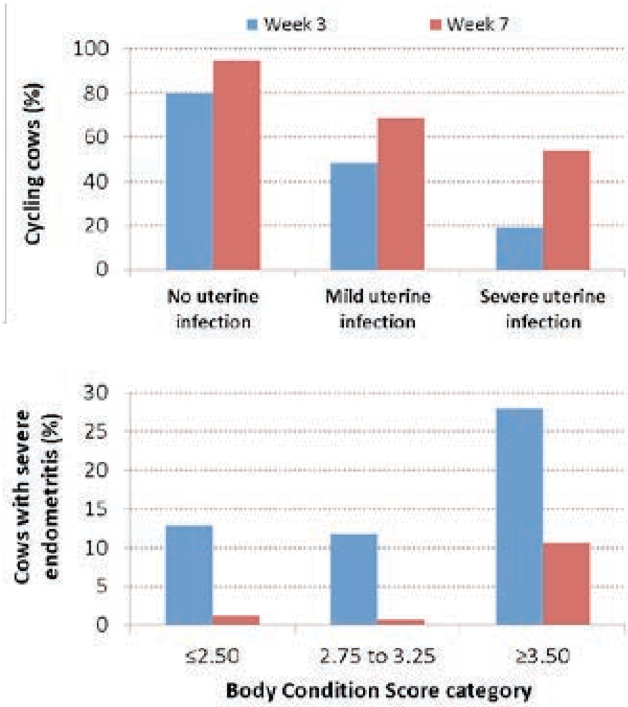

Figure 2. Top panel: *Cows with no uterine infection had the highest likelihood of having resumed oestrous cyclicity at Week 3 and Week 7 compared with cows with either mild or severe uterine infection.* **Bottom panel:** *Cows with BCS ≥3.50 were more likely to be diagnosed with severe uterine infection compared with cows in the ≤2.50 or the 2.75 to 3.25 categories.*

Conclusions

Cows that had BCS either above or below the target range were associated with later resumption of cyclicity and poorer uterine health status during early lactation. Absence of uterine infection was associated with earlier resumption of cyclicity. The results highlight the associations between different phenotypes during the postpartum period. As BCS is largely under management control, it is important to avoid having thin or fat cows at calving to promote prompt resumption of cyclicity and minimise the incidence uterine infection.

Sexed semen: Grow your dairy herd and increase beef output at the same time

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

Summary

- Sexed semen is a potential revolutionary technology for dairy cattle breeding.
- A simulation model was developed to determine the effects of sexed semen use in heifers and lactating cows on replacement heifer numbers and rate of herd expansion in a seasonal dairy production system.
- Use of semen from an easy-calving short gestation beef breed on cows that return to heat was considered as an additional scenario.
- Herd size growth was accelerated by use of sexed semen. Using beef semen instead of conventional dairy semen on cows that returned to heat slowed growth in herd size, but had favourable effects on profitability and cash flow due to the more valuable calf crop.

Introduction

Sexed semen may be a useful technology to rapidly increase dairy heifer calf inventory, while also facilitating increased output of crossbred beef calves. Artificial insemination (AI) is widely used in the dairy industry to generate replacement heifers. With conventional semen, roughly 50% the calves born are male, but >99% of male dairy calves are a low value by-product of using dairy semen for AI. A large Irish field trial in 2013 indicated that sexed semen resulted in conception rates that were approximately 87% of the conception rates achieved with conventional semen. A study in New Zealand reported that fresh sexed semen could achieve conception rates that were approximately 94% of the conception rates achieved with sexed semen. In the near future, it is likely that sexed semen will be capable of achieving conception rates that are similar to conventional semen.

Simulation study

A simulation model was developed to determine the effects of sexed semen use in heifers and lactating cows on replacement heifer numbers and rate of herd expansion in a seasonal dairy production system. Four AI protocols were established according to the type of semen used:

- conventional frozen-thawed semen (CONV),
- sexed semen in heifers and conventional semen used in cows (SS-HEIFER),
- sexed semen in heifers and a targeted group of cows (body condition score ≥ 3 and calved ≥ 63 days), with conventional semen used in the remainder of cows (SS-CONV),
- sexed semen in heifers and a targeted group of cows, with conventional semen in the remainder of cows for the first AI and conventional beef semen used for the second AI (SS-BEEF).

A schematic outline of the sexed semen protocols is illustrated in Figure 1. Each AI protocol was assessed under three scenarios of sexed semen conception rate (SS-CR): 100, 94 and 87% relative to conventional semen. AI was used on heifers for the first 3-wk and on cows for the first 6-wk of the 12-wk breeding season. Initial herd size was 100 cows and all available replacement heifers were retained to facilitate herd expansion, up to a maximum herd size of 300 cows. Once maximum herd size was reached all excess heifer calves were sold at one month old. All capital expenditure associated with expansion was financed with a 15-yr loan. Each AI protocol was evaluated in terms of annual farm profit, annual cash flow, and total discounted net profit.

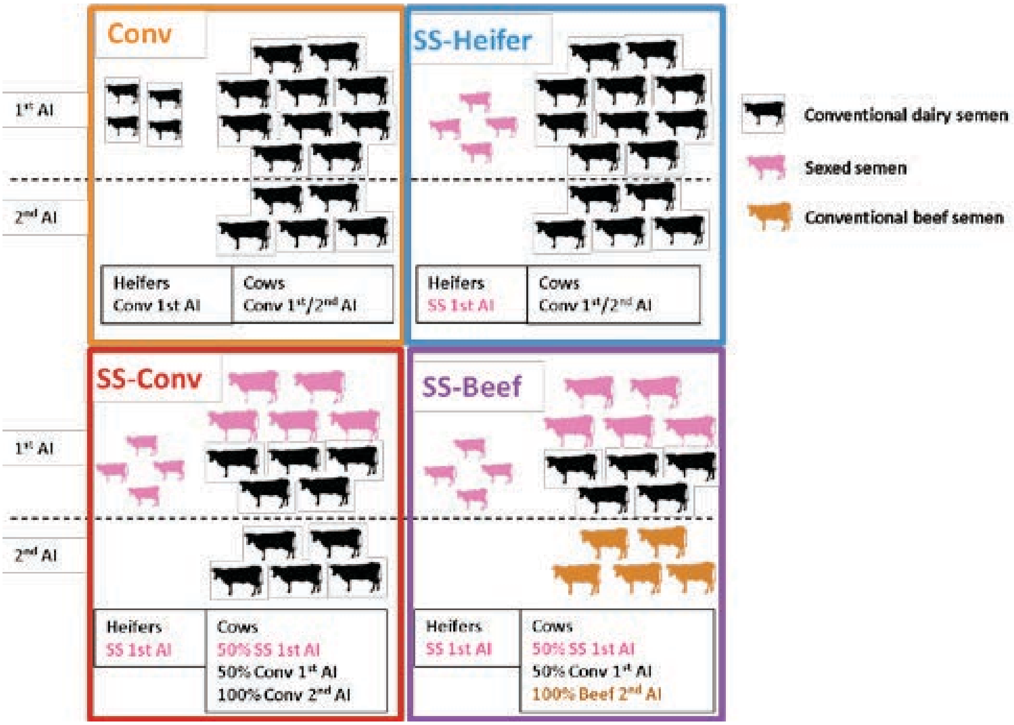

Figure 1. *Schematic outline of the different sexed semen usage scenarios investigated at varying levels of sexed semen conception rate relative to conventional semen*

Results

SS-CONV generated more replacement heifers than all other AI protocols, facilitating faster expansion, and reached maximum herd size in year 9, 9 and 10 for 100, 94 and 87% SS-CR, respectively. All AI protocols except SS-BEEF at 87% SS-CR reached maximum herd size within the 15-year period. Negative profit margins were experienced for SS-CONV in the first five years, four years and third year of expansion for 100, 94 and 87% SS-CR, respectively. On the other hand, use of SS-BEEF did not result in negative profit margins in any year at any of the SS-CR levels analysed. Total discounted net profit was greater in all sexed semen AI protocols compared with CONV.

Conclusions

The current study examined a variety of strategies for sexed semen use when expanding from 100 to 300 lactating cows. Using sexed semen generally facilitated faster herd expansion and increased discounted net profit compared to CONV. The quickest expansion strategy, SS-CONV, resulted in negative cash flows with high fertility sexed semen (100 and 94% SS-CR) during the period of most rapid expansion and at all SS-CR when milk price was low, placing the viability of the farm business at risk. Combining sexed semen use with conventional beef semen provides alternative strategies for expanding farmers, which have the potential to generate additional income. Further work is required to validate the findings from this simulation model.

Beef crossing of the dairy herd

Ruth Fennell[1] and Stephen Connolly[1,2]

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Summary

- When the requirement for replacements has been filled through the use of dairy sires, beef bulls are crossed with the dairy herd to increase calf value.
- Choosing a beef bull based on its terminal traits is important for optimising farm profit for both dairy and beef farmers.
- A sire evaluation trial, in conjunction with ABP, is on-going to identify the most suitable beef genetics to cross with dairy herds.

Introduction

The dairy beef sector in Ireland is an important and growing industry. Due to the growth in the national dairy cow population in the post-quota era, there has been a proportional increase in the number of dairy calves available for beef production. The contribution of the calf enterprise to the profit of the dairy farm is generally considered small, but when milk prices are low, its value is greater. Optimising the value of the calf enterprise should be an important target for dairy enterprises, with the dairy-beef breeding policy being the first place to start making improvements.

Calves from the dairy herd for beef production

Beef bulls are generally used on the dairy herd after sufficient dairy replacements have been sired. Currently, approximately 30% (~380,000) of dairy calves born are replacement dairy heifers (AIM, 2016), leaving the remaining calves (~920,000) available for beef production. Male dairy calves and early-maturing crossbred calves (male and female) account for 41% and 43% (26% Angus and 17% Hereford), respectively. Limousin, Belgian Blue and other crossbred dairy calves make up the remainder.

Choosing the right bull

There is strong evidence that the sire has a large impact on the performance of the calf, and subsequently on dairy beef profitability. According to a recent survey, the dairy farmer identifies two priority traits when choosing a beef bull for crossing with their dairy herd: easy calving and short gestation. Calf value/saleability is the third most important trait. When dairy farmers select beef bulls solely for ease of calving, however, they are ultimately selecting bulls that produce smaller calves with smaller carcasses.

The ICBF Dairy Beef Gene Ireland Programme

Dairy farmers involved with the Gene Ireland Dairy Programme have the option of using beef straws from selected beef bulls. These are unproven, short gestation and easy calving sires with high genetic merit for important terminal traits. Dairy farmers record traits such as calving difficulty, gestation length and calf quality. The aim is to identify the higher performing bulls, and use them to improve the genetic merit of the pedigree beef breed(s) to produce the next generation of beef bulls for the dairy herd.

The programme promotes the recording of beef bulls used on dairy farms. Dairy beef producers are encouraged to source calves based on their genetic merit and sire, and hence recording the beef bull used is of increasing importance and value for dairy farmers.

Table 1. Development of the ICBF Dairy Beef Gene Ireland Programme from 2015 to 2017		
2015 Programme	2016 Programme	2017 Programme
2,750 straws	5,666 straws	7,000 straws
12 bulls- Angus, Hereford and Limousin	14 bulls- Angus, Hereford, Limousin and Shorthorn	19 bulls- Angus, Hereford, Limousin, Shorthorn, Saler and Belgian Blue
108 herds involved	166 herds involved	208 herds involved
1,400 inseminations	3,760 inseminations	

The Teagasc/ABP Dairy Beef Programme

The Teagasc/ABP Dairy Beef Programme began in 2015. The first year's objectives were to compare the performance of progeny from easy calving short gestation sires with average gestation sires. For 2016 and 2017, the programme evolved into a sire evaluation trial, with two primary objectives: 1) to identify the most suitable beef bull genetics for crossing on dairy herds and 2) to genetically improve the main breeds supplying beef bulls to the dairy herd.

In conjunction with the ICBF Gene Ireland Dairy Beef Programme, 12 to 14 sires are identified each year and distributed to interested dairy farmers. A total of 600 calves are purchased and reared through the ABP Blade Programme. At 15 weeks of age, 350 calves remain on an ABP trial farm until slaughter, while 250 are purchased by Teagasc and finished in Johnstown Castle. The programme involves measuring animal performance throughout the production cycle. From the results, it is hoped to develop an index of the best beef sires for dairy farmers to use on their dairy herds. These sires will generate offspring with desirable traits: high growth rates, improved health characteristics, high feed efficiency, well-fleshed carcasses, and good meat quality, while retaining economically important traits for dairy farmers, i.e. easy calving and short gestation.

Preliminary data from the ABP/Teagasc dairy beef programme examined the beef value of calves sired by two different Angus bulls. Both were easy calving and short gestation length, but one bull was good and one bull was poor for terminal traits. For a farmer slaughtering 50 animals, progeny from the bull with good terminal traits would generate €6,000 greater profit through increased carcass weight, better carcass conformation and a higher percentage of animals reaching breed bonus specification.

Conclusion

When choosing beef bulls, striking the balance between economically important dairy traits, such as easy calving and short gestation, and economically important beef production traits, such as calf growth, health and conformation, will increase profitability on both dairy and dairy-beef enterprises.

PROFITABLE SYSTEMS OF MILK PRODUCTION

Implications of changing calving date and pattern for seasonal grazing systems

Brian McCarthy and Brendan Horan

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Summary

- The start of calving should be approximately 50 to 60 days before magic day with a recommended mean calving date between February 10th and 25th depending on farm specific characteristics.
- On most farms, calving compactness is of more immediate concern with current six week calving rate far below target levels (58 vs. 90%).

Introduction

Within grazing systems, high levels of milk production are achieved when the appropriate herd mean calving date and distribution of calving is combined with the optimum stocking rate (SR) to align grass supply to herd feed requirements. There is broad consensus that, in a strictly seasonal production system, timing the start of calving approximately 50 to 60 days before magic day (when daily grass growth rate equals the herd's feed demand; Figure 1) is generally appropriate for most dairy farms. Such a recommended calving start date is designed for compact calving systems whereby 50% of cows calve within 14 days of planned start of calving and with a further 40% calving in the following four weeks. In practice, calving compactness on Irish dairy farms is far below target levels, consequently making any debate about ideal mean calving dates less important. Irish national statistics reveal that the average six week calving rate on Irish dairy farms in 2016 was 58%, and far below the 90% target for efficient grazing systems. Based on previous estimates for the financial penalty associated with reduced calving compactness (€8.22 /cow per 1% below target), outspread calving is costing the average 100 cow dairy herd approximately €27,000 per year in lost productivity through reduced grass utilisation and milk production and increased infertility. Consequently, and irrespective of the mean calving date desired, increasing six week calving rate will be among the principle improvement criteria on which every dairy farmer must focus to increase productivity from grazing.

Thereafter in the presence of optimum calving patterns, the optimum herd mean calving date will be the earliest date possible which will allow the herd to be turned out to a predominantly grass diet immediately from calving. Many dairy farmers have chosen to delay calving because of higher SR and more compact calving patterns on farms in recent years. While this will shorten the interval to magic day and consequently reduce the requirement for supplementation at grass in spring, it will also shorten lactation length and require increased supplementation during autumn. While overall farm SR is of consideration, the optimum mean calving date will be chiefly influenced by both the farm soil type and spring growth capability and will range from February 10th to 25th depending on the specific characteristics of the farm (from drier/ warmer to colder/ wetter soil types).

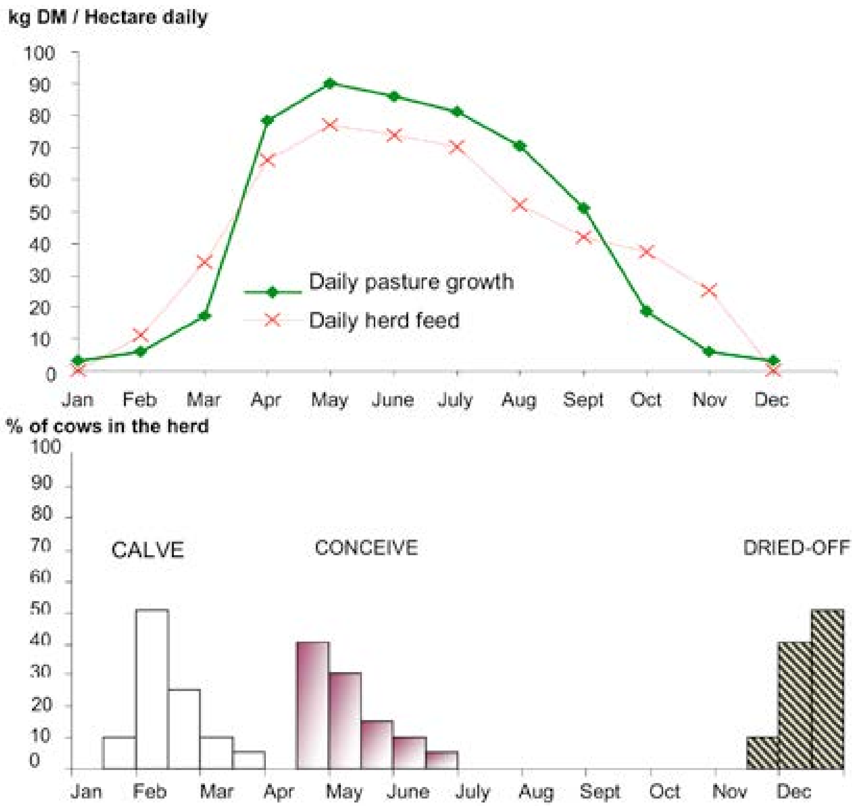

Figure 1. *A conceptual representation of the important impact of calving date to better align grass production and utilisation within a profitable grazing system*

In research studies undertaken at Moorepark, delaying herd mean calving date has been associated with increased daily milk yield per cow during a shorter lactation, increased milk protein concentration, reduced silage and concentrate supplementation and with no impact on herd reproductive performance. Ultimately, the ideal herd mean calving date for any individual farm will be the earliest date possible when a compact calving herd, stocked at the correct overall farm SR, can be calved to facilitate a 280+ day herd mean lactation length and allowing 90% of the herds feed requirements to be achieved from grass.

Conclusions

The start of calving should be approximately 50 to 60 days before magic day with a recommended mean calving date between February 10th and 25th depending on soil type and grass growth characteristics of the individual farm. This is generally appropriate for most compact calving dairy farms that want to have a predominantly grass-based diet and to ensure a rising plane of nutrition in spring while maximising grass production and utilisation before magic day.

The effect of grazing platform stocking rate on farm profit

Donal Patton[1], Laurence Shalloo[2] and Brendan Horan[2]

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Summary

- The financial performance of alternative grazing platform stocking rate systems were evaluated based on the physical performance data obtained from a four year farm systems study.
- Increasing SR from 3.1 to 4.5 cows/ha and importing additional supplementary feeds reduces farm profitability at low and medium milk prices with only marginal economic benefits at higher milk prices.
- The results reinforce the necessity for pasture-based dairy farmers to improve pasture productivity to provide additional grazable grass to expand milk production profitably into the future.

Introduction

Numerous studies have identified grazed grass as the cheapest source of feed for the dairy herd. However, within the context of an expanding Irish dairy industry, access to sufficient land adjacent to the grazing platform may become a major stumbling block for many farmers wishing to increase the scale of their business. Stocking rate is a key driver of the productivity and profitability of grazing systems. Increasing stocking rates results in increased output per ha and greater levels of pasture utilisation. Some previous studies have suggested that where increased supplementary feed is used to sustain higher stocking rates, both high output per cow and high levels of pasture utilisation per hectare can be achieved. The objective of a recent four year study was to investigate the economic sustainability of alternative pasture-based systems of milk production differing in terms of stocking rate, supplementary feed inputs and land availability.

Treatments and results

Physical performance data was used from a multi-year farm systems study evaluating the effect of grazing platform stocking rate (GPSR) on pasture production and utilisation, milk production per cow and per hectare, reproductive performance and the requirement for externally sourced feed supplements. Two GPSR treatments were compared: HCFS (High Closed Feed System: 40 ha milking platform, 124 dairy cows, 3.1 cows/ ha) and HOFS (High Open Feed System; 40 ha milking platform, 180 dairy cows, 4.5 cows/ ha).

Milk production per hectare increased considerably by increasing GPSR from 3.1 to 4.5 cows /ha. However, this increase in productivity was driven solely by imported silage and concentrate feed and grass utilisation remained at similar levels for both systems (Table 1).

The economic implications of the treatments were also evaluated based on average, low and high expected future milk prices and full average current dairy production costs (Table 2).

Table 1. Effect of grazing platform feed system on purchased feed requirements and milk production performance

Feed system	HCFS	HOFS
Total milking platform, ha	40.0	40.0
Herd size, no. cows	124	180
Stocking rate, no. cows/ ha	3.1	4.5
Labour units required, no.	1.47	2.14
Grass utilisation (tonnes DM/ha)	10.1	9.8
Purchased feeds, t DM ha-1 year-1		
Silage	1.92	5.80
Concentrate	1.71	3.92
Milk production performance		
Milk yield, kg/cow	4,648	4,865
Milk yield, kg/ha	14,190	22,229
Fat plus protein yield, kg	377	390
Fat plus protein, kg/ha	1,153	1,786

Table 2. The effect of base milk price and pasture productivity on farm system profitability for alternative grazing platform feed systems1

Feed system	HCFS	HOFS
Net profit at 29 € c/l milk price		
per farm, €/farm	29,075	14,443
per ha, €/ ha	727	361
Net profit at 24 € c/l milk price		
per farm, €/farm	-3,800	-34,837
per ha, €/ha	-95	-871
Net profit at 34 € c/l milk price		
per farm, €/farm	62,019	63,825
per ha, €/ha	1,550	1,596

[1]*Grazing Platform Feed System: High Closed (HCFS) = 3.1 cows/ha, High Open (HOFS) = 4.5 cows/ha*

The results show that within a limited land area, increasing SR from 3.1 to 4.5 cows/ha and importing additional supplementary feeds reduces farm profitability at low and medium milk prices with only marginal economic benefits at higher milk prices. The results reinforce the necessity for pasture-based dairy farmers to improve pasture productivity to provide additional grazable grass to expand milk production profitably into the future.

Conclusions

Increasing stocking rate on the grazing platform and maintaining animal performance with increased levels of bought in feed has a negative impact on farm profitability at low and medium milk prices. In order to maximise profitability per ha, farmers must insure that increases in stocking rate are matched by improvements in pasture productivity and utilisation.

Restricting dairy cow access to pasture and milk production on a heavy wet soil

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Summary

- At Solohead Research Farm we have conducted a number of experiments with the objective of quantifying the impact of poaching damage on grassland productivity on a heavy soil.
- The results of our studies indicate that poaching was less damaging to pasture productivity than anticipated.
- Cows performed better when they were outside on grazed grass even under very difficult conditions compared to cows indoors on silage and concentrates.
- Keeping cows out fulltime, albeit incurring some poaching damage, was more profitable than on-off grazing and substantially more profitable than keeping cows indoors until such time as poaching was avoided.

Introduction

During wet weather, farmers are faced with the decision of turning cows out to grass or keeping them indoors and incurring higher costs. The outcome varies widely from farm to farm, mainly due to differences in soil type but also due to the mind-set of the farmer. Farmers are justifiably cautious in avoiding poaching damage because it has consequences for grassland productivity. However, there is no consensus as to what is or is not acceptable poaching damage. This is because there is a lack of knowledge of the long-term impact on grassland productivity.

Decision support

In a recent study we used soil water content measured using a soil moisture probe as a decision support for turning cows out to pasture or keeping them indoors. There were four grazing systems:

- System 1 cows were turned out the pasture full-time as they calved from early February and remained at pasture until late November or early December regardless of soil and weather conditions.
- System 2 cows were turned out to pasture in February but were put on on-off grazing at any stage of the grazing season when soil water contents were above 60%.
- System 3 was similar to System 2 except that cows were on on-off grazing at any stage of the grazing season when soil water contents were above 50%.
- System 4 cows were housed fulltime until soil water content dropped below 50% and were housed again in the autumn when soil moisture went above 50%, equivalent to turning cows out in April and housing them again in October.

In Systems 2 and 3, on-off grazing involved allowing cows access to pasture for four hours after morning and evening milking. They were housed for the remainder of each day and were not supplemented with silage. This study was conducted over three years between autumn 2013 and autumn 2016. The long term average annual rainfall at Solohead is 1,075 mm. During the study, there was above average rainfall in 2014 (1,202 mm) and 2015 (1,214 mm) and below average rainfall in 2013 (975 mm). Despite an exceptionally wet winter and spring, rainfall during 2016 was close to average.

The herd of cows that was outside fulltime, even under very difficult conditions, performed substantially better than the herd kept inside with higher milk yield and protein percentage and, hence, higher milk solids production (Table 1). There was little difference in the performance of the herds on on-off grazing and the herd outside fulltime although there was a trend for higher milk protein percentages among the cows which were outdoors fulltime. Furthermore, there was no difference in grass growth between the four systems. On-off grazing increased labour requirement compared with keeping cows out fulltime and keeping cows indoors substantially increased costs. Keeping cows out fulltime, albeit incurring some poaching damage was more profitable than on-off grazing and substantially more profitable than keeping cows indoors to avoid poaching damage.

Table 1. Average milk production per cow between October and May (SW = soil water content)

	Outside fulltime	On-off grazing until SW = 60%	On-off grazing until SW = 50%	Inside until SW = 50%
Milk (kg)	3,027	2,966	2,979	2,779
Fat (kg)	141	139	138	127
Protein (kg)	115	112	111	100
Milk solids (kg)	256	251	248	227
Fat (%)	4.66	4.74	4.65	4.63
Protein (%)	3.80	3.77	3.68	3.61

Implications

There was no benefit to avoiding poaching damage. Perennial ryegrass is well adapted to coping with poaching particularly where soil pH and P and K are maintained at optimum levels and, under such circumstances, can recover reasonably well from a once-off severe poaching event. However, repeated severe poaching can lower subsequent grass growth by 20%. Damaging repeated poaching is most likely to occur during April and early May when soil water contents are still high and grazing rotations are short (21 days). In contrast, although soil water contents can be very high in the early spring and autumn, longer rotations (of 42 days or so) provide the sward with a longer interval to recover and this has a big bearing on subsequent pasture productivity. Likewise, pastures badly poached in the autumn have plenty of time to recover during the winter.

The best defence against inevitable poaching damage is the maintenance of soil fertility. Resting the sward and applying a compound fertilizer containing N, P and K is the best way to recover a damaged sward. Over-sowing with grass seed can also benefit severely poached swards while using a lighter cow (jersey crossbred) offers a marginal additional advantage. We have found the impact of rolling a poached sward to be far more damaging than the original poaching. Grass will grow equally well on a rough surface as on a level one. Allowing cows in to graze out a sward under good soil conditions (<50% soil water) is an effective way of levelling a previously badly poached sward with minimal impact on subsequent grass growth.

Conclusions

The soil moisture probe gives an objective measure of soil wetness. At or below a soil water content of 50%, there is little or no poaching damage. Poaching damage increases with increasing soil water between 50% and 70%, but with acceptable damage levels once the situation is managed by strip grazing and back fencing.

Update on the Greenfield dairy farm

Abigail Ryan[1] Tom Lyng[2] and James Keegan[2]

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Summary

- Milk Production has increased each year up to a total of 137 t MS sold in 2016. The herd has achieved an end of breeding season in-calf rate of 90% in each of the past four years using only artificial insemination with a six week calving rate of >80%.
- The herd is a predominantly Jersey crossbred with an EBI of €113.
- In 2016, the farm grew 14.7 t DM/ha, an increase of 0.8 t DM/ha on 2015. Soil fertility is monitored annually. The farm is at soil Index 3 for both phosphorus & potash.
- To date, emphasis was placed on building a financial reserve on deposit (€125,000) and an overall net cash surplus at the end of 2016 (€225,000). Farm debt is now at €555,000, down from €850,000.
- To date, Greenfield farm has participated in each of the Glanbia fixed milk price schemes with currently 25% of total volume is fixed.
- Total cost of milk production were 37c/l in 2016.

Introduction

The Greenfield farm is now over half way through its 15 year lease. Cow performance has been ahead of target and grass production is slightly lower than expected to date, but indications are that the grass growth is now increasing to the original target levels set in 2009. The success of the project to date is attributed to keeping the set up model simple, having the right cow, good grassland management and the excellent farm staff employed since start up. Some key figures relating to farm performance are provided (Table 1).

Herd health

An annual preventative herd health plan is closely followed. Annual health costs were 2 c/l in 2016 with lameness being the main herd health issue. Mobility scoring, earlier intervention and resurfacing of some roadways has reduced lameness in 2017. A significant effort has been made for the past few years to maintain Somatic Cell Count (SCC) at low levels. Practises such as regular milk recording, CMT tests, treatment of young cows, maintaining high SCC cows in a second herd, extending dry periods and teat sealing heifers have helped to manage SCC.

Grass production and soil fertility

Grass production is improving each year from 10 t DM /ha in 2013 to 14.7 t DM/ha in 2016. The farm is located in the south-east of Ireland (annual rainfall is 800 mm). Each paddock is soil tested annually. Maintaining soil phosphorous levels while complying with the nitrates directive is a constant challenge. Potash levels have decreased in 2016 in spite of applying 80 kg K/ha during the year. Some of the best cultivars to manage on the farm include Aston Energy, Dunluce, Bealey and Tyrella. White clover is also contributing to the quality and yield of the swards on the farm.

Herd performance and business plan update

Receipts are higher than in the original budget as the milk price achieved has exceeded expectation and cows have performed well. Total costs (Table 1) excluding capital repayments and development expenditure are similar each year, but higher than the original business plan. Bought in feed, higher fertiliser costs and facility maintenance costs are also higher than the business plan.

Table 1. Physical and financial performance of the Greenfield Dairy Farm (2011-2016)

Physical Performance	2011	2012	2013	2014	2015	2016
Peak herd size (No. cows)	295	294	324	307	328	331
Median calving date	20-Feb	1-Mar	12-Feb	19-Feb	19-Feb	12-Feb
Mating start date	26-Apr	16-Apr	24-Apr	24-Apr	22-Apr	22-Apr
Empty rate (%)	13	11	10	10	5	9
Replacement rate (%)	24	20	36	30	26	22
Milk solids sales (kg/cow)	368	372	386	396	400	415
Total milk solid sales (tonnes)	110	113	125	125	131	137
Grass grown (tonnes DM/ha)	11.8	11.8	10.0	13.5	13.9	14.7
Concentrate fed (kg/cow)		307	620	270	180	240
Phosphorus (% Index 3 & 4)		87	71	55	58	60
Potash (% Index 3 & 4)		51	61	56	70	77
Financial Performance						
Total cash costs (c/l)	40.5	40.0	41.4	42.0	37.1	37.2
Total cash output (c/l)	42.7	43.6	49.4	48.8	40.3	36.6
Milk price received (c/l)	38.0	35.9	41.8	42.6	34.3	31.6
Net Farm Profit (€)	81,433	45,323	90,283	100,898	69,122	7,994
Return on Investment (%)	9	6	10	11	8	3

Key lessons learned to-date

Disease screening and source farm heard health history are critically important when purchasing animals. The key diseases to build up a history on are TB, IBR, BVD, Leptospirosis, *Salmonella*, Johnes, Mycoplasma and SCC.

Labour and people

Tom Lyng is the current farm manager with assistant farm manager James Keegan (since January 2017). All machinery work, stock rearing and relief milking are contracted out. This spring, a night watch person was employed for eight weeks during calving. Cows were milked once a day in February to allow additional time to focus on calving and reduce body condition loss immediately post calving.

Conclusions

Successful start-up and expansion, whether small or large scale, is possible provided proper planning is carried out and the right principles for milk production are closely followed. Good genetics, a proper herd health plan and good grassland management must be adhered to. Early extensive planning in the project and sensible production targets during the initial expansion years are critical.

Demonstrating resilience at Shinagh dairy farm

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Summary

- Shinagh Dairy Farm is demonstrating best practice in the conversion of a beef farm to dairy production and the operation of resilient grass based systems.
- As grass growth has increased over the first six years of the project, stocking rate has been increased to maximise grass utilised per hectare.
- Production costs have been controlled by using high EBI fertile cows with very high milk solids and minimum investment in depreciating assets.

Introduction

Shinagh dairy farm near Bandon in West Cork is a Teagasc-led project demonstrating efficient spring milk production from pasture on a farm converted from beef production in 2010. The 78 ha farm is owned by the four west Cork co-ops and was leased for 15 years by Shinagh Dairy Farm Ltd. 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 with a 15- year loan (and the first two years on interest only).

Increasing the resilience of Shinagh dairy farm

There has been a focus on the farm to reduce the cash breakeven milk price (i.e. the base milk price where all of the cash commitments can be made including capital repayments). Over the past number of years, the breakeven base milk price (excluding vat at 3.3% protein and 3.6% fat) has dropped from just over 29.5c/l to 23.0 c/l. Below this base milk price, the farm would be expected to generate a cash deficit. The factors associated with this reduction can broadly be characterised into five areas:

Reducing costs of production

There has been a focus on the farm to reduce total costs from €397,258 to €360,104 between 2013 and 2015 by maximising the conversion of grass to milk, minimising supplementary feeding, breeding a cow for the system and operating with minimal investment in depreciating assets.

Maximising stock sales and value

There has been an increase in livestock sales from the farm, which has a significant impact on reducing the farm breakeven base milk price. The increase in livestock sales values arises from reduced cow losses, a very low empty rate, more cows sold from the farm in-calf and by retaining surplus female calves in order to add value.

Increasing stocking rate to match increased grass growth

There has been a consistent increase in grass growth during the project which has been matched with a comparable increase in the number of cows managed on the farm. This trend will continue as grass growth levels increase further in future. When compared against the average of the first two years of the business, the farm is now carrying a stocking rate that is 17% higher which is entirely facilitated by increased grass growth on farm.

Increased milk solids concentrations

Milk solids concentrations have increased from 3.52% protein and 4.24% fat in year one to 3.73% Protein and 4.44% fat by 2015. This was as a result of a strong focus on grassland management and breeding strategies within the herd. This increase in solids is worth 3.2 c/l at a milk price of 29 c/l, but even more importantly, is worth 2.8 c/l at a milk price of 23 c/l and substantially reduces the exposure of the business.

Managing cash

The farm has generated very healthy cash surpluses over the first five years (Table 1). Some of these reserves have been used to create a cash buffer in the business to allow the farm deal with issues as and when they arise. The creation of this reserve fund was made possible by a strong focus on cost control and was facilitated by the taxation structure of the Shinagh Dairy Farm Ltd.

Table 1. Costs and returns from Shinagh Dairy Farm Ltd. (2011-2016)

Year	2011	2012	2013	2014	2015	2016
Cows milked (No.)	195	197	227	215	222	225
Stocking rate (LU/ha)	3.12	2.84	2.89	2.79	2.89	2.91
Grass grown (t DM/Ha)	12.25	11.53	12.4	13.2	15.6	15.4
Grass utilised (t DM/Ha)	10.0	9.5	10.5	10.8	12.4	12.4
6-week calving rate (%)	58	62	78	79	93	96
Empty rate (%)	13	7	10	8	7	9
Mean calving date	28-Feb	22-Feb	16-Feb	17-Feb	16-Feb	19-Feb
Milk solids produced (kg/ha)	817	921	1,032	1,058	1,250	1,149
Milk solids sold (kg)	50,903	63,039	80,297	82,320	93,018	88,412
Milk sales (€)	235,557	281,510	429,964	434,645	395,623	353,015
Total receipts (€)	268,986	319,416	492,240	511,737	468,188	389,699
Labour (€)	66,183	72,407	65,466	64,589	68,623	69,819
Land lease (€)	35,530	35,530	35,530	35,530	35,530	35,716
Contract heifer rearing (€)	-	20,054	37,025	36,203	33,908	47,836
Fertiliser (€)	19,537	27,142	34,232	28,457	35,166	28,939
Concentrate (€)	13,311	34,324	33,890	23,115	15,456	19,296
Bank interest (€)	11,411	12,658	11,507	9,242	8,520	7,609
Bank capital (€)	-	-	38,088	37,627	38,291	38,590
Total costs (€)	246,221	317,643	397,258	366,742	360,104	390,312
Cash flow (€)	22,765	1,773	94,983	144,995	108,084	-619
Net Profit (€)	313	-33,316	132,457	135,721	123,276	22,309
[1]Return on capital	1.1%	-2.5%	17.9%	17.7%	16.2%	7.7%
[1]Return on equity	0%	-13%	51%	46%	37%	21%

[1]*Total Capital Employed of €820,000 including equity of €260,000*

Conclusion

The Shinagh farm is now in its seventh year in business and, after the initial period where cash flow was extremely tight, the farm is in a very sustainable position and capable of dealing with significant challenges if they arise in the future.

Johnstown Castle winter milk herd project update

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Summary

- The function of winter milk systems within the Irish dairy industry should be to meet market demand for defined volumes of off-season milk.
- Similar to spring milk production, high grass utilisation per hectare (12 t DM) drives profit from winter milk systems. These targets are met at Johnstown Castle by early spring grazing, achieving target post-grazing residuals and controlling peak autumn grass supply. High quality grass silage is also critical.
- Breeding policy in Johnstown is based on high EBI functional cows that work well indoors and at grass. Annual yield in 2016 was 530 kg milk solids per cow on 1.1 t DM concentrate fed. Calving interval was 368 days.
- The current project compares milk profiles and inputs across spring calving, split spring/autumn calving, and block autumn calving systems. Preliminary comparisons show that split calving systems, while meeting the objective of increased winter volumes, cause only a moderate reduction in peak summer volume.

Introduction

Winter milk can be defined as a means of altering supply pattern to meet a defined market demand for off-season milk. To be financially viable, this shift in supply must increase net milk value beyond the total additional costs at farm level. Winter milk forms part of the production system for approximately 2,800 dairy farms nationally. Of these, 1,750 have registered contracts for liquid milk (National Milk Agency, 2016), a small cohort are contracted for winter manufacturing milk, and the remainder produce a proportion of annual output as off-season milk without any formal contract.

Given the advantages of grass based spring-calving systems in the Irish dairy industry, it is essential that the role for winter milk systems be clearly defined at farm and processor level, that key performance indicators are identified, and that technologies are developed to help winter milk suppliers develop robust production systems. The Teagasc winter milk project, located at Johnstown Castle Research Centre in Wexford, was established in 2006 to meet this requirement.

The Johnstown Winter Milk Project

The 144-cow Johnstown Castle herd calves 60% in an autumn block (commencing late September) and 40% in a spring block (commencing early February) and operates on 48 available grazing ha, with a 21 ha out-block for heifers and early first cut silage. Focus areas for development over the last number of seasons have included; increasing grass utilised for winter milk systems, increasing herd EBI and assessing the effects of calving pattern on feed input, grazing and milk production profiles.

Grazing and feeding targets

A core objective across all Johnstown experiments has been to improve annual grass utilised to in excess of 12 t DM/ha, and milk from forage to in excess of 4,000 litres per cow. For winter milk herds, these strongly relate to farm profit, to a much greater extent than volume per cow for example. Some key messages are:

- Graze 40% of the farm by early March. Do not delay start of spring grazing due to high feed demand. Budget available grass and supplement with silage if necessary.
- Peak grass cover per ha in autumn should be no more than 900 kg DM/ha in late September. Bale excess grass in late August if needed. Start the last grazing round in early October and finish in 40 days, closing at 650 kg DM/ha.
- Grass silage of at least 74 DMD is required for winter milking cows. Focus on energy (UFL) content in the total ration and balance for protein based on PDI.

Cow type for winter milk

Optimum cow type for winter milk has generated much debate over recent years. However, breeding policy in Johnstown is to select high EBI bulls that deliver increased solids kg in moderate milk volume, but with a primary emphasis on fertility and survival as functional traits. The herd is in the top 10% nationally for milk solids and fertility (Table 1).

Table 1. Comparing Johnstown herd EBI to national winter milk average

	EBI (€)	PD milk (kg)	Milk solids (kg/cow)	Calving interval (days)
Johnstown herd	112	34	530	368
Winter milk herds	48	74	419	415

Comparing calving pattern strategies for winter milk

The current study compares block autumn calving, a 50% spring plus 50% autumn split system, and block spring calving, in terms of the effects on milk profiles and input costs. Each group is stocked at 2.9 cows per grazing ha and are balanced for genetic merit. Preliminary data shows interesting effects on supply profiles (Figure 1). Autumn calving systems derive most of the additional winter volume from late summer and early autumn milk foregone (as cows are dried off), while the effect at peak (May) is modest due to the increased persistency of lactation of autumn calvers. This highlights that ‘peak capacity’ and ‘winter supply’, while related, are separate issues for the wider industry. Concentrate feed levels and costs increase in proportion to autumn calving percentage.

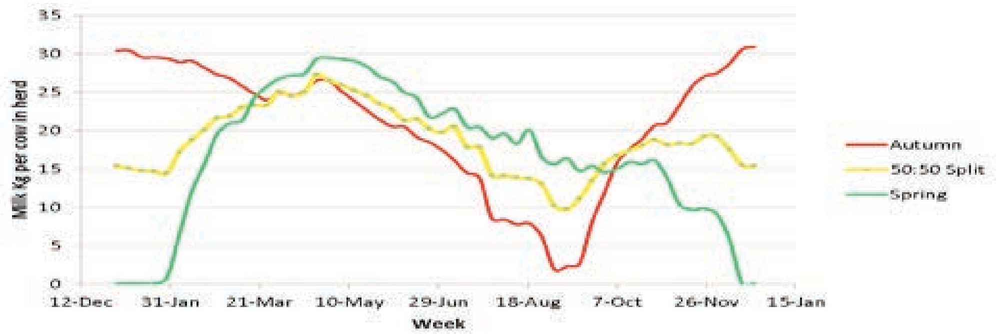

Figure 1. *Milk supply profiles for different calving pattern systems*

Conclusion

The drivers of profit for autumn calving herds are milk produced from forage and high solids, high fertility cows. The Johnstown Castle system uses structured grazing management, high DMD silage and high EBI genetics to achieve these objectives. Peak capacity and winter supply need to be treated as separate issues by the industry.

Do Automatic Milking Systems have a role on Irish dairy farms?

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Summary

- Labour demand associated with the dairy enterprise is reduced by 36% on automatic milking (AM) compared to conventional milking (CM) farms.
- Despite this reduction in labour associated with AM, medium specification CM technologies achieved greater farm profitability.
- AM was competitive when compared with a CM parlour of similar high specification technology.
- The lower labour requirement associated with AM still makes it an attractive lifestyle choice for some farmers.

Introduction

Today, there are about 40,000 automatic milking (AM) units in place worldwide and that number is increasing. Approximately 50% of all new milking parlours installed in many EU countries are AM systems. It is envisaged that 20% of cows in the EU will be milked automatically by 2020. Thus, it is clear that dairy industry stakeholders and dairy farmers consider that AM systems have significant potential on dairy farms in EU countries. The successful integration of AM systems and grazing has resulted in AM becoming a feasible alternative to conventional milking (CM) in pasture-based systems, such as that practised in Ireland. Two of the main factors influencing decision making regarding investment in AM are social and economic factors. Thus, these two issues will be examined to establish if AM has a role on Irish dairy farms.

Labour input on AM and conventional milking (CM) farms

A labour audit was conducted on both AM and CM farms over a 12-month period. Total dairy labour input was less on AM compared with CM farms, with AM farmers requiring 15.8 hr/cow per year and CM farmers requiring 25 hr/cow per year. As milking with an AM system does not require the farmer to be present at milking time, the milking process (AM cleaning and data monitoring) only consumed 40 min/day (range 25 to 60 min/day). This saving in labour associated with the milking process (from 3 hr/day with CM to 40 min/day with AM), was partially counteracted by an additional 15 min/day being spent at grass allocation on farms with an AM system. Despite labour being reduced by 9.2 hr/cow per year, daily end of work times were similar for each milking system, at 18:32. However, daily start times were different with AM farms starting work 50 min later than CM farms, at 07:55 and 07:05, respectively. Overall, the 36% reduction in labour demand could represent a key motivator for farmers to adopt AM.

Profitability of AM and CM in a pasture-based system

Automatic milking is generally regarded as a system that requires two to three times more initial capital investment than a CM system. A majority of studies examining the economics of AM and CM in indoor milk production systems suggest that AM is not cost effective when examined solely on a financial return basis, due to higher capital costs combined with higher running costs. A study was conducted in Ireland on a pasture-based system in which the pre-tax profitability of AM and CM systems were compared at two different levels of automation, across two farm sizes, over a 10-year period following the initial investment. The scenarios that were evaluated were (1) a medium size farm milking 70 cows twice daily with either a single AM unit, a 12-unit CM medium-specification (MS) parlour or a 12-unit CM high-specification (HS) parlour; and (2) a large farm milking 140 cows twice daily with two AM units, a 20-unit CM MS parlour or a 20-unit CM HS parlour. The capital required for each investment was financed at an interest rate of five per cent and repaid over 10 years. Milking equipment and buildings were depreciated over 10 and 20 years, respectively.

In the medium farm scenario, lowest profitability was observed with the 12-unit CM HS system; intermediate profitability by the single AM unit and greatest profitability by the MS technology. The difference in profitability was greatest in the years immediately after the initial investment; the single AM unit was €8,102 less profitable than the 12-unit CM MS system in year 1, but that difference had reduced to €4,740 as interest on the debt was reduced greatly by year 10. Trends for the large farm scenario were similar to those for the medium farm, with the 20-unit CM MS system displaying the greatest profitability. However, the double AM unit achieved just marginally lower profitability than the 20-unit CM HS parlour. The reduction in profitability associated with AM (compared to the CM MS parlour) was less in percentage terms for the large compared to the medium farm situation (20% and 43%, respectively). However, despite the reduction in labour associated with AM, MS CM technologies consistently achieved greater profitability, irrespective of farm size. The availability of data on the individual cow at each milking with an AM system may lead to more accurate decision making on a daily basis. Despite the potential benefits of such information, it is difficult to establish the monetary value of such data to the farmer, as it is at the discretion of the individual farmer what role the available data plays in supporting decision making on the farm. This study indicated that although milking with AM was less profitable than MS technologies, it was competitive when compared with a CM parlour of similar HS technology. Increasing the cost of labour from €12.50 to €20 /hr increased the competitiveness of AM relative to CM technologies for both farm sizes.

The decision to change from CM to an AM system

The labour associated with AM systems includes monitoring of milking data, observation of cows, checking of attention lists, cleaning, increased attention to grass allocations, etc., rather than the physical tasks associated with milking. Consequently, farmers with AM systems report improved physical and mental health and improved lifestyles. Furthermore, AM allows operators some time flexibility, as their presence is no longer required at specific milking times, thus allowing for alternative options, such as off-farm employment. A key issue for many is that AM could make dairy farming more attractive to the next generation, thus increasing the likelihood of the dairy farming tradition being continued within the family. For farmers with leased land, a mobile AM unit may provide a positive alternative to a fixed AM unit, since this would facilitate movement to a different land base at the end of the lease.

Conclusion

Although the AM system is associated with greater interest and capital repayments, depreciation, maintenance, running costs and lower profitability (compared with CM MS technology), the lower labour associated with AM still make it an attractive lifestyle choice for some farmers. The analysis suggested that profitability should not be the sole reason for investing in AM technologies. Any decision to invest in AM should consider several factors, such as the availability of skilled labour, lifestyle sought by the farmer, interest in technology, and the initial capital investment requirement by the milking system.

The declining carbon footprint of milk from Irish dairy farms

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Summary

- To realise climate change policy ambitions, there is an increasing desire for food producers to mitigate their carbon footprint, which is the greenhouse gas (GHG) emission generated by a product or a service.
- The goal of our research was to use the Teagasc national farm survey to estimate the annual change in the carbon footprint of milk from Irish dairy farms and to identify strategies to reduce the footprint in the future.
- Our results showed that from 2013 to 2015, the average carbon footprint of milk declined by 11% to 1.04 kg of CO_2-equivalents per kg of fat and protein corrected milk. Improvements in milk solids yield and grass utilisation per hectare largely explained the fall in the average footprint of Irish milk.
- Farmers can readily adopt animal breeding and grassland technologies to improve these farm performance measures, thereby reducing carbon footprint.

Introduction

Greenhouse gas emissions from the production of products and services have increased dramatically in the past century and are contributing to climate change. To avoid adverse impacts of climatic change, Ireland has agreed as part of the EU climate and energy framework to contribute to reducing the EU's annual GHG emissions by up to 30% from 2021 to 2030. However, unlike most EU economies, dairy farming is a major source (10-12%) of Irish emissions. In addition, Irish milk production is expected to increase over this period and so there is a growing requirement to reduce GHG emissions per unit of milk (carbon footprint) from dairy farms. The aim of our research was to estimate the national change in the carbon footprint of Irish dairy farms and to use this analysis to identify strategies dairy suppliers could apply to reduce that footprint in the future.

Data collection and carbon footprint modelling

The Teagasc National Farm Survey (NFS) was used to collect data required to calculate farm carbon footprints. Farms were classified as dairy producers in the NFS when at least 66% of the standardized gross output of the farm came from dairy revenue. Over the three years, 275 to 314 dairy farms were surveyed and represented around 16,000 specialist milk producers. Trained auditors surveyed all farms, three to four times per year. The auditors collected financial information, infrastructure data and technical data needed to estimate farm footprints such as the amount of concentrate fed (Table 1). A GHG model certified to comply with the British standard for life cycle assessment (PAS 2050) was applied within the NFS to compute farm carbon footprints. The model calculated annual on-farm GHG emissions and off-farm emissions from the production of imported inputs (e.g., concentrate feeds) up to the point milk was sold from the farm in kg of CO_2-equivalent (CO_2-eq). Annual GHG emissions computed using the model were allocated between milk, culled cows and surplus dairy calves based on the economic value of these products and expressed per kg of fat and protein corrected milk (FPCM) to quantify the carbon footprint of milk.

Table 1. Descriptive characteristics of specialized Irish dairy farms

Item	2013	2014	2015
Number of farms	275	318	314
Number of cows	73	73	78
Cows culled %	17	18	14
Stocking rate, cows/ha	1.98	1.99	1.97
Milk solids yield[1], kg/ha	798	806	859
Concentrates, kg/cow	1,172	947	934
Days access to pasture	256	258	255

Carbon footprint of Irish dairy farms

The box and whiskers plot (Figure 1) indicates that the average carbon footprint of milk from Irish dairy farms decreased from 1.17 to 1.04 kg of CO_2-equivalent/kg of FPCM from 2013 to 2015. The reduction in the average milk footprint was largely due to an increase in milk solids yield/ha and a decline in concentrate feeding. This led to a reduction in animal methane emissions and carbon dioxide and nitrous oxide from feed production. However, for all years, there was a wide range in the distribution of footprints. Generally, farms that had low milk footprints had higher milk production and grass utilisation than the average, and used N fertiliser more efficiently. The research suggests that farmers can mitigate carbon footprint by adopting management practices that increase milk output from grassland e.g. breeding higher Economic Breeding Index (EBI) dairy cattle.

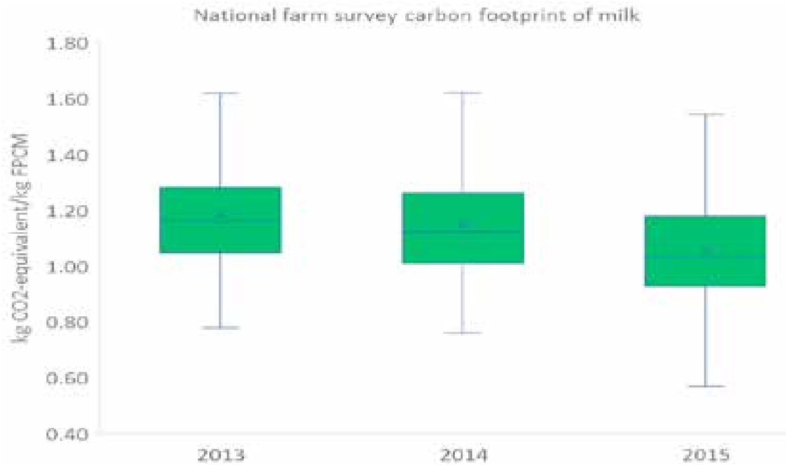

Figure 4. *The carbon footprint of milk from Irish dairy farms.*

Conclusions

For the period considered, we found a significant decline in the milk carbon footprint of Irish dairy farms and identified practices to further reduce dairy farms footprint. Our estimates of the average carbon footprint of Irish milk were amongst the lowest internationally, which is consistent with recent EU and international reports.

Key factors affecting dairy farm efficiency

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Summary

- The key driver of resilience in the dairy business is the dairy system operated on the farm.
- A focus on a high EBI/ crossbred cow within a system that maximises grass utilisation while minimising capital investment will result in a business that has a low overall cost base and which is best placed to deal with price volatility.

Introduction

Milk price volatility is a key feature of dairy farming today and this is likely to continue as the world market responds to changes in product supply and demand. Consequently, resilient sustainable agricultural systems with the highest food safety standards and capable of withstanding external or internal business shocks are required. Along with this, it has been estimated that the world will have to increase food production by up to 70% by 2050 to feed its increasing population. This will require producers to maximise production efficiencies while minimising environmental impacts. Grazed grass provides a unique competitive advantage as it is a highly nutritious feed which can be converted into milk at low cost in a sustainable manner. Ireland's unique advantage in grazing systems provides the ingredients to generate an international competitive advantage once exploited through a continued focus on the key drivers of efficiency at farm level.

Analysis

Across an eight year period (2008 to 2015), the National Farm Survey (NFS) was analysed to gain an understanding of the factors affecting profitability, Family Farm Income and costs of production across a range of demographic, social and physical constraints at farm level.

Table 1. Teagasc National Farm Survey data for the years 2008 to 2015 (inclusive)

Year	Herd size (No. cows)	Stocking rate (L.U./ ha)	Proportion purchased feed	Protein (%)	Fat (%)	Grass utilised (kg DM/ ha)	Net profit (€/ha)
2008	57	1.71	0.19	3.36	3.83	6,728	964
2009	57	1.95	0.17	3.35	3.84	7,282	221
2010	56	1.67	0.18	3.34	3.86	6,657	830
2011	66	1.74	0.16	3.37	3.90	7,107	1,297
2012	67	1.72	0.19	3.39	3.93	6,811	805
2013	68	1.76	0.22	3.38	3.96	6,802	1,290
2014	69	1.78	0.18	3.42	3.99	7,240	1,390
2015	70	1.93	0.17	3.50	4.03	7,796	1,165

Key performance indicators

A number of core management factors are associated with net profit on Irish dairy farms including grass utilisation per hectare, 6-week calving rate, grazing season length, supplementary feed usage and milk solids production. While net profit and costs of production are significantly affected by year, region and soil type, we have little or no control over such fixed effects. Whereas factors which are under management control, such as, grass utilisation per hectare and 6-week calving rate, have proven to be key measures of farm efficiency, with each additional tonne of grass dry matter (DM) utilised increasing net profit per hectare by €173 and gross margin per hectare by €278. Furthermore, each one per cent rise in 6-week calving rate has been shown to increase net farm profit by €8.22 per cow in a separate study. Increased grass utilisation is largely driven by stocking rate, grazing season length and proportion of bought in feed with every extra grazing day in the year increasing net profit per hectare by €1.85. The analysis also shows that for every 10% increase in the proportion of bought in feed in the overall diet, net profit per hectare reduces by €97 and net profit per kg MS reduces by €0.21. Furthermore, the analysis showed that while an increase in milk solids production per cow was associated with an increase in farm profitability per hectare; this relationship was only realised from increasing the proportion of grazed grass in the system.

Table 2. The financial implications of improvements in key performance indicators

Key performance indicator	Net profit (€)
1 tonne DM increase in grass utilisation	173/ ha
1% increase in 6-week calving rate	8.22/ cow
1 day increase in grazing season length	1.85/ ha
10% increase in proportion of purchased feed	-97/ ha
1 kg additional MS per cow	3.26/ ha

Improving farm efficiency

Overall farm efficiency has consistently increased over the 2008 to 2015 period with higher stocking rates, increased grass utilisation and milk solids production per hectare. However, there is scope for further improvements at farm level, including increasing grass utilisation through improved grazing practices, such as early spring grazing, which in turn would further increase grass quality and production for the remainder of the grazing season. While region and soil type had a significant effect on production costs and profit, it has been shown in the past that a high level of profitability can be achieved on less favourable soil types if high levels of grass utilisation are being ascertained. Farmers that utilised more grass tended to achieve increased milk fat and protein composition resulting in increased farm profitability. Nevertheless, grass growth and utilisation are intrinsically linked; therefore grass utilisation is heavily dependent on grazing management, soil fertility status, grass cultivars used and reseeding programmes implemented. High profitability dairy farming should focus on improving overall farm technical efficiency through the use of decision support tools such as PastureBase Ireland, ICBF Herdplus, e-Profit Monitor and Cost Control Planners to enhance the decision making processes at farm level.

Conclusions

Efficient grass-based milk production will be achieved by appropriately setting farm stocking rates to the grass growth and utilisation capabilities of the farm, while maintaining high levels of grassland management, fertile grazing dairy cows and stringent cost control. Such levels of technical efficiency will require informed decision making through the use of grass measurement and budgeting combined with high levels of stock management, thus achieving high levels of grass utilisation and farm profitability.

Financial performance of dairy farms in 2016

George Ramsbottom[1] and Tom O'Dwyer[2]
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Summary

- Spring milk producers generated a net profit, excluding premia, of €1,043/ha in 2016 according to the Teagasc eProfit monitor results.
- The corresponding figure for winter milk producers was €1,164/ha.
- When own labour is deducted from net profit, the margin remaining on spring and winter milk dairy enterprises averaged €116 and €286/ha respectively in 2016.

Introduction

The Teagasc Profit Monitor (PM) is an online financial analysis tool available to all Teagasc clients. Dairy farmers work with their Teagasc Dairy Adviser to gather the data required. Once the data is entered and analysed, the Adviser can produce a range of reports for each enterprise (dairy, replacements, cattle and tillage) or the overall farm. A summary of the average physical and financial performance from an analysis of over 1,500 dairy farms that completed PM by the end of February 2017 for the 2016 financial year is presented in Table 1.

Table 1. Physical and financial performance of spring and winter milk producers who completed Profit Monitor for 2016

	Spring milk (N = 1,352)	Winter milk (N = 153)
Herd size (no. cows)	115	146
Dairy area (ha)	52	63
Stocking rate (LU/ha)[1]	2.24	2.32
Grass used (tonnes DM/ha)	9.1	8.7
Milk composition		
Fat / Protein (%)	4.23 / 3.53	4.13 / 3.42
Milk solids (kg/cow/kg/ha)	426 / 954	469 / 1,088
Average co-op price	28.17 c/l	29.69 c/l
Financial	€/ha	€/ha
Gross output	3,471	4,264
Variable costs	1,367	1,724
Gross margin	2,104	2,539
Fixed costs	1,060	1,376
Net profit excl. premia	1,043	1,164
Own labour cost[2]	927	878
Margin after own labour	116	286
Est. total labour (hours/cow)	33.2	32.2
Own/hired labour (hours/cow)	27.6/5.6	26.0/6.2

[1]Based on overall stocking rate [2]Own labour valued at €15/hr

Both groups of farmers were larger scale, more intensive and more productive than the national average. The charge for own labour equates to a total cost of over €48,000 and €55,000 attributed to owner and family labour on spring and winter milk dairy farms, respectively.

Calculating the value of own labour

One of the observations made of PM is that many of the reports generated do not include a value for own and family labour in the profitability figures generated. In the 2016 report, we report net profit as usual, but we address the own and family labour issue by using the estimate of own labour inputted by farmers completing PM. This labour is then allocated, similar to hired labour, in proportion to the percentage of farm gross output contributed by the dairy enterprise as detailed in the following example for a dairy farm with 100 cows producing 500,000 litres per annum.

Farm gross output	€300,000
Dairy gross output	€200,000
Dairy gross output as a % of farm gross output	67% (200,000 x 100 ÷ 300,000)
Total own and family unpaid hours	3,000
Hours apportioned to the dairy enterprise	2,000 (3,000 x 67%)
Cost assumed per hour	€15
Total cost calculated for own and family labour	€30,000 (2,000 hrs x €15/hr)
Own labour cost per cow	€300 (€30,000 ÷ 100 cows)
Own labour cost per litre	€0.06 (€30,000 ÷ 500,000 litres)

The hours worked per cow is separated from the hours worked in other farm enterprises. Other farm enterprises such as replacement heifer and drystock enterprises have to reward the farming family for the remaining hours worked on the farm. The trend in total hours worked per cow is presented in Figure 1. On average, as herd size increases, the number of hours worked per cow tends to decline but by a reducing amount. So for herd sizes of 50, 100 and 150 cows, estimates of total labour inputs are approximately 40, 30 and 27 hours per cow respectively.

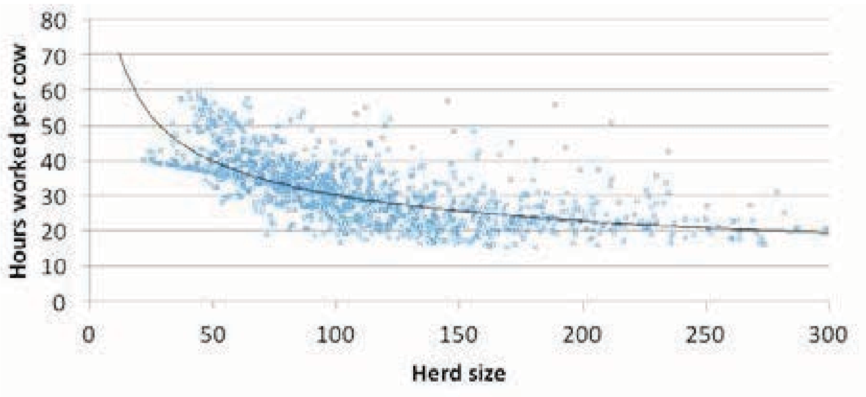

Figure 1. *Trends in total hours worked per cow on spring calving farms in 2016*

Differences between Profit Monitor and National Farm Survey farms

Farms selected for inclusion in the National Farm Survey (NFS) are chosen on the basis of a nationally representative sample of dairy farms from around the country. In contrast, those completing the PM tend to be larger, more intensive and more productive than NFS farms. Typically, the financial performance of farmers completing PM is equivalent to the top third of dairy farmers nationally. The purpose of the PM reports generated is not to provide national averages but to provide participating farmers with data from more similar profit-focused, more intensive operators against which they can benchmark themselves.

Taking stock to take control

Tom O'Dwyer[1] and Lynaire Ryan[2]

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Summary

- All too often dairy farmers can get bogged down in the day-to-day running of the farm business while neglecting to take the time for longer term strategic planning.
- Taking control of the future direction for your business requires time spent just sitting and thinking. Stand back and take a "helicopter view" of your life and business.
- A strategic business plan is like a road map: it will allow you to take a reliable route to your planned destination. A map is especially important when you are in unfamiliar territory e.g. a larger herd, additional land, a new employee or volatile milk prices. You may not need a map around your local area, but once you drive in unfamiliar territory your map is vital.

Why is strategic planning important?

Denis Brosnan, former CEO Kerry Group, is quoted as saying "If you are looking to grow your business, 80% of the growth will come from your strategic planning and 20% from the operational performance". A pretty compelling reason for strategic planning, you would think. Add to this that a well-crafted strategic plan can: (1) provide clarity on what you really want to achieve; (2) allow you to communicate this clearly with family members, your staff, your support team – consultant, accountant, banker; and (3) allow you to actively move towards what you want rather than just drifting along.

The four key strategic planning questions

What is your business purpose?

Or put another way, why are you farming? There are many possible answers to this question, each of which will be unique to the dairy farmer in question. Farmers that have absolute clarity on their purpose (their why) tend to be more successful. Such clarity provides the motivation for decisions and action. The next three questions are perhaps the ones that are most associated with strategic planning. Answer the following three questions with your business purpose in mind, specifically how is what you are doing now, and what you plan to do in the future, helping you to achieve your business purpose? Because you could be undermining your business purpose with your current and planned future actions.

Where do you want to be?

Picture yourself (and your family) in 5, 10 or 20 years from now. What do you want that picture to look like? Ask your family members to contribute to the creation of this picture of the future (or vision). Try to be as descriptive as possible. While your current situation (starting position; see question 3 below) undoubtedly has an influence on where you can get to, don't let it unduly influence your future vision.

Where are you now?

Consider where you are now, both in terms of your farm business and with your personal circumstances. Determine how satisfied you are with a range of areas e.g. work / life balance, health and fitness, family time, personal development, farm performance, financial performance, environment and sustainability.

It is extremely difficult, if not impossible, to improve performance in a given area unless you know the current level of performance. Dairy farmers receive many reports on a monthly/ quarterly and annual basis and from these reports it should be possible to measure current technical (physical) and financial business performance. Other measures might relate to labour efficiency, hours worked, work/life balance etc.

A useful tool to complete this aspect of strategic planning is the SWOT (strengths, weaknesses, opportunities and threats) matrix. Strengths and weaknesses are typically internal to the farm business (things that you can control) whereas opportunities and threats are typically external to the farm business (things that are usually outside of your direct control but can impact on your business).

What will you do to get there?

In answering this question, you will identify the strategies and actions you will take to make your vision a reality (question 2). These strategies and actions will differ depending on your vision and your starting point. For one farmer, the strategies may relate to business growth, for another, to family/ work life balance and for a third, to succession. You really have to answer all questions for your own situation – this isn't something that you can take off the shelf.

Why is it important to write it down?

"Why do I have to write it down…sure I know the direction in which my business is heading?" Firstly, it focuses you, as the business owner, on the strategic planning process. Secondly, writing helps to clarify the thinking process and reduces selective recall. A written document also provides a record which allows for improved communication with family members, staff and other stakeholders. Having a written plan allows you to prioritise the work to be done and will facilitate making short-term decisions based on long-term implications. It will allow you to decide whether today's decisions positively contribute to the farm's long-term viability. Will this current decision take me in the right direction or lead me in the wrong direction? That said, the primary benefit is not the document at the end of the process but the thoughts that are developed and evaluated during the process. It need not be overly long; for example the Plan It worksheet allows you to create a strategic plan on one page.

Alternatively, the Teagasc 'My Farm, My Plan' strategic planning workbook will guide you through the strategic planning process for your business.

Conclusion

You can plan your future rather than just let it happen. Being a top-class 'operations manager' is no longer enough if you want to be a successful dairy farmer. You also need to be able to think and plan strategically. Take the time to answer the key strategic planning questions for your business, record your answers and then set about taking the first steps towards realizing your dreams.

"The best way to predict the future is to create it." Abraham Lincoln

How sustainable are Irish dairy farms?

James Humphreys
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Summary

- Ireland has an excellent international reputation for safe, high quality and sustainably produced dairy products.
- This is reflected in Irish products gaining premium status and greater access to markets worldwide.
- The sustainable image is underpinned at farm level by grass-based production in a clean environment.
- It is imperative to objectively and credibly verify criteria used to assess dairy farm sustainably to the highest scientific standards.
- When examined within the context of the three main pillars of sustainability; economic, societal and environmental, Irish farms perform very well generating good incomes for farm families on farms with world-leading phosphorus (P) use efficiency and producing milk with one of the lowest carbon footprints in the world.

Introduction

The concept of sustainability can mean different things to different people. From the perspective of the companies who process milk and manufacture dairy products, the key question is whether farmers will remain in business and continue to supply milk of an acceptable standard in the future. Long-term investment decisions are based on such assessments. Dairy farm economic viability is clearly an important aspect. Societal requirements in terms of compliance with legislation for the protection of the environment and animal welfare are also important aspects. Recently we have seen the forced partial depopulation of the Dutch dairy herd by 175,000 cows or 10% of the national herd due to failure to reduce P use on dairy farms. Although the intensity of milk output per ha in Ireland is less than one third of that in the Netherlands, it demonstrates the increasing pressures on farmers in an increasingly crowded world.

Pasture-based production of milk and milk products have historically occupied a significant economic and cultural position in Ireland and are a major contributor to the national economy. It has had a major influence on land use, on the shaping of our landscapes and on the quality of the water in our rivers and lakes; the ecological status of Irish rivers and lakes are ranked sixth of the EU27 and amongst the highest worldwide. Aspects of milk quality such as somatic cells, antibiotics and other residues, and traceability are strictly controlled under national regulations and industry standards. Best practices are encouraged by a well-established Sustainable Dairy Assurance Scheme and milk quality awards.

How do we compare?

The typical Irish pasture-based system of milk production is a relatively low cost system and typical, established, well managed Irish dairy farms are competitive internationally generating incomes that compare favourably with counterparts in the EU and other developed countries. Furthermore average dairy farm incomes have exceeded the average industrial wage (€35,000 to €45,000 over the past decade) in Ireland in all years over the past decade except 2009 although there are differences in hours worked per week and working conditions. Nevertheless dairy farm incomes must be interpreted in the context that average incomes in Ireland are among the highest globally. The level of borrowing on

Irish dairy farms (approximately €97,500) is low relative to asset value and compared with counterparts in Western Europe and New Zealand. Although the purchase price of land and land rental are relatively expensive in Ireland this hasn't proven to be an obstacle to the successful transition of new entrants to dairying from other farm enterprises and to the recent rapid expansion of milk production in Ireland.

Survey results have shown that in general Irish dairy farmers are reasonably satisfied with their position in society with a substantially better self-image than dairy farmers in France and Spain and more in line with dairy farmers in the Benelux countries. Heavy workloads and long working hours in spring are a major complaint of Irish dairy farmers and they differ in this regard from EU counterparts. The big divergence in workload between the first half and second half of the year is one aspect of our seasonal low cost system that might prove increasingly challenging in future.

Pasture-based production on permanent grassland is a key contributor to the generally low nutrient contamination of Irish rivers and lakes. Nitrate losses to water tend to be low under permanent grassland particularly on the heavier textured soils and high rainfall conditions that predominate in Ireland. Nevertheless, there is no room for complacency because the continuation of the nitrates derogation is conditional on improving water quality. Furthermore, nitrogen fertilizer use on Irish dairy farms is higher than most other EU countries including the Netherlands, where there is greater reliance on maize. This is a matter for concern because not only can fertilizer N impact on water quality it also contributes to greenhouse gas emissions.

High reliance on grazed grass and a low proportion of concentrate in the diet of dairy cows in Ireland is a key contributor to Irish dairy farms having the highest P use efficiency in the world, which is in sharp contrast to the situation in most other EU countries and even Northern Ireland, where concentrate inputs are higher. There have been substantial improvements in slurry storage and slurry and dirty water management on Irish farms over the past decade. Paradoxically, soil deficiencies of lime, P and K have been identified as a key area for improvement because of their impact on grass growth and the economic performance of farms.

Across the EU and in most countries worldwide the trend is towards indoor systems of dairy production whereas there is a growing societal pressure, particularly in the EU, to reverse this trend. There is a lot of evidence to show that cows prefer to be outside on pasture. Research has shown that cows are less stressed and more comfortable when they are at pasture because they are freer from competition and bullying and likely to spend longer lying down when outside, even under winter conditions grazing crops of kale. The sustainable image of Irish dairy products is underpinned at farm level by grazing cows in a clean environment.

It is well known that Irish milk has one of the lowest carbon footprints in the world. The problem is that Ireland has the highest per capita greenhouse emissions in the EU because of our huge reliance on livestock based agriculture and low population density. The challenge for policy makers is how to meet the growing global demand for high quality and safe food while transitioning to a low carbon economy.

Conclusions

Dairy production in Ireland is built on solid sustainable foundations and is proactive in meeting emerging societal requirements for environmental protection and animal welfare. More than ever it is important that dairy farmers are ambassadors in promoting the sustainable image of their farms.

Sustainable dairy farming: The Carbery experience

Donal O'Brien, Eleanor Murphy, James Humphreys, John Upton, Kevin McNamara, Phillip Shine and Laurence Shalloo

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Summary

- To satisfy growing consumer interest in the provenance of their food, large purchasers of primary food products increasingly require dairy farmers to quantify the sustainability of their production process.
- The goal of this research was to measure or model the sustainability performance of a group of Carbery dairy farms from 2012 to 2016.
- Over the four years, we identified technologies to increase energy and water efficiency and practices to correct deficiencies in soil fertility that partly led to improvements in several sustainability indicators.
- Comparing the group's sustainability performance to relevant past estimates showed the farms results were amongst the best globally.

Introduction

Consumers and food companies increasingly desire sustainable food products that are both animal and environment friendly, healthy, nutritious and also provide primary producers with a decent standard of living. The aim of the Carbery Greener Dairy Farms project was to provide this information to its customers by measuring the sustainability performance of dairy farms across a range of indicators including food production, soil fertility, energy and nutrient use efficiency, water use and carbon footprint. The project began with 12 farms in 2012 and was expanded to 18 farms as part of a DAFM funded project in 2014 that aimed to develop easy to measure sustainability metrics for dairy farms.

Milk production

Almost all Carbery farms increased milk output during this research project. The average fat plus protein (milk solids; MS) production increased from 649 kg/ha in 2012 to 788 kg/ha in 2015, while the total agricultural area increased by an average of 10 hectares/farm over the same period. The increase in milk production was achieved through an increase in average herd size from 100 to 126 cows per farm during the period. On average, 80-85% of the herd diet on a dry matter basis came from grass during the study period.

Energy and water use

On average, five per cent less electrical energy per litre of milk was used in 2015 when compared with previous years. Moreover, energy consumption per cow also dropped by 12 kWh/cow per year (Table 1). These efficiency gains were realised mainly through improvements in milk cooling efficiency. Farmers increased their cooling efficiency by installing plate coolers during the project and increased water flow through the plate cooler. This resulted in plate cooler water consumption approaching the optimum ratio of 2:1 water: milk flow. However, there is still some scope for further efficiency gains in milk cooling as some farms were seen to have water: milk flow ratios of 0.5:1.

Finding efficient recycling strategies for plate cooler water was key to reducing the direct water consumption of dairy farms while maintaining energy efficiency. A number of Carbery Greener Dairy Farmers have already implemented water recycling and have maintained net water efficiency while allowing more water to flow through the plate cooler resulting in reductions in cooling energy consumption. These strategies will be critical to minimise water consumption as milk output increases further in future.

Table 1. Key annual performance measures and sustainability indicators for the Carbery greener dairy farms

Item	2012-2014 (Ave)	2015
Milk solids (kg/cow)	428	445
Milk solids (kg/ha)	704	788
Bought-in concentrate (kg/livestock unit)	686	540
Herd EBI (€)	131	154
Electricity (kWh/cow)	199	187
Water pumping (l water/l milk)	6.5	6.9
Nitrogen efficiency	21%	24%
Phosphorus efficiency	66%	59%
Carbon footprint, kg CO_2e/kg milk	1.15	1.01

Soil fertility and nutrient use efficiency

Approximately 75% of soil samples had a pH of less than 6.0. To improve grass production from fertilizer, it was recommended that farmers apply lime to raise the soil pH to 6.5. The level of lime use on farms increased from an average of 0.1 tonne/ha in 2012 to approximately 1 tonne/ha from 2013 to 2015. Of all samples analysed, 43% were in index 1 and 2 for phosphorus (P). The P levels in the soil samples on individual farms varied considerably, from 1.9 to 12.4 mg P/L. Generally, fields furthest away from the farmyard had lower P levels, which suggested that slurry was largely being recycled on fields closer to the farmyard. A key recommendation to the group is to target slurry application to fields low in P and K (Index 1 or 2). Applying these recommendations during the project increased grass production by 0.5 tonnes/ha over the period, while nitrogen use efficiency also increased from an average of 21% in 2012-2014 to 24% in 2015. Although P use efficiency declined from an average of 66% for 2012-2014 to 59% in 2015 as soil P deficits were corrected, the overall level of P use efficiency remained at the higher end of the range (i.e. 24-70%) for European dairy farms.

Carbon Navigator and Carbon Footprint

The carbon navigator decision support tool was completed by each farmer in 2012 and targets were set for 2015 for various measures e.g., improving economic breeding index. In 2015, the mean carbon footprint of milk in kg of CO_2-equivalent/kg of fat and protein corrected milk (FPCM) for the Carbery farm was well below the European average of 1.4 kg and 11-12% lower than the groups mean for 2012-2014 (Table 1). The footprint reduction also surpassed the groups nine per cent reduction target based on the group's carbon navigator. The farmers surpassed several of their own targets including milk yield, N fertilizer efficiency and concentrate feeding rates thereby explaining the significant footprint reduction in 2015.

Conclusions

This project demonstrates a range of metrics to quantify sustainability at farm level. We identified practices and technologies that dairy farms can use to increase productivity, and which if applied nationally, would further enhance the sustainability credentials of Irish food production.

Pioneering once a day milking in Ireland

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Summary

- There is growing interest in full and part season once-a-day (OAD) milking for a variety of reasons.
- Reducing the milking frequency of a cow will reduce her daily milk and fat plus protein (milk solids; MS) yield but will result in increased milk protein and fat composition and improved animal health and fertility.
- Being a relatively new practice in Ireland, successfully switching to full season OAD milking requires two to three years of planning in most cases, a comprehensive re-evaluation of your farm system and excellent grazing and breeding management.

Introduction

With increasing herd sizes, longer walking distances and a shortage of suitably skilled labour on farms, there is increasing interest in full and part season OAD milking. Internationally, the practice of OAD is not a new concept and has been widely practiced in New Zealand since the 1950's. In 2006, Teagasc Waterford brought a group of Waterford farmers to New Zealand where we met some researchers and advisors from Massey University and DairyNZ who had done a lot of research on OAD. We also visited a 700 cow herd in the South Island where the farmer was now making more profit on OAD than previously on twice-a-day milking (TAD).

What is the Science of OAD?

Reducing the milking frequency of a cow from TAD to OAD will reduce her daily milk volume and MS yield and will also result in increased milk protein and fat composition and improved animal health and fertility. In Ireland, a 26% reduction in milk volume per cow and a 20% reduction in MS yield per cow was observed on OAD when compared to TAD. In addition, milk fat percentage increased by 10.3% while milk protein percentage increased by 7.3%. Animals on OAD also had significantly higher body condition score and body weight compared to TAD animals. While there were no significant fertility and SCC differences observed in the Irish study, significant increases in SCC and improved fertility performance were observed in other international studies. Studies in New Zealand have shown that OAD can be as profitable as TAD when the reduction in milk production is minimised and cost savings are achieved. In general, the farmers who see the most benefit from OAD are those whose current resources are under stress on a TAD system.

In terms of part-season OAD, milking OAD in early to mid-lactation has been shown to improve labour productivity, animal body condition score and reproductive performance. The reduction in immediate MS production is approximately 20% post-calving and 15 to 20% in mid-lactation, with the magnitude of the reduction increasing with the duration of OAD milking. In addition, OAD milking in early to mid-lactation can have negative carry-over effects on later TAD production with the magnitude of the carry-over effect increasing as the duration of OAD increases. More recently, studies in New Zealand have also shown that the effects of milking frequency and nutrition on MS yields are separate and additive and so cows should not be restricted beyond that of a normal TAD herd.

The OAD Discussion Group

In 2015, a specialised OAD discussion group called the POADII - Pioneering Once A Day (milking) in Ireland was established. With the help of my dairy advisor colleagues throughout the country, we identified clients who were milking OAD. Now we have a wide ranging group (36 members) which are geographically diverse (from Sligo to Wexford and from Wicklow to Cork) with a range of herd sizes (50 to 250 cows) and consisting of 32 members who are milking OAD full time. Based on ICBF Co-op Performance reports, 12 of the members (40% of group) delivered over 300 kgs MS/cow in 2016 and the average performance of those 12 members was close to Glanbia averages of 372 kgs/cow for TAD herds at 360 kg MS/cow. The formation of the group has been a great source of support and information/back up for members. Every three weeks during the main production months, members send in current data to Chairperson Gillian O'Sullivan who then emails out a group report. The group have four meetings this year.

Planning for OAD milking

I firmly believe that OAD milking has a definite and growing future in Ireland resulting in comparable financial performance and with a much better lifestyle for the farm family. For farmers who are considering transitioning to OAD or indeed using it with a second herd, careful planning is needed with good breeding and grazing management. Before changing to OAD, it is essential to assess the potential benefits against the reduction in milk production and that a realistic budget is completed. From my experience, some considerations during the transition include:

- Milk recording data is essential to eliminate poor performing, high SCC and poor udder confirmation cows from the herd.
- The first year on OAD will see the biggest reduction in yield of approximately 25% in volume and about 20% in milk solids with Friesian type cows and first calvers affected most. Carrying an extra 5 - 10% of cows can compensate for the drop in initial milk production with OAD.
- Over five to six years of OAD, yields may be reduced by only 10% relative to the original TAD yield as cows that do not perform well on OAD will be culled with better replacements coming from cows better suited to OAD.
- Recent research suggests that Holstein Friesian Jersey crossbred cows adapt better to OAD due to lower volume and higher fat and protein composition. Consequently, breeding for a high EBI crossbred cow and minimising the number of first lactation animals will minimise the effect of OAD and keep SCC under control.
- There are a number of factors that will compensate for the drop in milk receipts on OAD farms. Firstly, milk price will be five cent per litre higher due to higher milk composition. There will also be a reduction in parlour and herd health costs with reduced incidence of low body condition, lameness and infertility and financial gains through in increased calving compactness, better herd longevity and reduced requirement for replacements.

This report is dedicated to the memory of Emeritus Professor Colin Holmes' of Massey University and originally from Co. Antrim. Colin was a respected researcher, lecturer and OAD advocate who made a significant contribution to the grassland dairy industries of both Ireland and New Zealand.

HEALTHY COW – HEALTHY MILK

How to achieve high milk quality

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Summary

- Initial raw milk microbiological quality is a major determinant of dairy product quality, therefore, it is important to control bacterial levels (total bacterial count and thermoduric count) during milk production on-farm.
- Cow environment (i.e. roadways, housing, collecting yard), udder hygiene, milking parlour hygiene, milking equipment cleaning, milk pre-cooling system and milk storage conditions contribute to the total bacterial count and thermoduric bacterial count in milk.
- An average total bacterial count of 4,000 cfu/ mL was achieved in bulk tank milk after four days of storage when milk was cooled to either 2 or 4°C, under recommended hygienic conditions.

Introduction

Milk is one of the main Irish export commodities and 6,634 million tonnes were produced in 2015; the production is expected to expand with the increase in demand for dairy products worldwide. Therefore, maintaining milk quality is essential to hold market share and produce dairy products in accordance with specific quality parameters. Many factors along the milk supply chain could impact negatively on milk quality, however not all the quality factors can be addressed with processing technology, therefore raw milk quality is a determining factor of final product quality and safety. Total bacterial count and thermoduric bacterial count are two of the main quality indicators and several farm practices can influence their levels in milk.

Total bacterial count and thermoduric bacterial count

Total bacterial count (TBC) and thermoduric bacterial count (THERM) are laboratory tests used to infer on-farm general hygiene conditions, milking equipment cleanliness and milk storage conditions. Thermoduric bacteria are microorganisms capable of surviving pasteurisation, which may cause quality defects in milk products (i.e. reduction of pasteurised milk shelf life, protein and fat degradation) or even severe illness when milk is contaminated with pathogenic strains (Bacillus cereus). Irish milk processors apply a TBC limit within the range of 30,000 to 50,000 cfu/ mL, and impose a thermoduric bacteria limit ranging from 500 to 1,000 cfu/ mL. To control TBC in milk, appropriate hygiene practices are required throughout the production process, including the stages of udder preparation, milking plant hygiene and storage of milk. The thermoduric bacteria control is focused on the cow environment, considering that this type of bacteria could occur in feed, forage, bedding material, dust, faeces and soil. Cow's udders and teats are contaminated when their environment is not appropriately managed, resulting in the possible contamination of milk and milking equipment. Recommendations regarding hygiene practices that should be carried out in order to achieve low levels of TBC and thermoduric bacteria in milk are presented in Table 1.

Cooling rates and refrigerated storage conditions

Cooling and storing milk at an adequate temperature is essential to reduce microbial growth rates, preserve milk's sensorial characteristics and composition. Pre-cooling of milk, prior to its entry to the bulk tank, can also aid in reducing the microbial growth rate during storage.

Table 1. Hygienic practices on-farm to achieve low TBC and thermoduric levels

Production stage	Hygiene practices
Udder hygiene	Wash cows teats with warm water; and dry with individual highly absorbent paper
	Water should be of bacteriologically potable quality
	Ensure clean hands and wear gloves during milking
Milking plant hygiene	Follow a milking equipment cleaning routine, https://www.teagasc.ie/animals/dairy/milk-quality/cleaning-guidelines-for-milking-equipment/
	Use correct water quantity for wash (9 litres/unit) and rinse (14 litres/unit)
	Use hot water (75 – 80˚C)
	A weekly acid wash is recommended
	Use registered cleaning agents,
	(https://www.teagasc.ie/media/website/animals/dairy/joint-programmes/Chemicalanalysisofdetergentsterilizerproducts_201704.pdf)
	Replace cracked rubberware

The effects of three milk pre-cooling protocols on TBC were evaluated: no plate cooler (NP), single (SP) and double (DP) stage plate coolers; which cooled milk to 32, 17 and 6˚C, respectively. The milk volumes pre-cooled by each system were stored in three identical bulk milk tanks, which cooled milk to 3˚C. Milk was added to each tank twice daily, mimicking a farm milking routine. After three days, the TBC in milk that was not pre-cooled (9,950 cfu/ mL) was higher than in milks that were pre-cooled (average of 4,770 cfu/ mL) (Figure 1A), indicating that pre-cooling milk could aid in reducing the bacterial growth rate during an extended storage time. There was no significant difference in TBC between milk pre-cooled to 6 and 17˚C. In a subsequent study, milk was pre-cooled using a SP system (15˚C) and valves in the milk-line were used to divide the milk flow in equal proportions to two tanks. The milk was subsequently stored at 2 or 4˚C, for four days; and after that period, a minimal TBC increase was observed in milk stored at 2 or 4˚C, reaching 3,388 and 4,786 cfu/ mL on day four, respectively, (Figure 1B).

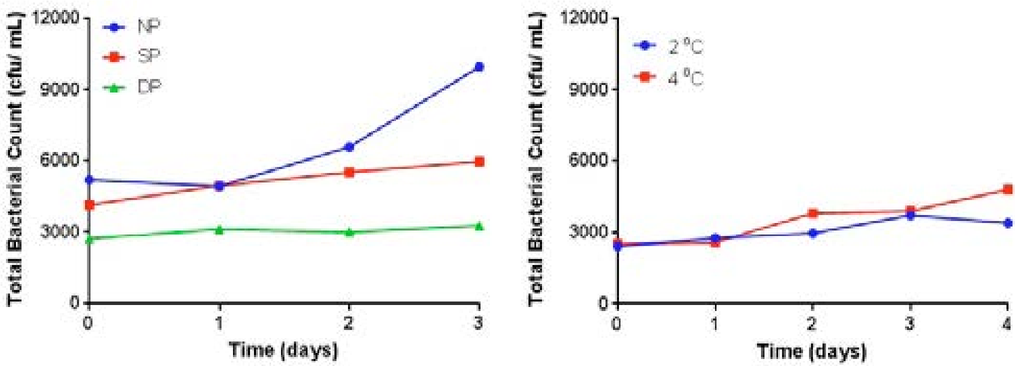

Figure 1. *Effects of (A) pre-cooling (NP- no plate cooler, SP- single stage, DP- double stage) and (B) storage temperature (2˚C, 4˚C) on TBC*

In both studies, the storage temperatures did not affect THERM in milk. The average initial TBC and THERM of milk in both studies was 3,390 and 18 cfu/ mL, respectively. Low initial bacterial levels are essential to achieve results similar to those demonstrated in these studies, and can be achieved following good udder hygiene practices and recommended milking machine wash routines.

Conclusions

Adequate hygiene practices at milking, good equipment wash routines, in conjunction with an adequate cooling rate and storage temperatures are essential to obtain high milk microbiological quality.

New wash routines (involving no or minimal chlorine) for cleaning milking equipment

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Summary

- Removing chlorine from cleaning routines will reduce the likelihood of detection of TCM and chlorate residues.
- Teagasc are presently testing four new non-chlorine based cleaning protocols.
- Re-calibration of automatic dosing systems for both machine and bulk milk tank is necessary when changing cleaning product type.

Non-chlorine based cleaning protocols

To meet product specifications particularly in relation to residues such as Trichloromethane (TCM) and Chlorates, some milk processors are now specifying that milking equipment should be cleaned using non-chlorine based chemicals. While a reduction in chlorine residues is likely with this practise, it provides a challenge to maintain optimum hygiene levels of milking equipment and microbiological quality of milk. Chemical manufacturers have developed a new product range to meet the demand for non-chlorine cleaning. To address industry queries on these new products and protocols, Teagasc are presently evaluating four such systems on research farms (from companies Biocel, Diversey, Ecolab and Kilco) over a five month test period. These cleaning protocols are described as chlorine free but all are not necessarily chlorate free, as sodium hydroxide products (caustic detergent) still contain low levels of chlorate, formed during manufacture. The details of the wash routines as they are being evaluated are outlined in Table 1. A further protocol promoted by Grassland Agro included in Table 1 was recently tested at Teagasc and this wash protocol maintained low bacterial counts with no chemical residues detected over a four month trial period.

Minimum chlorine based cleaning protocols

The 'cold wash' powder based cleaning protocol with chlorine added on just one wash occasion per week has been used on dairy farms for over 40 years and has been proven to be satisfactory, where manual washing is used. A similar protocol, 'GleeColl' adapted from this powder system, but using existing available liquid caustic products, with a detergent steriliser used once weekly has also been evaluated at Moorepark and has proved satisfactory from both residue and microbiological viewpoints. Average total bacterial counts of 3,000 cfu/mL and thermoduric counts of 19 cfu/mL were observed over a three month trial period. A key point to remember here is that chlorine is used once per week for the two previous mentioned protocols and extra care with immediate rinsing should be conducted on that occasion.

Table 1. Minimum wash routines containing minimum chorine on test at Moorepark

Weekly Wash routine	Chemical Cleaning products			Wash time	
	Name	Main ingredient	Usage-weekly	AM	PM
Biocel Chlorine free	Multisan CF	Sodium hydroxide 25%	Main wash AM	Hot x 7	-
	Serpent	Acid-Acetic/ peracetic, hydrogen peroxide	Main wash PM	-	Cold x 7
	Boost	Hydrogen peroxide	Added to AM wash twice weekly	Hot x 2	-
Cold wash Powder Minimum chlorine	Powder, no chlorine	Sodium hydroxide (76%)	Main wash AM & PM	Hot x 1	Cold x 11
	Acid Descaler	Acid-phosphoric	Once weekly	Hot x 1	-
	Detergent/ Steriliser liquid	Sodium hydroxide (≥15%) chlorine (≤3.5%)	Once weekly	Hot x 1	-
Diversey Chlorine free All in one product	Divosan OSA-N	Acid –Nitric, glycolic, octanoic, octenylsuccinic	Main wash AM & PM	Hot x 4 Cold x 3	Cold x 7
Ecolab Chlorine free	LactivateClean	Sodium hydroxide (40%)	Main wash AM & PM	Cold x 3	Cold x 7
	LactivateAcid	Acid-phosphoric, hydrogen peroxide	Main wash AM	Hot x 4	-
GleeColl Minimum chlorine	Liquid detergent	Sodium hydroxide (25%)	Main wash AM & PM	Hot x 4 Cold x 2	Cold x 7
	Peracetic acid	Acid-Acetic/ peracetic, hydrogen peroxide	Final rinse twice daily	Cold	Cold
	Detergent/ Steriliser liquid	Sodium hydroxide (≥15%) chlorine (≤3.5%)	Main wash AM Once weekly	Hot x 1	-
Grassland Agro Chlorine free	Hypracid One	Acid- Methanesulfonic	Main wash AM & PM	Hot x 6	Cold x 7
	Hypral One	Sodium hydroxide (28%)	Main wash AM Once weekly	Hot x 1	-
Kilco Chlorine free	AUTOSAN BLUE	Sodium hydroxide (21%)	Main wash AM & PM	Hot x 4	Cold x 7
	AUTOSCAN RED	Acid-phosphoric	Main wash AM	Hot x 3	-

Systems are being evaluated as outlined, changes to the routines does not guarantee successful cleaning

Washing routine guidelines

With non-chlorine based cleaning protocols the use of regular hot washes is necessary and no recycling of detergents is practised. Non-chlorine cleaning protocols are generally more expensive than existing detergent based protocols. Most of the new protocols are acid based with the acid acting as a steriliser as well as having cleaning benefits. Therefore, additional care needs to be adhered to when using these products i.e. eye protection and gloves. Acid based products are ideally suited to situations where automatic cleaning systems are in place. If changing from chlorine based detergent steriliser products to non-chlorine (caustic) products it is critical that re-calibration of automatic dosing systems for both machine and bulk milk tank is carried out, as take-up rates will be considerably lower with products which have a caustic concentration.

Conclusions

Results of bacterial counts and residue levels for the chlorine free cleaning protocols on trial are considered satisfactory to-date. Full reports on each protocol including cost of cleaning will be made available to industry later this year.

Current focus on chemical residues in milk

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Summary

- Trichoromethane (TCM) and chlorate residues are caused by milking equipment cleaning protocols that include chlorine.
- Maintaining low milk TCM levels at farm level is achieved by practising correct milking machine and bulk tank cleaning procedures.
- Recommended iodine intake for animals is 0.5 mg of iodine per kg DM intake per day, or 10–12 mg of iodine per cow per day, but iodine is frequently added to feed concentrate at higher levels.

Importance of residues in dairy products

Extensive testing of milk is carried out by the dairy industry and regulatory agencies to protect public health in Ireland and support the export of Irish food abroad. Eighty percent of dairy products are destined for international markets. Of particular significance are the high quality butter, cheese and infant formula export markets. Milk supplies for these products are sourced from local dairy farmers through Irish dairy processors. Credentials around Irish food safety gives a premium image in the market-place and this has to be maintained for both the national and the export market. Chemical residues such as TCM, chlorates and iodine (at various levels) are reported as potentially carcinogenic, capable of inhibiting thyroid iodine uptake and exceeding the tolerable upper level of iodine (which is just three times higher than the adult requirement). Thus monitoring of such residues in milk is needed.

Trichloromethane (TCM) in milk

TCM is one of the most important quality parameters of milk destined for butter manufacture. TCM in milk must be at levels ≤0.0015 mg/kg to achieve the standard of 0.03 mg/kg butter, imposed by the importing country. TCM is a residue in milk caused by the interaction of chlorine (from cleaning detergent) and milk.

What can a farmer do to avoid excessive TCM levels in milk?

Intensive milk sample analysis is on-going at Teagasc Moorepark and up to 30,000 milk samples are tested annually for TCM. Advice is targeted towards farms identified with high milk TCM levels and farm visits may be required to identify incorrect machine or bulk tank washing practices. Maintaining low (≤0.0015 mg/kg) TCM in milk is best achieved by using a correct cleaning/disinfection product type and quantity; the cleaning product should be selected from the Teagasc list, http://www.agresearch.teagasc.ie/moorepark/cleaningguides/cleaning.asp ; using cleaning products with a chlorine content of <3.5%; sufficient rinsing of milk and detergent from the milking equipment surface (14 litres/milking unit); sufficient rinsing of the bulk tank before and after detergent cleaning; not reusing the detergent solution more than once and not using chlorine in a pre-milking rinse of the milking plant. Minimum chlorine based cleaning routines may also be considered. Any strategy to reduce TCM or chlorate residues during the milk production and dairy processing stages should ensure the absence of any negative impact on microbiological quality and food safety.

Chlorates in milk

Chlorate residue in milk products is a new emerging food safety concern. Development of an EU maximum residue limit for this residue is currently in progress. Chlorate is formed as a by–product when chlorine, chlorine dioxide or hypochlorite is used for the disinfection of drinking water and cleaning of surfaces coming into contact with milk. While the importance of chlorine per cent in product and volumes of product and rinse water used have been discussed previously in relation to minimizing TCM, age of product and storage conditions are also critical to chlorate residue levels. Chlorate formation can occur in the cleaning product as a consequence of chlorine degradation during storage of that product, thus chlorate development is exacerbated by extended storage time and sunlight exposure.

What can a farmer do to avoid excessive chlorate levels in milk?

Only use cleaning products within the best before date on the label (normally less than six months); minimize storage period on the farm, i.e. do not stock–pile chemicals; store chemicals correctly out of direct sunlight and protect from frost. Also, it is best to avoid teat disinfectants that contain chlorine dioxide or chloride.

Iodine supplementation to cows

The target level for iodine in milk powder as an ingredient in infant feed formula is <130 µg iodine/100 g powder; this is often difficult to achieve in an Irish production system. There are two main mechanisms by which iodine enters the cow's system, (i) through the cow ingesting relatively high quantities of iodine in concentrate feed and (ii) through disinfection of cow teats with products containing iodine pre and/or post-milking. International recommendations on iodine intake of animals (on a routine basis where cows are not deficient) is 0.5 mg/kg dry matter intake or 10-12 mg/cow/day. It is important to establish if the herd is deficient in iodine or not, and supplement accordingly. This is a key point – as it is known that excess iodine intake by cows is just excreted into the milk and urine. Often higher iodine supplementation levels are not being reserved for herds/cows seriously deficient in iodine, but being used indiscriminately. Other methods of iodine supplementation are also available and may be more consistent and/or easier to control, e.g. adding iodine through the drinking water. Likewise, teat disinfection practises have potential to increase milk iodine levels, with pre-milking disinfection posing a very substantial risk, as it is dependent on the degree of iodine removal from the teats prior to cluster attachment.

What can a farmer do to avoid excessive iodine levels in milk?

A farmer can maintain appropriate daily cow intake of iodine by being aware of all the potential iodine sources for the cow. Examples include: (i) concentrates should be fed in a way that ensures maximum total iodine delivered = 12 mg/cow/day for routine supplementation; (ii) if adding iodine to drinking water, it should be ensured that a maximum daily intake of 12 mg/cow/day of iodine is delivered to the cow; (iii) pre-milking teat disinfection with iodine should be avoided; (iv) post-milking disinfection with iodine should be also be avoided unless teats are washed and dried pre-milking; (v) other products such as boluses, drenches, etc. can be of benefit if cows are deficient in some important trace elements (including iodine), but they can seriously impact on milk iodine levels. These recommendations are in place on Teagasc research herds and monitoring of milk iodine levels is on-going.

Conclusions

The contributing factors to TCM, chlorate and iodine residue concentrations are largely known, the remaining step is to control these contributing factors and maintain these chemical residues at safe and market acceptable levels.

Can we reduce antimicrobial use and prevent mastitis?

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Summary

- Antimicrobial resistance (AMR) presents a threat to both human and animal health. Appropriate use of antimicrobials is necessary to limit AMR.
- Cows with an SCC <200,000 consistently in lactation given blanket dry cow therapy (DCT) may represent unnecessary use of antimicrobials. Selective administration of DCT to infected cows only represents more prudent usage.
- Infusion of teat seal (TS) is effective in minimising the risk of new infections during the dry period, but requires strict hygiene. Accurate herd and animal selection is critical when considering adopting TS only strategies.

Introduction

The World Health Organisation defines antimicrobial resistance (AMR) as "resistance of a microorganism to an antimicrobial drug that was originally effective for treatment of infections caused by it". Antimicrobials include antibiotic, antiviral and antifungal treatments. Interest in AMR has gathered traction over the past number of years with the emergence of multi-drug resistant "superbugs". A number of these "superbugs" represent a serious threat to human health. It is estimated that each year, drug-resistant infections result in 25,000 patient deaths and cost the EU €1.5 billion in healthcare costs. Any use of antimicrobials (e.g. in human and veterinary medicine) can result in the development of AMR. The risk increases if such antimicrobials are used inappropriately, for example, in an untargeted manner (e.g. mass medication). There is growing concern regarding the impact of antimicrobial use in agriculture on the emergence of antimicrobial-resistant bacteria.

The majority of antimicrobials used in dairy cattle are administered via the intra-mammary route. Blanket dry cow therapy (DCT) involves the administration of long acting antimicrobials into all quarters of all cows at drying off. In Ireland it is estimated 93% of herds use blanket DCT. The purpose of DCT includes treatment of existing infections and prevention of new infections. Due to the success of mastitis control programmes involving blanket DCT, regular milking machine maintenance and improved udder hygiene, many animals are now uninfected at drying off. In light of such trends, it has been suggested blanket DCT is no longer required, especially as concerns have been raised that blanket DCT represents an indiscriminate overuse of antimicrobials. Elsewhere stringent controls on availability of antimicrobials have been implemented. Potentially, similar restrictions will follow in Ireland (2015/C 299/04). Commission Notice: Guidelines for the prudent use of antimicrobials in veterinary medicine).

Selective dry cow therapy

Internal teat sealants have been shown to be effective in preventing new infections in the dry period. The seal forms a physical barrier in the teat canal preventing entry of bacteria capable of causing mastitis. When administering teat seal (TS) strict hygiene is ESSENTIAL (Figure 1). Failing to thoroughly disinfect the teats could allow the accidental introduction of bacteria and have disastrous consequences for mastitis control. Antibiotic treatment of cows at drying off based on infection status is known as selective DCT (SDCT). The addition of TS to a SDCT protocol ensures that all quarters have some protection against new infections. In herds with BMT SCC consistently <200,000, <2% clinical case rate in last three months and individual cow milk recording data available SDCT +/ TS may be worth considering.

Teat preparation pre-teat seal administration

- Wear clean gloves.
- Remove any dirt from the udder and teats.
- Scrub the teat end with cotton-wool swabs and surgical spirit or the disinfection cloths provided.
- Use a separate swab for each teat. Clean the teat end until the swab is completely clean.
- Clean the teats on the far side of the udder first.
- Infuse teat seal to teats nearest the operator first.

Figure 1. *Strict hygiene is essential when infusing teat seal.*

SDCT Study

A herd with consistently low bulk tank SCC was recruited to the SDCT study. The study was conducted in two concurrent years. At drying off cows were deemed eligible for inclusion if their SCC had not exceeded 200,000 and they had not presented with a clinical case of mastitis throughout the previous lactation.

Eligible cows were randomly assigned to Treatment 1 (TS only n=82) or Treatment 2 (TS plus antibiotic (Cefalonium) n=87). To determine SCC and bacteria present, quarter sampling was conducted at drying off (pre-treatment) and at three time points post calving. The effect of treatment on SCC at the cow and quarter level was ascertained at each time point. Preliminary analysis of results has revealed that although TS only cows had higher composite SCC levels across lactation, no difference was observed at the individual quarter level between treatments. To increase confidence in results, additional research is planned involving a greater number of cows and herds. Initial results, however, indicate that in appropriately selected herds/ cows, administration of TS only may be an effective mastitis control strategy that limits the unnecessary use of antimicrobials.

Heifer teat seal trial

Four to six weeks pre-calving, heifers from four separate herds were enrolled. Each heifer had TS infused in two quarters. The remaining quarters acted as controls. Quarter level sampling was conducted at similar time points to the SDCT trial. The study aim was to examine the association between TS administration and infection levels in the subsequent lactation. Results showed that teats not administered TS were between 1.99 ($P< 0.05$; mid-lactation) and 3.85 ($P<0.001$; first milking) times more likely to have bacteria present than those administered TS.

Conclusion

Antibiotics are a finite resource. They are a privilege we have become accustomed to, but future guaranteed access is by no means certain. While antimicrobials continue to be essential in safeguarding the health and welfare of our animals it is important we use them prudently, to obtain maximum benefit both therapeutically and economically, while also limiting development of AMR. Results from these studies have shown that prevention of mastitis using non-antimicrobial therapies is possible.

The California Mastitis Test (CMT): an important tool in the fight against mastitis

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Summary

- The California Mastitis Test (CMT) is a simple cow-side indicator of somatic cell count (SCC).
- A rapid and inexpensive technique for detecting subclinical cases of mastitis at an individual quarter level.
- It is good practice to CMT newly purchased cows to identify problems prior to milking them with your own herd.

Introduction

Bacteria in the udder cause the cow's immune system to respond by sending a large number of inflammatory cells to the udder and into the milk. These inflammatory cells, combined with a small number of body cells shed into the milk from the udder, are referred to as somatic cells. A somatic cell count (SCC) is a measure of the concentration of these body cells in milk. The SCC is quantified as cells per millilitre. As SCC is a measure of body cells, SCC does not increase after milk leaves the cow. The SCC is a way of estimating the likelihood of a cow having mastitis. Generally, uninfected cows have an SCC <100,000 cells/ml. If cow SCC increases above 200,000cells/ml it typically indicates infection has occurred.

SCC can be measured at

- Individual cow level: sample taken at milk recording.
- Herd level: sample taken from the bulk tank.

Herd level SCC provides a good overview of the udder health on the farm. Increasing bulk tank SCC indicates the presence of infected cows. In a herd where mastitis is under control, bulk tank SCC should be below 200,000 cells/ml.

Regular individual cow milk recording (ideally monthly) is one of the most important tools in tackling high SCC and mastitis. Individual cow SCC allows monitoring of the udder health of each cow. It consists of an amalgamated sample from all four quarters. This allows identification of problem cows that may be contributing to bulk tank SCC problems. Additionally, individual cow SCC may also help identify uninfected cows that may be suitable for selective dry cow therapy.

The California Mastitis Test (CMT) is a simple individual-quarter, cow-side indicator of SCC. It functions by disrupting the cell membrane of the cells present in the milk sample. This allows the DNA in those cells to react with the test reagent, forming a gel. It is a rapid and inexpensive technique for detecting subclinical cases of mastitis (starter kits containing paddle and reagent available for <€30).

Benefits to CMT include:

- CMT allows identification of an individual problem quarter, to allow targeted treatment. The test is subjective and false positive and false negative results can occur. The negative predictive value of CMT, however, (i.e. the probability that cows with a negative CMT truly don't have mastitis) has been reported to be >95%.

- When investigating a herd mastitis issue, it is recommended to take samples for milk culture from individual high cell count (>200,000) cows. CMT can aid identify which quarters to collect milk culture samples from, to maximise chances of detecting the causative bacteria. It is essential to know which bacteria e.g. *Staph. aureus, Strep. uberis* etc. are present to decide where to look for the problems and select appropriate management strategies.
- One of the most common ways of introducing contagious mastitis bacteria into a herd is through introduction of infected cows into the herd. CMT should be performed on all newly purchased cows to identify problem quarters, prior to milking them with your own herd.

Procedure to carry out a CMT

- Remove any dirt/ bedding from the udder and teats.
- Discard the first squirt of foremilk.
- Squirt milk from each quarter into a different well on the CMT test tray (approximately 2 ml from each quarter).
- Mix each milk sample with equal volume of reagent (available commercially).
- Swirl the mixture vigorously for maximum of 20 seconds and examine the degree of the thickening/ gelling in each sample.
- Gelling indicates High Somatic Cells in that Quarter.

Figure 1. *Californian Mastitis Test (CMT) may be used to identify subclinical infected quarters. The CMT estimates the SCC of milk by measuring the degree of thickening or viscosity when reagent is added to the milk sample*

Conclusion

CMT is a rapid and inexpensive technique to identify individual problem quarters. Become familiar with conducting and interpreting CMT and incorporate into your mastitis control strategies. It's worth it!

CellCheck - The national mastitis control programme

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Summary

- Based on the actual improved SCC performance nationally in 2015 relative to 2013, the increased milk value was worth almost €38million to the industry; approximately €11m to processors, and €27m to farmers.
- The proportion of herds with SCC<200,000 cells/mL increased from 39% in 2013 to 60% in 2015.
- The proportion of milk volume with SCC<200,000 cells/mL increased from 46% in 2013 to 64% in 2015.
- There has been a reduction in in-lactation intramammary use, from a high of 69.9 (defined course dose per 100 animals per year) in 2008 to 46.56 in 2015.

Introduction

While the removal of quotas in 2015 presented Irish farms with an opportunity to increase their milk production, it also brought with it the challenge of market volatility. Ensuring optimal udder health and milk quality is one way that suppliers and processors can maximise profitability, remaining competitive and sustainable in challenging markets and times. Based on economic research completed in the early years of the *CellCheck* programme, and the actual improved SCC performance in 2015 relative to 2013 alone, the increased milk value was worth almost €38 million to the industry; €10,816,276 to processors, and €27,129,108 to farmers.

Significant progress has been made nationally in the udder health of Irish herds, since the commencement of the *CellCheck* programme in 2011. The bulk tank SCC data within the national SCC database, established in recent years show that the proportion of herds and milk volume nationally with an annual average SCC <200,000 cells/mL increased from 39% to 60%, and 46% to 64% respectively, between 2013 and 2015. (Figure 1).

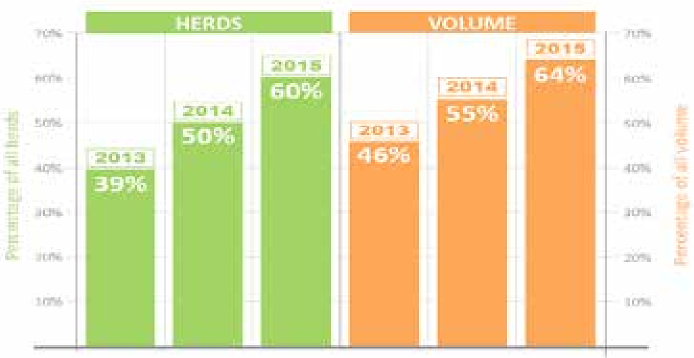

Figure 1. *Proportion of herds and milk volume with SCC <200,000 cells/mL*

Analysis of national sales data for intra-mammary products also shows a positive trend, with a reduction in the 'defined course dose' (DCDvet) for in-lactation products, which indicates a reduction in the number of mastitis treatments administered during lactation.

This analysis looked at sales data from 2003 to 2015, with DCDvet per 100 animals per year reducing to 46.56 in 2015 from a high of 69.91 in 2008. (Figure 2).

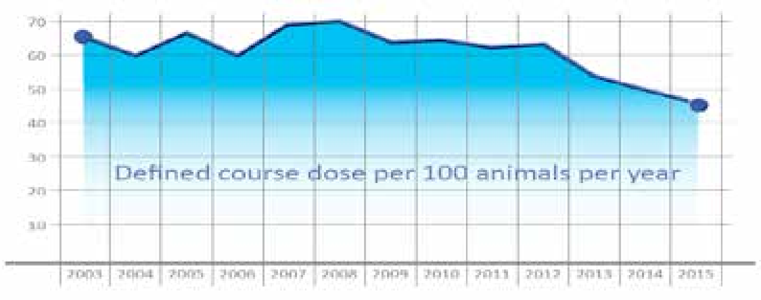

Figure 2. *Estimated on-farm usage of in-lactation intramammary antimicrobials in Ireland (2003-2015)*

Analysis of these datasets also highlights some of the ongoing and future challenges to continued progress in udder health in Ireland. The uptake of milk recording in Ireland is considered low in comparison to competitor countries, and 2016 has seen a reduction in the numbers of herds carrying out whole herd milk recording. (Figure 3). This may be as a result of the low milk price in that year; however this short-term saving has the potential to have a longer term negative impact on udder health in Ireland.

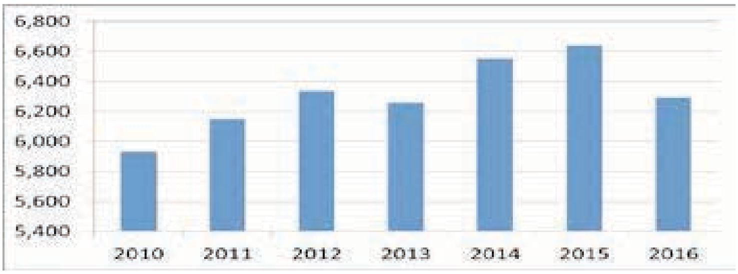

Figure 3. *Number herds milk recording in Ireland 2010-2016*

Similarly the analysis of national intra-mammary sales data suggests that blanket dry cow antibiotic therapy is practised on almost 100% of Irish farms, which in light of the increasing awareness and focus on prudent antibiotic use no longer aligns with international best practice and thinking.

While clear progress is being made, there are still opportunities to improve udder health nationally. The *CellCheck* programme has focussed on building awareness, knowledge and capacity to facilitate improvements in mastitis control. This has been done through the development of independent, science-based resources and training, for both service providers and farmers. These have facilitated engagement between service providers, and the development of regional networks. *CellCheck* also enhances the regional support network available to farmers in relation to mastitis control, and the consistency and quality of information available to them. There has also been an increasing emphasis on working with industry partners to ensure that suppliers receive clear, consistent signals about the desired quality of raw milk produced in Ireland. The establishment of a national SCC database, which allows trends in the national herd to be examined and the impact of the programme to be evaluated, has been another key achievement of the programme.

Conclusions

CellCheck will continue to work closely with stakeholders to identify the industry needs, and challenges, to continual improvement of udder health, and work with industry partners to develop targeted solutions to those challenges.

Improving the welfare of Irish dairy herds

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Summary

- Animal welfare is defined as how well the animal is coping with its environment.
- It is vital to ensure the welfare of Irish dairy cows is of a high standard for ethical reasons, to optimise cow productivity, and to maintain a positive image of Irish dairy production to address growing consumer concerns.
- Lameness is an important welfare concern and minimising lameness is a critical area for welfare improvement.

Introduction – what is welfare?

Animal welfare can be defined, broadly, as the extent to which an animal is able to cope with its environment. More specifically, whether its needs in three main areas are being met. These three areas are: 1) biological functioning – is the animal functioning well, i.e. is she healthy, producing milk, reproducing normally?; 2) affective state - is the animal feeling well, i.e. is she suffering unpleasant feelings such as pain, fear or hunger, or experiencing positive states such as pleasure associated with play?; 3) natural living – is the animal able to live a relatively natural life and express normal behaviour? Animal welfare is also often defined according to the Five Freedoms (Farm Animal Advisory Council, 1979); an animal has good welfare if the following Five Freedoms are satisfied: 1) freedom from hunger and thirst, 2) freedom from discomfort, 3) freedom from pain, injury and disease, 4) freedom to express normal behaviour and 5) freedom from fear and distress.

Why is welfare important?

That Irish dairy cows have a high standard of welfare is of great importance for many reasons. Firstly, we have an ethical duty to the animals in our care. Secondly, the welfare of cows is linked to their health; and therefore high welfare standards are likely to be associated with healthier cows and thus increased productivity. Finally, societal concerns regarding the welfare of dairy cows are increasing. In order to maintain Ireland's image as a sustainable, welfare-friendly producer of dairy products, which is essential for the marketing of Irish dairy products nationally and internationally, it is vital that the welfare of cows in our dairy production systems is demonstrated to be of a high standard. It is vital that the issue of cow welfare is addressed proactively so that herd expansion may be achieved without compromising dairy cow welfare.

How can welfare be measured?

Welfare can be assessed by measuring whether the environment and management provides the resources needed by the cow (resource-based indicators; e.g. does the winter housing provide enough cubicles for cows? 10% more cubicles than cows are required), and also by measuring the actual impact of the environment and management system on the cow herself (animal-based indicators; e.g., measuring the body condition score of the cow will tell us whether her nutritional needs are being met by the diet provided, locomotion-scoring of the cow to measure lameness will tell us whether her hooves are coping with the husbandry system in which she exists, records of disease incidence will tell us how the health needs of the cow are being met by the current management system, the presence of skin lesions indicates a lack of "cow comfort" in her environment). Animal-based measures are considered to be a more direct measurement of welfare, as they more closely reflect the animal's experience.

Figure 1. *Indicators of poor welfare in dairy cattle (from left to right); poor BCS, lameness, high levels of disease, skin lesions*

Have we measured the welfare of Irish dairy cows?

Previous research at Teagasc has demonstrated that there are welfare benefits associated with pasture-based systems compared to indoor systems of milk production. One study showed that cows at pasture had longer lying times and lower levels of lameness than housed cows, and another demonstrated that reproductive health in grazing cows was better than in cows that were housed. It is likely that the standard of welfare in general on Irish dairy farms is high. However, there is little published data available at present to support this. One of the aims of the Teagasc research program over the next year is to carry out an epidemiological study to assess the welfare of Irish dairy cows and identify risk and protective factors for cow welfare; this will provide valuable information to the industry, and allow Teagasc to identify areas for improvement and prioritise further research required.

How can welfare be improved on farm?

Very generally, a high standard of dairy cow welfare can be ensured by adhering to the principles mentioned above; i.e. by ensuring that cows have proper access to a diet that meets their nutritional requirements, that the housing and pasture provided are appropriate, that herd health management plans are in place to minimise disease levels and that sick animals are treated correctly and promptly, that appropriate pain-management is used when required, that cows are kept in a manner that allows them to express natural behaviour (such as grazing and oestrus behaviour in cows, play behaviour in calves) and that management procedures are in place to minimise fear and distress, i.e. that stockmanship is good and that cows are handled gently.

Lameness is widely regarded as of the greatest welfare problems of dairy cows, with up to 25% of cows estimated to be lame worldwide. Taking steps to minimise lameness within the herd is a critical area in order to improve overall levels of welfare. Lameness prevention involves: 1) management of cows and environment to minimise risks to hoof health and 2) institution of an effective hoof care programme to promote healthy hoof growth, and to achieve early identification and treatment of lame cows. This is detailed further in the paper *"Lameness in Dairy Cattle"*.

Conclusions

The welfare of dairy cows in our care is an issue of growing importance. It is vital that every step is taken to ensure a high standard of welfare in our production systems, to ensure our ethical obligations to the cows in our care are met, and to demonstrate that Irish dairy products are produced in a welfare-friendly, sustainable manner, in order to maximise the productivity of the Irish dairy industry.

ProWelCow: Understanding risks and protecting Irish dairy cow welfare

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Summary

- Dairy cow welfare can be compromised in expanded herds by lack of investment in infrastructure and poor management/herding practices.
- Nationally, the current absence of animal-based welfare indicators in the Sustainable Dairy Assurance Scheme (SDAS) and the need for research on new welfare traits for inclusion in the EBI need to be addressed.
- Protective factors for cow welfare include the benefits of pasture access for cows, Co-Op welfare initiatives and our good national agri-dissemination infrastructure.

Introduction

ProWelCow was a one year project (DAFM RSF 14/S/890). It aimed to understand risks to cow welfare associated with expansion in the dairy industry to develop protective recommendations. A summary of the key findings from the four main tasks is outlined here.

Task 1 - Breeding for better welfare

The multifactorial nature of animal welfare means there is no single 'welfare' indicator ('trait'). Many existing indicators of relevance to cow welfare do not fulfil the criteria for inclusion in a breeding index (e.g. not easily measured). Nevertheless, several existing EBI traits have relevance to welfare. Important areas where genetics play a role in improving cow welfare are in reducing the high incidence of painful diseases such as lameness and mastitis. These traits are included in the health sub-index of the EBI. However, while high EBI cows show less lameness, there has been no improvement in genetic merit for lameness in recent years (see paper by Ring, page 75). Hence there is a case for strengthening the current weighting on lameness to protect cow welfare. While SCC is in the health sub-index, the absence of data on clinical mastitis means high accuracy of selection for mastitis itself is not possible. Finally, all traits in the current index are solely derived from their economic impact and take no account of societal implications. There is a need for research to identify new welfare traits, derive weights and on improving routine access to data.

Task 2 - Stakeholder perceptions about cow welfare

Semi-structured interviews were conducted with 30 dairy industry personnel. Welfare was seen by most as an essential component of the 'Green Ireland' brand. However, a common view was that cow welfare was not a problem within the industry and that measures were already in place to protect it; such complacency could pose risks to cow welfare. On the other hand, interviewees across several stakeholder groups recognised the potential threat to welfare posed by herd expansion and an over-riding focus on low-cost production. This is encouraging, as an awareness of the possible risks means that proactive steps to mitigate them are likely. Low financial viability and mental health challenges for farmers were seen by many as risks for cow welfare. Increasing demands from international buyers were cited as being the most important factor driving increased focus on cow welfare in the industry. Bord Bia's SDAS was generally well regarded though some thought it should be extended to better address cow welfare issues. There was a perception that more focused training of Teagasc/Co-Op advisors in cow welfare would improve their dissemination of relevant knowledge.

Task 3 - Current management, housing and herding practices on Irish farms

Dairy farmers (n=115), cattle vets (n=60) and Teagasc advisors (n=48) were surveyed in 2015. Unsurprisingly, the majority (77%) of farmers increased herd size in the previous three years. More farmers who expanded invested in the milking parlour (93.5%) than those who did not expand (6.5%). This is encouraging as it indicates that cow welfare is not likely to be adversely affected by inefficiencies in the milking process. However, there was no more investment in housing, roadways or handling facilities on farms that expanded than on those that did not. Vets (90.0%) and advisors (87.5%) agreed that the best way to herd cows is on foot. However, more than 30% of farmers used quads/tractors; on those farms, herds were larger than where cows were herded on foot (152.7 vs. 99.0 cows). Farms with the longest distance to the furthest pasture (884.4 m) were also the largest. The lack of investment in roadways combined with potential for faster herding and longer walking distances in large herds pose lameness risks. Furthermore, given that cows were housed for c. 3.6 mths, the lack of investment in housing poses risks of overcrowding/social stress; indeed 32.9% of farmers provided less than one cubicle per cow. Almost one third of respondents in the three groups reported that social stress was the primary welfare issue for cows in expanded herds. However, stakeholders differed in their perception of the primary cause of poor welfare. Low BCS was ranked as the main welfare issue by a higher proportion of farmers (72.2%) than vets (13.9%) or advisors (13.9%). Most vets selected lameness as the main cause of poor welfare (28.3%), followed by farmers (13%) and advisors (2.2%). This task identified a need for better knowledge dissemination on cow welfare across, and better communication between, stakeholder groups. It is possible that poor BCS, overcrowding and lameness are all potentially important causes of poor cow welfare in expanding, low cost, pasture-based systems.

Task 4 - Evaluation of dairy assurance assessment schemes in four EU countries

Four assurance schemes were evaluated: Bord Bia's SDAS; RSPCA/Freedom Food's AssureWel (UK); Friesland Campina's Cow Compass (NL) and Arla's Arlagarden (DK). Assurance of cow welfare standards was implied to a lesser (SDAS) or greater (AssureWel) extent in all schemes but all, excluding the RSPCA's AssureWel (and possibly Cow Compass), were deficient in this regard. One of the main concerns relates to the credibility of the standards underpinning the schemes. It was not always obvious that the stated benefits to animals and consumers were justified because of the lack of objective data to support them. Most of the indicators used were poorly defined and not science-based and little information was provided to assessors on how to measure them. No scoring scales or sample size estimations were provided and there was no information on their validity for on-farm use. Very often it was difficult to measure objectively on farm that which was promised by the standard. Many of the schemes (especially the SDAS) relied more heavily on the inspection of records than of resources and the animals themselves even though the latter are of more relevance to animal welfare.

Conclusions

Welfare-centric farm investment and management and improvements in the EBI and the SDAS could protect cow welfare.

Lameness in dairy cattle

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Summary

- Lameness is a major health and welfare problem of dairy cows; causing pain for the cow and economic loss (€300/year/clinically lame cow).
- Risk factors for lameness include those related to the cow, management, and the environment.
- Risk factor management and institution of an effective hoof care program are key to prevention of lameness.

Introduction – Why is lameness important?

Lameness can be broadly defined as a deviation from the normal walking pattern of the cow, which refers to a gait with four evenly spaced beats with no suspension phase. Research indicates that approximately 25% of cows are lame worldwide. Pasture-based systems of dairy production have been associated with lower levels of lameness than indoor systems. However, some studies have reported lameness levels of up to 42% in grazing herds.

Lameness is one of the greatest health and welfare problems currently facing the dairy industry, resulting in pain and suffering for the cow and productivity losses on farm. Economic costs result from reduced milk production, veterinary treatment and milk withdrawal, but also the often-hidden, indirect costs of reduced fertility, an extended calving interval and increased culling. As herd sizes expand post-quota abolition, and distances walked by cows increase, lameness is likely to become a bigger problem on Irish farms and one it is critical to address.

Causes, risk factors and prevention of lameness

A number of diseases cause lameness in cattle (Figure 1), and cows are predisposed to developing these diseases by certain risk factors which negatively impact claw structure and function (Table 1). Preventing lameness in the first instance is the most important means by which lameness in a herd may be reduced. Lameness prevention involves: 1) management of cows and environment to minimise risks to hoof health and 2) institution of an effective hoof care programme to promote healthy hoof growth, and to achieve early identification and treatment of lame cows. Regular locomotion scoring of cows (https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/lameness/husbandry-prevention/mobility-scoring/#.WSaeHnmFPwp) is key to identify those that are lame (moderately and severely lame cows, but also mildly lame cows which may require corrective trimming to prevent lameness progressing).

Figure 1. *Important lameness-causing diseases of the bovine hoof (from left to right); white line disease, solar ulcer, digital dermatitis, foul-in-the-foot and heel horn erosion*

Table 1. Risk factor management to prevent lameness			
Category	Risk Factor	Effect	Prevention
Environmental	Rough/poorly-maintained walkways	Mechanical trauma to hoof	Maintenance of roadways (free-draining, stone-free)
	Poor hygiene and standing in slurry	Softening of claw horn/skin → bacterial growth	Ensure indoor housing clean/dry
	Inadequate number of cubicles when housed	Increases standing time and stress on hooves	Provide 10% more cubicles than cows
	Inadequate space in collecting yard	Slipping/falling → trauma to hoof	Provide adequate space (≥1.5 m^2/cow)
Management	Poor handling of cows when herding	Cows rushed → trauma to hoof	Allow cows to walk at their own pace
	No routine locomotion scoring/claw inspection	Lameness not detected early enough → poorer recovery rates	Locomotion score at least monthly to identify cows in need of claw trimming/ treatment*
	No footbathing programme	Facilitates spread of infectious organisms	Footbath** weekly when at pasture, more frequently when housed
Nutritional	Low body condition score	Fat pad in hoof reduced → lack of cushioning and support in hoof	Ensure appropriate BCS, particularly post-calving
Animal	Early lactation	Physiological changes weaken support in hoof	Management of all risk factors particularly important in these cows
	Previous lameness episode	Weakens hooves → ↑chance lameness will recur	Prevent lameness! (particularly important in heifers)

**Treatment of individual diseases should be carried out in consultation with the herd veterinarian. Hoof-trimming improves hoof shape and horn quality, but should be done by an appropriately-trained person, as poor trimming technique can cause more damage than no trimming at all. ** Footbaths should be built according to proper construction guidelines and appropriate disinfection agents used (e.g. copper sulphate or formalin). https://dairy.ahdb.org.uk/non_umbraco/download.aspx?media=1347; https://www.youtube.com/watch?v=mC8y65aKc44; http://www.lamecow.co.nz/pdf/Footbaths.pdf*

Conclusion

Lameness is an important welfare issue and cause of economic loss. Prevention of lameness through risk factor management and early identification and treatment of lame cows is key to reducing lameness in the herd.

Why do calves die at calving and what can you do about it?

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Summary

- Dairy herd expansion has prompted concerns about calf health, mortality and welfare, particularly in large herds.
- Recent Moorepark research in commercial dairy herds has shown that the main reason calves die at calving is lack of oxygen (anoxia) at unobserved, prolonged and difficult calvings.
- Many of the causes of death are not detectable without a post-mortem; farmers are encouraged to submit dead calves to the local Regional Vet Lab.

Introduction

With the success of herd expansion and improving herd fertility, dairy farmers are now facing into shorter but busier calving seasons, especially in larger dairy herds. This has prompted concerns that calf health and welfare could be compromised. In order to address these concerns Teagasc, Moorepark is conducting a large scale research study on calf survival in commercial dairy herds. The most recent results for 2017 are reported.

Methods

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. The majority of calves submitted were stillborn (84%; n=259, with 21 placentas), the remainder were aborted (12%; n=36) or young calves (4%, n=15). Farmers provided details of the dam, sire, calf and calving and all calves were subjected to post-mortem examination and testing at multiple laboratories (DAFM, Farmlab and SAC).

Results

The top five reasons why calves die at calving are lack of oxygen (e.g. at prolonged, unobserved calvings), calves not presented correctly, (e.g. at difficult calvings), birth defects (e.g. in calves with a blocked bowel; 'waterbelly'), haemorrhage or anaemia, (e.g. bleeding before/during calving) and the placenta (cleaning) separating prematurely (Table 1). Cows that lost calves at calving were bred primarily to Holstein-Friesian sires (59%), but with a substantial percentage (28%) by natural service (NS) bulls. These cows were in normal body condition (BCS = 3.2) and calved at term (279 days) but with a substantial percentage (38%) of first calvers. The stillborn calves were predominantly male (60%) with a normal birth weight (average 32 kg) but with a substantial percentage of calves with defects (33%) and twin calves (11%). The observed calvings of these stillborn calves were, on average, an hour long but varied widely (3-360 mins). Mineral deficiencies were not commonly diagnosed with <5% of calves having goitre (iodine deficiency).

For calves that die during a hard calving, the main causes of death are malpresentation, anoxia (lack of oxygen) and a pre-existing congenital defect. In contrast, for calves that die at an observed but unassisted calving, the main causes of death are birth defects, anoxia and haemorrhage/anaemia. Where the calving was not observed, the main causes of death are anoxia, haemorrhage/anaemia and birth defects. Unobserved calvings have the highest incidence of unexplained stillbirths (21%, Table 1).

Table 1. Causes of death in calves (n=259) in each calving assistance category						
Cause of calf death (%)	Not seen calving (n=70)	Seen, no assistance (n=46)	Easy assistance (n=57)	Slight difficulty (n=47)	Hard calving (n=39)	All calvings (n=259)
Anoxia	30	17.4	14	12.8	20.5	19.7
Mal-presentation	0	2.2	17.5	34	43.6	17
Congenital defect(s)	10	21.7	12.3	10.6	12.8	13.1
Haemorrhage	14.3	15.2	10.5	2.1	2.6	9.7
Placenta separated	1.4	2.2	19.3	23.4	2.6	9.7
Other	22.9	21.7	14.1	12.8	17.9	18.1
No significant findings	21.4	19.6	12.3	4.3	0	12.7

Discussion

Many of the causes of death diagnosed in this study are not detectable without a post-mortem examination, yet <5% of dead calves go to a Regional Vet Lab (RVL). This is an area where farmers could improve herd health and ensure the future viability of their local RVL. Other areas farmers could address include checking the calving difficulty SI particularly of beef sires (69% of calves >45 kg were beef-sired), recording service dates of NS bulls (34% of unobserved stillbirths were NS-sired), asking the vet when scanning cows to check for twins and calf sex (74% of stillbirths at hard calvings were male) and improving calving supervision (extra seasonal labour, investing in calving monitoring technology, e.g. cameras, sensors) to reduce the number of unobserved calvings (27%).

Farmers appear to be managing the nutrition of dry cows well with <10% of cows over-conditioned (BCS >3.5) and trace element deficiencies not common, but lack of progress during calving was reported in 11% of cases, suggesting possible milk fever.

Since the inception of this research study, this sentinel herd model of animal health surveillance has now been adopted by DAFM for both calf and lamb mortality. In addition, the high incidence of abnormalities detected here has stimulated the establishment of a national congenital defects register and a joint research project between Teagasc Moorepark and Grange, the six RVLs nationally and ICBF.

Conclusions

The causes of calf death differ between unassisted and difficult calvings with anoxia predominant in the former and malpresentation in the latter. Farmers can reduce calf mortality by selecting low calving difficulty beef sires, recording stock bull service dates, scanning cows for twins and foetal sex, improving calving supervision, and by utilising results from calves submitted to the local Regional Vet Lab.

Optimising calf immunity

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Summary

- Measuring colostrum quality prior to feeding is essential if all calves are to achieve good levels of immunity, and become healthy and productive animals.
- Research at Moorepark has identified that while the immune status of heifers tends to be lower than that of cows, the quality of colostrum produced by both is similar.
- The Brix refractometer is a relatively inexpensive piece of equipment that can be used on Irish farms to provide a quick and accurate estimate of colostrum quality. Colostrum should be at least 22% on the Brix refractometer if given to calves for their first feed.

Introduction

Providing calves with a sufficient volume of good quality colostrum, in the first two hours after birth, is essential to achieve an adequate level of immunity. Colostrum quality is determined based on the immunoglobulin, or antibody, concentration, and colostrum with an antibody concentration of 50 mg/ml, or greater, is described as being of good quality. Anything below this is described as poor quality, and regardless of feeding time, can leave calves with weak immune responses, and increases their risk of experiencing health issues. This not only affects short-term health, but can also have a negative effect on long term health and production in later life. By measuring colostrum quality, poor quality colostrum can be identified and withheld, ensuring each calf receives colostrum capable of providing them with a sufficient level of immunity. Currently, little is known on the length of time antibodies to a range of diseases (e.g. IBR) present in colostrum remain active in the calf's bloodstream, and such information could prove significant in improving calf health, not just in the first days and weeks of life, but in the months thereafter.

Colostrum quality

Research at Moorepark has investigated the quality of colostrum produced by over 700 dairy cows in Teagasc research herds using a laboratory based method, internationally recognised as the gold standard test for colostrum quality. The quality of these colostrum samples had a large variation, and IgG concentrations ranged from 13-256 mg/ml, with approximately five per cent of samples falling below the 50 mg/ml quality threshold. A survey carried out at Moorepark identified that on-farm measuring of colostrum quality is not commonly practised in Ireland, and an increased uptake of this practise could contribute to an improvement in calf health and performance. Currently, a quick and accurate method of estimating colostrum quality on farm is through the use of a Brix refractometer (Figure 1). A study at Moorepark evaluated the brix refractometer as a method of estimating colostrum quality, by using this method and comparing it to that of a laboratory based method. This revealed that the brix refractometer provides a good estimation of colostrum quality; values of 22% Brix had ≥50 mg/ml antibody concentration and were suitable to feed to calves as their first feed.

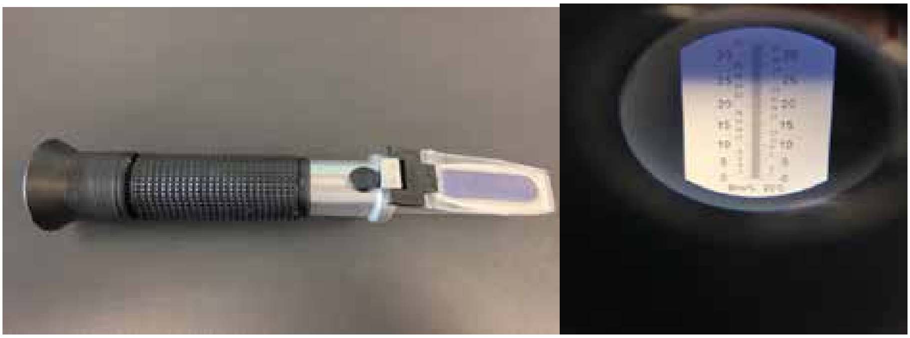

Figure 1. *On the left is a Brix refractometer and on the right is the scale observed through the refractometer. When using a refractometer the measurement is recorded at the point where the white and blue colours converge, and for this image the colostrum is estimated to have a Brix value of approximately 25%*

Heifers colostrum

A perception exists among some farmers that colostrum produced by heifers is not of sufficient quality to feed to calves. A recent study at Moorepark investigated the immune status of cows and heifers prior to calving, through blood sampling for a range of diseases, and also examined the quality of colostrum produced by the same group of animals after calving. This revealed that while the immune system of heifers has been subject to fewer disease challenges, the IgG concentration of their colostrum was on average, similar to that of cows. Despite lacking comprehensive immunity, and a fully developed mammary gland, heifers have the ability to produce colostrum capable of providing their offspring with an adequate level of immunity, dispelling doubts held by some. Based on this research, colostrum from heifers should not be discarded indiscriminately, but should be subject to the same quality testing as that of colostrum produced by cows, before a decision is made on its use.

Antibody depletion

Disease specific antibodies present in colostrum provide immunity for a limited period of time, and little is known on the length of time these antibodies remain present. By investigating this, information could be gathered on periods of increased susceptibility to specific diseases, and management practises that may be required at these times. One such management practise would be the timing of commencing calf vaccination programs to minimise periods of susceptibility to infection. A study at Teagasc Moorepark is currently investigating this, and will document changes in antibody levels, specific to a wide range of diseases, in calves, during the early stages of life.

Conclusion

To ensure calves get off to the best possible start in life, good quality colostrum is required. This can come from heifers or mature cows, and quality can be measured quickly and accurately on-farm using a Brix refractometer.

Reducing labour associated with calving and calf rearing

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Summary

- Calf rearing has a high labour demand; labour input associated with calf rearing averaged 1.4 h/cow/year on labour efficient farms.
- Feeding silage to cows at night-time pre-calving may reduce the number of cows calving by night.
- Calf feeding practices such as using high quality colostrum from another healthy dam for the first feed and once-a-day feeding of milk from four weeks of age can reduce labour input.

Introduction

Labour is an important issue on Irish dairy farms and calf rearing is a major contributor to increased labour demand during spring-time. In a recent Moorepark study, the labour input associated with calf rearing ranged from 0.48 h/cow/yr to 2.85 h/cow/yr (average 1.4 h/cow/year) on 38 labour-efficient farms. All calves were fed manually with colostrum through a stomach tube on the most labour efficient farms. Alternatively, a combination of practises of unassisted suckling of the dam and feeding colostrum from a bucket (without a teat) was used on the least efficient farms. Calf houses occupied by the youngest calves were situated between 5 m and 20 m from the milking parlour on the most efficient farms. Alternatively, calf houses with similar aged calves were situated between 15 m and 500 m away on the least efficient farms. In addition to these aspects there are further practices which can be implemented to reduce the labour requirement in spring-time.

Feeding of silage at night to pre-calving cows

In the Irish spring-calving milk production system, farmers attempt to have the majority of cows calving during a 12-week period. Most labour is available on farms between 06:00 and 17:00 h, and during this time maximum supervision may be given to calving. However, calving events outside of this time can put a strain on labour resources and can also result in less supervision at calving. A study was carried out to investigate the effect of restricting the duration for which silage was made available to cows on time of calving and calving performance in Holstein-Friesian cows. Silage feeding time was restricted to between 20:30 and 10:30 hours in the days prior to the expected calving date. This tended to result in less cows calving by night compared to cows with full access to silage.

Overall silage intake, gestation days, calf weight, calf mortality and cow body condition score were not affected by feeding regimen. Feeding silage to cows in small groups, in the evening, after an extended period of restricted access appeared to give the optimum result in limiting the number of calving events occurring by night. It is critical that placement of feed is completed during normal working hours and that cows have adequate feed face when silage is made available.

Colostrum source

Feeding colostrum from the calf's own dam is generally considered to be the best practise; however this can be a very laborious task in a spring calving system. It means that regardless of calving time, each cow must be milked immediately after calving and colostrum maintained separate from other milking's before feeding to the calf. Using colostrum from another single cow (other dam) can reduce the labour requirement associated with calf management as this eliminates the need to milk every cow immediately after calving. Instead, freshly calved cows are milked at the next milking time, only colostrum from healthy cows, calved within eight hours of milking, is collected, and all colostrum is tested using a Brix refractometer to ensure it is over 22% (see paper by Barry, page 152). If it is under 22% it is not suitable to give to the calf as it's first feed as quality is too low. A recent study at Moorepark compared the effects of feeding colostrum from the calves own dam and from another single cow (not the calf's dam) on calf health and performance, all colostrum quality was assessed prior to feeding. This showed that when good colostrum management practises (feeding a sufficient quantity, in a timely manner, from healthy cows) and good hygiene practises were applied, no difference was observed in the health and performance of calves receiving colostrum from their own dam or from another dam. If colostrum is stored in order to feed another calf, it should be refrigerated immediately after collection to limit bacterial growth. Colostrum quality can be maintained at 4°C for 48 hours. After this time unused colostrum should be discarded. Frozen colostrum lasts for a year if frozen immediately after collection.

Feeding colostrum

Substantial labour input is required when a large number of cows are calving simultaneously; the separation of colostrum and transition milk is laborious and can be prone to error. This difficulty may be overcome by commencing milk replacer feeding immediately after the first feed of colostrum. This can also be considered as a good practice for herds with Johne's positive cows. A recent experiment at Moorepark showed that once calves received 8.5% of their birth bodyweight (e.g. three litres for a 35 kg calf) in the form of high quality colostrum (tested with a Brix refractometer and found to be greater than 22% on the Brix scale) within two hours of birth, weight gain pre- and post-weaning, respectively, was similar to that of calves fed colostrum and four feeds of transition milk before moving to milk replacer. This suggests that in well managed systems, especially where the transfer of disease may be an issue, milk replacer can be offered immediately after colostrum. However, if there are issues with rota or corona virus and cows are vaccinated, calves should be fed transition milk for a number of days to reduce the risk of a scour outbreak.

Once-a-day milk feeding

Labour input per calf may be reduced by utilizing a once a day milk feeding regime in the knowledge that it has no unfavourable repercussions on the growth and health of calves. However, once daily feeding <u>before calves are four weeks old</u> can create health concerns by overloading the abomasum and EU regulations also state calves need to be offered liquid feed twice daily, up to 28 days of age at least. In a recent Moorepark experiment calves fed milk replacer to a level of 15% of their birth weight (six litres) from four weeks of age, either once daily or in two equally divided feeds, did not have an increased likelihood of developing diarrhoea. No differences in calf performance or health were observed between calves fed once or twice a day. However, even if feeding on a once a day basis, they still need to be checked thoroughly twice a day and offered solid feed as a second feed. Once a day milk feeding also allows the opportunity to feed calves in an off peak time during the day.

Conclusions

Although calf rearing is extremely labour intensive there are practices which can be implemented to reduce the labour requirement during the busy spring period. An appraisal of calf rearing systems should be carried out during the quieter months on the farm to ascertain what improvements can be made for the forthcoming season.

Replacement heifers: Achieving target weight

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Summary

- A successful heifer rearing programme has defined targets such as achieving a specified weights or calving between 22 and 26 months of age.
- Feed conversion efficiency is greatest in the young calf and should be taken advantage of – proper pre-weaning feeding improves post-weaning weight gain.
- Important that all heifers achieve target weight individually i.e. minimise the difference between the lightest and heaviest heifers in the herd.

Introduction

According to ICBF data, for the past five years average herd replacement rate is over 20% in Irish dairy herds, an increase of almost three per cent compared to previous years. Consequently, a greater number of replacement heifers need to be reared to meet requirements. ICBF data also indicates that only 59% of heifers are calving at the targeted 22 – 26 months of age. The top five per cent of herds (based on data from HerdPlus® dairy calving reports) calve 100% of their heifers within the target age range, while farmers in the bottom five per cent calve none of their heifers at the correct 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 26 months of age. In order to recoup the investment made while rearing a replacement heifer a cow needs to complete 1.63 lactations. Recent Teagasc data shows that 16.5% of Irish cows do not survive beyond the mid-point of their second lactation; consequently, their rearing costs are not fully paid off. Achieving specified targets while rearing replacement heifers is an integral component of the system, especially when aiming to maximise return on investment.

Pre-weaning nutrition

Good nutrition is fundamental to animal health, welfare and productivity. 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. Moorepark research shows that average daily gain (ADG) during the pre-weaning period affects BW post-weaning; this may have repercussions on the attainment of target live-weight at mating start date (MSD). Data from the US also shows calves fed a higher plane of nutrition during the pre-weaning period have previously been shown to have improved growth performance, greater feeding efficiency, reach sexual maturity at a younger age, have more mammary parenchymal tissue and produce more milk as a lactating animal. This theory is currently being investigated at Moorepark using heifers in a pasture based system. A recent Moorepark experiment showed 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 10-15% of mature BW when they were weighed again at 190 days (approx. six months old).

Target weights

Bodyweight and body condition score (BCS) are of greater importance at MSD than age, i.e. heifers can be less than 15 months at MSD but should not be greater than 17 months of age. Every heifer rearing program should have a target BW or proportion of mature BW to achieve 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.

Table 1. BW targets (kg) for maiden heifers at weaning, six months, breeding and pre-calving

	Weaning	Six months	Breeding	Pre-calving
% Mature Weight	18	30	60	90
HF	105	175	350	525
NZFR*HF	100	165	330	495
NR*HF	105	175	350	525
J*HF	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 using weighing scales from weaning onwards. When heifers are brought back to the yard for dosing every 6 – 8 weeks their 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. It is important to minimise the difference between the lightest and heaviest heifers in the herd. The target weights are for individual animals rather than to a group average. If weanling heifers are below target weight they should be supplemented with concentrate and given preferential access to high quality grass, 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.

First winter

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. 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.

Conclusion

Through correct feeding and continuous monitoring from the day the calf is born target weights can be achieved. Reaching these targets will result in more productive cows when they reach the lactating herd. Furthermore, these animals should last in the herd for greater than two lactations which will result in the initial investment during the rearing phase being recovered, thereby allowing cows to generate a profit for the remainder of her lactations.

Ensuring your herd stays healthy

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Summary

- Control of BVD, IBR, and liver fluke in Ireland is improving, and the national prevalence of these diseases is declining.
- The prevalence of *Salmonella* and Neospora, however, are worsening and further controls require implementation.
- The impact of any infectious disease will be reduced by implementing an on-farm health plan incorporating biosecurity, diagnostic testing and strategic vaccination.
- Greater awareness of infectious disease control now exists amongst dairy farmers, but improvements are needed to mitigate both existing and emerging infectious diseases.

Introduction

Diseased animals decrease on-farm efficiency and profitability through poor performance, waste feed, labour, and veterinary costs. Animal health is also an important contributor to the international competitiveness of Irish dairy products, both as a result of the impact of animal disease on product quality, and because of the special importance of animal health in international trade. Ireland has made considerable strides in on-farm health planning through Teagasc and Animal Health Ireland co-ordinated initiatives. A system of continuous improvement is required, however, to maintain and grow market share, as well as improving animal welfare, productivity and competitiveness.

Herd health programmes employ a combination of biosecurity, vaccination and diagnostics to determine the health status of a herd. The health profile of a dairy herd will determine its success in terms of milk production, reproductive status and growth rates (i.e. the key aspects in a successful dairying operation). In the past, farm health planning and biosecurity have been imposed on Irish dairy farmers through TB and brucellosis eradication schemes; voluntary practice has never been promoted nor encouraged. We are now in an era of farmer driven testing and awareness schemes, coordinated by Teagasc and Animal Health Ireland. A major focus has been placed on BVD, IBR, and liver fluke. The improvements in the control of these diseases between 2009 and 2014 can be seen in Table 1.

Despite improvements for some diseases, the prevalence of *Salmonella* and Neospora is worsening. Combined, these two diseases are responsible for the highest proportion of bovine abortions in Ireland in the past decade, and can be economically devastating at individual farm level. Teagasc, Moorepark has shown that total annual profits in unvaccinated herds are reduced by €77.31, €94.71, and €112.11 per cow at a milk price of 24.5, 29.5, and 34.5 cents per litre as a result of exposure to *Salmonella*. This can lead to losses of up to €11,000/year in a 100-cow spring-calving dairy herd (O'Doherty et al., 2015). The vast majority of these losses can be recouped by implementing an annual vaccination programme, and all dairy farmers should now vaccinate against this disease. Although not as significant in terms of on-going losses, Neospora can also result in annual losses (up to €1,500 annually). Individual herd outbreaks, however, cost considerably more depending on the level of foetal loss.

Table 1. Changes in prevalence of disease bulk milk seropositivity and vaccination status in Irish dairy herds between 2009 and 2014

Disease	November 2009		November 2014	
	BM antibody prevalence	Vaccination prevalence	BM antibody prevalence	Vaccination prevalence
BVD	93% (UV) 0.7% PI 2013*	63%	95% (UV) 0.15% PI 2016*	53%
IBR	80% (UV) 100% (V)	12%	72% (UV) 80% (V)	56%
Salmonella	55% (UV)	49%	65% (UV)	57%
Leptospira	86%	76%	n/a	n/a
Neospora	9%	n/a	18%	n/a
Liver Fluke	75%	n/a	55%	n/a

UV: unvaccinated V: vaccinated BM: Bulk Milk

Components of a herd health plan

- Keep the plan simple, realistic, and achievable. Use the combined knowledge of both you and your vet with regard to the disease status of your farm and your locality. At a minimum, a written herd health plan should identify actions to address the main disease risks: is the farm operated as an open or closed herd?
- Does the farm have disease-proof and secure boundaries, including out-farms?
- Does the farm use external contractors and for what service?
- Is slurry imported (not recommended)?
- What are the isolation procedures for sick and dead animals? Do not use calving pens to house sick animals.
- What is the cleaning schedule for housing and yards?
- Are there additional biocontainment procedures to be introduced or maintained around the farm e.g. wildlife control, clean veterinary equipment, footbaths etc.?
- What is the disease testing plan for the farm?
- What is the vaccination plan for the farm?
- What is the dosing plan for the farm (have a strategy for liver fluke, lungworm (hoose), gutworms, cryptosporidium, coccidiosis, and rumen fluke)?
- Is there a purchasing plan if stock are to be bought onto the farm?

Conclusions

Vaccines, anthelmintics, and antibiotics play a hugely important role in the control of many infectious diseases. Their use, however, without the supporting knowledge provided by diagnostic testing and the implementation of a biosecurity plan, could potentially undermine their effectiveness in a disease control programme. They should be viewed as a component of a control programme but not the sole means of disease prevention. Use all medicines responsibly, according to manufactures instructions and seek advice from your veterinary practitioner if required. Instructions for the majority of medicines licensed in Ireland are available on www.hpra.ie. Finally, in an era where antibiotic resistance is becoming an ever increasing worry, each antibiotic treatment needs to be fully justified.

Controlling Johne's disease on an Irish dairy farm

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Summary

- Due to the speculated link between Johne's disease (JD) and Crohn's disease, control of JD is important to maintain high milk quality status for international markets.
- Reductions in JD can be achieved through restricting purchasing, implementing colostrum/ calving area management changes based on test results and improving on-farm hygiene. Long term commitment is required however, when implementing JD programmes.
- Hygienic management practices implemented as part of a JD programme can help improve overall calf health.

Introduction

Johne's disease (JD), an incurable diarrhoea, is caused by *Mycobacterium avium* subspecies *paratuberculosis* (MAP). Thickening of the intestines occurs as the disease progresses, preventing absorption of nutrients, leading to weight loss and diarrhoea. Infection with MAP most commonly occurs in calves, but clinical signs usually do not become apparent until adulthood. Infection occurs primarily when an animal ingests faeces contaminated with bacteria e.g. calves sucking an infected cow's dirty udder. Infected cows can also shed the bacterium in their colostrum and milk which can lead to infection of calves fed this milk.

The economic impact of JD varies considerably between farms as it depends on the number of animals infected and how advanced the disease is in infected cattle. In Ireland, the economic impact of JD on most farms would appear minimal. One of the key issues, however, stimulating interest in JD is, an as yet unproven theory has been suggested, linking JD as a possible cause of Crohn's disease in humans. As Ireland is an exporting nation it is important the quality of our milk and milk derived products is above reproach, necessitating JD control measures.

Animal Health Ireland (AHI) launched a JD pilot control programme in 2013. This programme involves on farm risk assessments with a trained veterinarian, to identify high risk management practices placing farmers at risk of spreading the disease. The diagnostic element of the programme involves use of a blood or milk test (ELISA tests) to identify suspect animals and a faecal-based test to confirm the infection status of the animal. Control programmes aim to break the cycle of disease transmission through identification and removal of infected animals and optimal calf management. As contact with infectious faeces is a major risk factor for transmission of JD, hygiene is a key element in control.

Due to the slowly progressive and prolonged nature of the disease, JD is notoriously difficult to diagnose. None of the commonly used tests (ELISA, PCR or faecal culture) are 100% perfect. Interpretation of JD results is not clear cut and test results are best interpreted by a combination of farmer and their vet on an individual farm basis. Both false positive (not infected with JD but yield a positive test result) and false negative (infected with JD but yield a negative result) results can be generated during a testing programme. The more test results available for an individual cow, therefore, the greater the level of confidence associated with her test status.

Study

A long term study was conducted on a research farm with 139 cows to investigate if JD levels could be reduced following control programme implementation. On all animals aged ≥ 2 years, an intensive monthly ELISA testing regime was implemented in Year 1-3, and subsequently reduced to quarterly from Year 4. Faecal culture was employed as a confirmatory test (if ELISA positive) across the study. On farm management changes were implemented on the basis of ELISA results e.g. ELISA positive cows calved in isolation. Their colostrum was discarded and their calves were fed colostrum from a consistently ELISA negative dam. Swift removal of all calves from the calving area and overall farm hygiene were also important elements of the programme. Internationally, in addition to management changes, many programs adopt a test and cull policy where repeatedly ELISA positive animals are selected for culling, therefore, across this study 15 cows were selected for culling and post-mortem (PM)examination. Selection criteria to identify cows for PM examination included; i) cows recording multiple ELISA positive results and confirmed positive by faecal culture, and ii) cows due for routine end of lactation culling that recorded multiple ELISA seropositive results but were not confirmed positive by faecal culture.

In the initial herd test 7.9% tested MAP ELISA positive (2012). In 2014, following the removal of a confirmed positive cow, the entire herd tested ELISA negative for over a year. This negative status was transient in nature and in 2015, animals that previously recorded ELISA negative results subsequently tested positive. One of the positive animals included a purchased cow thus highlighting the importance of operating a closed herd. In the final herd test (2016) 1.4% of the herd tested positive (Figure 1). Of the animals that underwent post-mortem three showed classical signs of JD. All were culture positive indicating selection for culling based on a combination of repeated ELISA tests confirmed by faecal culture tests may enhance confidence animals are advanced in the disease process.

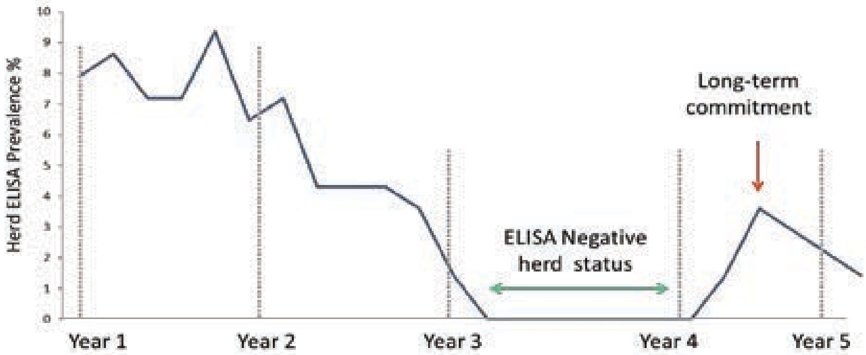

Figure 1. *Long term commitment is required in JD control programmes. JD can remain unidentifiable in infected animals for years making control difficult*

Conclusion

An overall reduction in the number of JD positive animals was achieved through implementing "gold standard" calving area and calf management practices as recommended by AHI, combined with selective culling. The long term commitment required for JD control programmes is however, emphasised. Our attainment of negative herd status was transient in nature and again reinforces the necessity of continuous monitoring programmes for JD. Selection for culling based on ELISA results confirmed by faecal culture may enhance confidence the animals are in an advanced stage of JD.

The impact of the Johne's disease ELISA status on milk production from test positive cows

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Summary

- ELISA tests currently available to screen Johne's are of limited accuracy and may lead to misclassification of the cow's current infection status.
- Accurate estimation of milk losses from cows sub clinically infected and tested by ELISA is challenging.
- Milk production recorded from cows testing ELISA positive and inconclusive for paratuberculosis during the JD Pilot Dairy Control Programme carried out in Ireland by Animal Health Ireland (AHI) was lower than cows testing negative for the disease.

Background

The effects of Johne's disease (JD) on animal productivity are documented in the literature. Classically infected animals demonstrate diarrhoea and weight loss which will certainly result in reduced output and poorer performance. However, animals testing positive through ELISA tests may not show reduced performance. This situation may be due to the lack of accuracy of the ELISA tests when testing animals for JD, particularly those sub clinically infected. This ELISA test technique may even yield false-positive results depending on the prevalence of JD within the herd and lead farmers to a low confidence on the JD status of their cattle. Therefore, the association between the JD status of cows - defined by their ELISA test result – with their milk production was investigated in this study. The results presented here can provide the farmer with a better understanding on the impact that JD may have on the productivity of his/her livestock.

Study

Animal Health Ireland (AHI) implemented a JD Control Programme (JDCP) in 2013 to assist farmers in identifying risk management practices associated with the disease spread within their herds. All lactating cows from herds that enrolled in the programme were screened for JD through their blood or milk samples (ELISA tests). Between November, 2013 and December, 2015, a total of 1,791 herds were screened through the JDCP, and 148,291 cows were tested on one or more occasions across the period. Test results were combined with milk recording data to assess the effect of JD status (negative, inconclusive or positive) on milk production. Testing was conducted by one of the eight laboratories across the Republic of Ireland designated for the purpose of the programme. One of the following test kits was used: *Mycobacterium paratuberculosis* Antibody Test Kit PARACHEK® (Prionics, Zurich, Switzerland), Paratuberculosis Antibody Screening Test® (Idexx, Maine, USA) and ID Screen Paratuberculosis Indirect Screening Test® (ID Vet, Montpellier, France). In order to study the effect of the cows' antibody response against JD on test-day milk records, the range of the ELISA test results available in the study (negative, inconclusive and positive) was represented in the following scenarios:

- **Scenario 1:** Cows tested ELISA inconclusive or positive were assigned a positive JD status.
- **Scenario 2:** Only cows tested ELISA positive were assigned a positive JD status.
- **Scenario 3:** Cows tested ELISA inconclusive or positive, from herds where at least two other cows were tested ELISA inconclusive or positive, were assigned a positive JD status.
- **Scenario 4:** Only cows tested ELISA positive, from herds where at least two other cows were tested ELISA positive, were assigned a positive JD status.

The year when the cow was tested, the cow herd and the laboratory where the test was performed were included in the statistical analysis. Breed, parity, stage of lactation and relevant economic breeding indices of animals were also accounted for in the statistics.

Results

Cows and their ELISA test results for JD assessed during the course of the programme are presented in Table 1.

Table 1. Distribution of ELISA test results from cows tested during the AHI JDCP, from November, 2013 to December, 2015

	Number of test results per year		
JD ELISA result	2013	2014	2015
Negative	1,599	66,345	48,135
Inconclusive	23	441	579
Positive	54	1,543	1,274

The average milk production recorded from cows according to each scenario used for comparison is presented in Table 2.

Table 2. Average Test-day milk records from cows according to their JD status during the AHI JDCP

Scenarios	Test-day milk records (Mean, kg/day)		Difference (Mean, kg/day)
	JD positive	JD negative	
Scenario 1	21.23	21.42	-0.182*
Scenario 2	21.12	21.42	-0.297*
Scenario 3	21.42	21.63	-0.209*
Scenario 4	21.94	22.30	-0.326*

**The mean difference recorded within each scenario was statistically significant.*

In all scenarios where animals were included as JD positive, cows recorded marginally lower milk production than those recorded from JD negative animals. The mean differences between the milk-recordings from cows with a JD positive status compared with JD negative cows, in all the scenarios depicted by this study, were statistically significant. The differences evidenced here are extremely low and might have been due to the large number of records representing each JD status and when scaled up to herd level with a low herd prevalence, the effects are lost.

Conclusions

Test-day milk records from cows testing ELISA positive or inconclusive for Johne's disease during the AHI JDCP were lower than those from cows testing ELISA negative. Although differences are statistically significant, they would account for close to one per cent of a difference per day or across lactation.

Liver fluke status: Associations with annual weather variations and treatment in a six year period

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Summary

- Liver fluke is an important parasitic disease and can result in large economic losses in Ireland and worldwide.
- Completion of the liver fluke life-cycle is dependent on climatic conditions for the development of immature free-living stages of the parasite and intermediate host.
- Monthly bulk tank milk (BTM) samples from 28 herds were tested over six years (2009-2014) with a commercial ELISA. A decrease in BTM ELISA results was recorded from 2010. Additionally, flukicide treatments were recorded and analysed and showed greater association with BTM status than weather variations. Also, the use of flukicides against mature and immature fluke highlighted improved results.

Introduction

Liver fluke (*Fasciola hepatica*) is a parasite of mammals, hosts include; cattle, sheep, goats, horses, deer and humans, among others. It has a worldwide distribution across these species and it is an important disease of domestic livestock, especially in temperate climatic zones like Ireland. It has been estimated by AHI to generate annual losses of €90 million in Irish livestock species and €2.5 billion worldwide.

Life-cycle

On ingestion by mammalian hosts, such as cattle and sheep, the infectious immature fluke reaches the intestine and migrates through intestinal and liver tissues towards the bile ducts; this internal migration stage is known as 'acute fasciolosis' and it is the most damaging stage of the disease. Sexual maturity of the parasite is attained in the bile duct, allowing egg production by the now mature flukes, at this stage the disease is known as 'chronic fasciolosis'. Once liver fluke eggs are produced, these leave the ruminant digestive system via faeces reaching the environment. A fundamental part of liver fluke development is the presence of the mud snail (*Galba truncatula*), in which hatched eggs will be hosted. Further larval stages develop into the snail host until the mobile and free-living stage migrates from the snail to grass forming a cyst, at this point the cycle has been completed and the infectious stage is ready to be ingested once again by the ruminant. The minimal period for the entire liver fluke life-cycle is 17-18 weeks.

Climatic conditions

The mud snail and free living stages of the parasite require specific environmental conditions. Mild temperatures and presence of muddy/sodden land are needed for fluke larval maturation and for development of appropriate snail host habitat; temperature and rainfall have been identified as important contributory risk factors for an increased prevalence of liver fluke. Ongoing and predicted weather changes in Ireland may present even more favourable conditions for *F. hepatica* development. A study was conducted by Teagasc aimed to examine annual trends in bulk milk ELISA results over time and to investigate associations between ELISA results, soil temperature, rainfall and fluke treatment. It was also aimed to inform the participant farmer about their herd annual fluke status and discuss about treatment.

Six years 28 herds study

A total of 28 herds, all located in Munster, were recruited for the study. Each study farm was requested to submit a monthly BTM sample over the course of each lactation between March 2009 and December 2014. All samples were analysed using a commercially available ELISA kit. It has been previously shown that liver fluke antibodies detected by this test decrease three to four months following treatment with a flukicide and it can also detect infection four to six weeks before eggs are detected by faecal egg count. Daily rainfall (mm) and soil temperature (oC) at 5 cm were recorded by an automated weather measurement station (Campbell Scientific Ltd. Loughborough, UK) located within 30 miles of study farms. Fluke management data were collected using a web-based survey tool.

Examination of annual ELISA trends highlighted the highest median on 2010 and the lowest on 2014 (Figure 1), these differences in annual medians were significant. Mean annual soil temperature was not associated with *F. hepatica* ELISA status and annual rainfall above 1,000 mm was associated with a reduced risk of liver fluke.

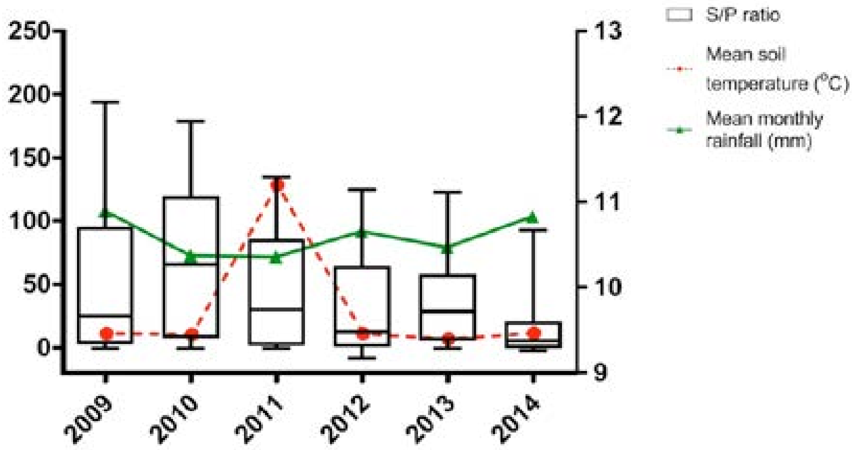

Figure 6. *Boxplot of annual median BTM ELISA results (left axis) across all study farms. Superimposed line graphs represent mean soil temperature (right axis) and mean monthly rainfall (left axis) in each year of study*

Statistical analyses highlighted an increase in dosing over subsequent years of the study. Better ELISA results were recorded in herds including a flukicide active against mature and immature fluke compared to herds using flukicides against only mature fluke or not treating. Also, control of liver fluke with doses active against more than one stage of the parasite achieved lower BTM milk seropositivity in study herds regardless of weather patterns or changes

Conclusions

International studies are predicting increases in liver fluke exposure due to global climate change, and the current study highlights the progress that can be made through a continuous monitoring program. The increase in dosing and the addition of flukicides active against mature and immature liver fluke improved BTM ELISA results regardless of climatic conditions. Further research is now required to design sustainable flukicide treatment programmes that will minimise the possibility of promoting anthelmintic resistance.

Schmallenberg - Is it back again?

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Summary

- Three years after the initial Schmallenberg epidemic, recent Moorepark research has confirmed significant re-circulation of Schmallenberg virus (SBV) in Irish dairy herds during 2016.
- Teagasc vector trapping studies have confirmed that the insects (biting midges) that transmit SBV are widely distributed on Irish dairy farms.
- As a consequence, it is likely that SBV will continue to circulate in Ireland every couple of years.

Introduction

Schmallenberg virus (SBV) emerged for the first time in north-western Europe in 2011. The first Irish case was confirmed in 2012. SBV most likely came into Ireland as a result of windborne spread of SBV-infected *Culicoides* midges from continental Europe. This resulted in an outbreak of abortions and congenitally malformed calves and lambs in 2012 and 2013. Immediately after the initial Irish cases, a large scale Teagasc research project was set up on dairy farms in Munster involving over 5,000 dairy cattle. The overall project objectives include monitoring SBV circulation in dairy herds between 2013 and 2017, evaluating the use of bulk-tank milk (BTM) samples for SBV surveillance, quantifying the involvement of SBV in abortions and perinatal deaths, determining the *Culicoides* insect vector species and habitats on dairy farms, and developing new research models to study congenital SBV infection and malformations in embryos.

This is a collaborative international research project between Moorepark and the Dept. of Agriculture, Food and the Marine (DAFM), the School of Veterinary Medicine (UCD), The Pirbright Institute (UK), The National Virology Research Institute (Poland) and The Elisabeth MacArthur Agriculture Institute (Australia).

Schmallenberg virus surveillance study

In spring 2014, SBV infection was investigated in 26 dairy herds located in Munster. Animal-level seroprevalence was 62.5% (cows 84.7%; heifers 0.6%) suggesting that SBV infection was widespread in these herds during 2013. From winter 2014 onwards, a sentinel population of 1,550 spring-2014-born animals in study herds were monitored prospectively for evidence of SBV infection over three years (2014, 2015 and 2016). Nine animals tested seropositive in winter 2014 while all animals tested seronegative in winter 2015, suggesting little or no evidence of SBV circulation in these herds during 2014 or 2015. As a consequence, a large population of naïve animals were present in these herds which resulted in a significant drop in SBV herd immunity during this time. In order to investigate SBV recirculation during 2016, blood samples were collected from 366 seronegative sentinel animals (15 samples per herd) and analysed for SBV antibodies in spring 2017; 256 animals (70%) tested seropositive demonstrating significant SBV re-circulation in these previously exposed herds during 2016. This renewed SBV circulation was probably due to incursion of virus from abroad in 2016 and the documented significant drop in herd immunity at the beginning of the 2016 vector-active season (the period of time when *Culicoides* midges are active, typically between April and November each year).

Bulk-tank milk (BTM) testing study

The usefulness of BTM samples as a SBV surveillance tool was also investigated; the ability of BTM ELISA results to predict within-herd SBV seroprevalence was evaluated using statistical analyses. Results demonstrate that BTM ELISA results are highly predictive of within-herd SBV seroprevalence and may be 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 necropsies were also carried out on stillborn calves submitted from study herds between 2012 (the year before the outbreak) and 2017 (the year of SBV re-emergence). While calves with lesions typical of in-utero SBV infection (skeletal and central nervous system malformations) were detected at a very low level in 2012 (0.5%), the increase in affected calves in 2013 (7%) and in 2017 (2.3%) confirmed the initial and most recent outbreaks.

Vector epidemiology study

Culicoides biting midges are the main insect vector to transmit SBV from an infected animal to a naive animal, potentially causing disease. *Culicoides* can also transmit other viruses (arboviruses) such as Bluetongue virus (BTV). 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, abundance and the ecological habitats of midges on farms where SBV had previously circulated. Ultraviolet light traps were set up at selected locations on 15 of the study farms to collect midges. *Culicoides* species were identified based on characteristic features such as wing pattern. The results of this study demonstrated that *Culicoides* arboviruses vectors were present ubiquitously and in abundance in these herds; the most abundant species identified were members of the C. pulicaris and C. obsoletus groups which are known to transmit SBV and BTV.

Virology laboratory study

As SBV is a relatively newly discovered virus,the number of experimental infection studies is limited. Given the difficulties in setting up such studies in cattle an alternative animal model was developed in collaboration with the Elisabeth MacArthur Agriculture Institute in Australia to study SBV infection in developing embryos. The results of this study demonstrate for the first time that experimentally infected chicken embryos are susceptible to SBV infection in the same way as calves and can develop typical SBV malformations such as twisted limbs, contracted tendons and vertebral malformations. This novel SBV research model can be used in future studies to elucidate the development of congenital SBV disease in ruminants.

Conclusions

Comprehensive research studies at Moorepark have highlighted significant SBV re-emergence and re-circulation in Irish dairy herds during 2016. This level of circulation was due to the low level of SBV circulation in 2014 and 2015 which resulted in the substantial drop in herd immunity at the beginning of the 2016 vector season. This, coupled with re-entry of virus from abroad and the documented presence of *Culicoides* insect vectors on Irish farms, is likely to have contributed to the re-emergence of SBV during 2016. Bulk-tank milk testing is a useful tool to monitor the circulation of SBV in dairy herds. It is likely that SBV will continue to circulate in Ireland in a cyclical pattern every couple of years.

INVESTING IN PEOPLE

Career opportunities in dairy farming

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Summary

- There are exciting career opportunities on dairy farms in Ireland created by the significant recent expansion due to milk quota removal, the profitability of dairying compared to other farming enterprises and an aging farming population.
- Teagasc expects that by 2025, approximately 6,000 people will be needed to enter the industry to work on larger scale dairy farms and to succeed farmers who plan to retire.
- There are a variety of employed career roles available on Irish farms from part-time relief work to full-time assistant or management positions. There are also a growing number of progression opportunities via leasing, partnerships or share farming arrangements with land owners.
- Key to having a successful career in dairying is having the skills needed to fulfil each career role. Education in combination with relevant work experience on high performing farms with employers who take an interest in their employee's learning are the best ways to develop the skills needed for successful farming.

Introduction

Dairy farming in Ireland is changing rapidly. Over the last six years, an extra 300,000 cows have been added to Irish dairy farms. In 2016, nearly 50% of cows in Ireland were milked in herds of greater than 100 cows. Teagasc expects that by 2025, approximately 6,000 people will be needed to enter the industry to work on larger scale dairy farms and to succeed farmers who plan on retiring. This increase in the number of larger scale farms has and will continue to create employed opportunities.

Reasons for increased career opportunities

There are a number of other factors along with increased herd size creating opportunities in dairy farming. These include:

- Future demand for dairy products. The long term projections based on a growing world population, are for the demand for dairy products to continue to grow. Ireland, with its grass based system of milk production, is in a great position to capitalise on this growing demand.
- Profitability of dairying compared to other enterprises. The 2016 e-profit monitor figures show that the average dairy farmer made a net profit of €1,000/ha. This in excess of what was achieved in other enterprises. With a higher milk price in 2017, dairy profitability is likely to exceed €1,500/ha.
- Increased interest in collaborative farming models. While many people were sceptical about the role of collaborative farming in Ireland, there is a large and growing interest in this area. The creation and subsequent success of the Macra Land Mobility Service, has facilitated the change of land use of over 25,000 acres in three years is evidence of the strong interest in collaborative farming. Successful business arrangements involving farms that have been converted to dairying and also existing dairy farms have been reinvigorated by the addition of a young, enthusiastic and skilled person are now in operation.
- Long term leasing tax incentives, can allow a farm owner to receive up to €40,000

per year without paying income tax (if leased for 15 years). This is increasing land availability to skilled farmers.

- Average age of farmers and lack of successors. The 2013 CSO data showed that the average age of farmers in Ireland was 57 years old. Specifically in dairying, 17% of farmers were over the age of 65. Macra surveys have identified that 50% of farmers over 50 have no identified successor. There is a lack of successors and a shortage of people with the necessary skills to take on the running of farms. If they have no successor, many of these farmers may consider employing labour or entering a collaborative farming arrangement to continue in dairying in the future.

A rewarding career

For the first time in a generation, there are now exciting opportunities and a career progression framework in place on Irish dairy farms. A person with no farming background can enjoy as much success as a person from a dairy farm and with opportunities for both to progress to business ownership. In addition to the potential to build your own business, there are many other reasons to consider a career in dairying such as:

- the opportunity to earn a good income and have a good work life balance.
- the variety of work outdoors with animals and nature.
- the opportunity to work both on your own and as part of a team.
- seeing the rewards of your effort every day by producing a high quality product.
- using the latest science to try and improve farm performance.
- working within growing businesses undertaking exciting expansion plans.
- the strong social aspect of farming through Macra, discussion groups and other farming events.

Skills required

Key to having a successful career in dairying is having the required skills needed to fulfil each career role. Education in combination with relevant work experience on different farms with employers who take an interest in their employee's learning are the best ways to develop the skills needed for successful farming. Agricultural education is an essential starting point for any young person and Teagasc provide specific dairy training through the Advanced Dairy Certificate and the Professional Diploma in Dairy Farm Management.

Training the next generation of dairy farmers

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

Summary

- The skill level required to manage larger herds is substantially greater and farm owners and managers must have the experience and skills needed to cope with the many challenges which arise.
- The benefits of a formal agricultural education include having increased farm size, greater income per hectare and being more efficient than those with no formal agricultural education.
- The Advanced Certificate in Dairy Herd Management and The Professional Diploma in Dairy Farm Management (PDDFM) programmes provide the next generation of dairy farmers with the additional skills and knowledge required for success.
- The core element of the PDDFM is a two year paid professional work experience based programme on high performance dairy farms where students have the opportunity to implement their technical knowledge in a controlled active learning environment.

Introduction

The increase in dairy cow numbers has been greater than predicted, with the fastest rate of growth happening within herds of 100 cows. However, this growth can only be achieved with a supply of well trained professional farmers. The technical, business and people management skills required to successfully manage larger herds are now substantially greater than required historically. Dairy farming operates in a context of continual changes requiring managers to update complex and varied skills. The next generation of farm owners and managers and their families should avail of every training and development opportunity available to achieve the requisite knowledge, skills and experience to secure the long term future of the family farm while building their own network of supports. Education and training, both formal and informal, can assist farm families to make changes to their farming practices and is widely acknowledged to significantly contribute to increased farm income. Furthermore, the practical learning attained while working on high quality dairy farm placements reinforces learning and provides excellent role models and mentors for students in their future farming careers.

Formal learning

Formal education and training usually takes place under the supervision of educational institutions leading to an accredited qualification. Teagasc are the leading providers in practical training for enthusiastic dairy farmers. The Advanced Certificate in Dairy Herd Management and The Professional Diploma in Dairy Farm Management (PDDFM) programmes provide the next generation of dairy farmers with the additional skills and knowledge to meet the challenges of an expanding industry.

Advanced Certificate in Dairy Herd Management

This programme provides the graduate with the knowledge and technical skills required to manage a dairy herd. Having completed one year in an agricultural college, students typically spend a further 20 weeks in college and 12 weeks on practical learning with a host farm in Ireland or abroad. Course content is a combination of technical (dairy management, nutrition, breeding, grass management including grazing infrastructure, and environmental modules) and farm business modules. Students who successfully complete the course have the skills and competencies to join the dairy industry as a herd manager. Progression routes after, include the PDDFM programme or to Institutes of Technology.

Professional Diploma in Dairy Farm Management

The specific purpose Level 7 PDDFM programme is the recognised standard for farm ownership and management training. The programme aims to provide enthusiastic dairy farmers with the latest research and best practice management knowledge to successful run large scale dairy operations in their future careers. Uniquely, this programme provides the mix of on-the-job/off-the-job diploma level training and accreditation for successful farm management. The core element of the PDDFM is a two-year paid professional work experience based programme on high performance dairy farms. While on work experience with approved progressive commercial dairy farms, students have the opportunity to implement their technical knowledge in a controlled active learning environment. Students on the programme learn from experienced agricultural researchers, advisors, teachers and from other like-minded enthusiastic students through classes that are interactive and discussion based.

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. Graduates from PDDFM course have been successfully employed in Ireland, New Zealand, Germany, UK and Saudi Arabia as dairy farm managers, or as managers on their own family farms.

Applicants must possess a Level 6 Advanced Certificate in Agriculture or an equivalent recognised agricultural award.

Informal training

Continuous education is a requirement of all people in business and farmers and their employees are no different. The main sources of informal learning include other farmers, family, the media and industry experts. Each farm business will benefit from informal training opportunities through discussion group meetings and attendance at open days. Knowledge gained from other farmers is valuable because it is local and comes from direct experience and observation over time. Employers should encourage and give the opportunity to employees to attend discussion group meetings. Technical information can be sourced from Teagasc advisors, media articles, conference proceedings, newsletters and through online resources such as the Teagasc website.

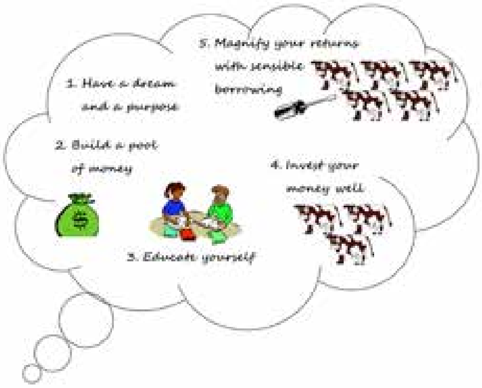
Steps to wealth creation in the dairy industry

Lynaire Ryan
Agribusiness Consultant, Christchurch, New Zealand

Summary

- The dairy industry offers a wonderful lifestyle, career path and wealth creating avenue for anyone willing to work diligently and develop their knowledge, skills and attitudes so as take advantage of the opportunities that come along.
- There are five steps that lead to financial success namely, have a dream, build a pool of money, educate yourself, invest well and use debt sensibly to magnify your returns.

Five steps that lead to financial success:



The five steps to wealth creation

Have a dream and purpose

Having a big enough dream will be a great motivator – it will provide the purpose and energy to achieve financial success. You need a strong enough purpose, or a desire so large, that you will make the effort to set up a regular savings programme, learn ways to invest wisely, further your education or go that extra mile at work to build your reputation. Having a dream and belief is important.

Build a pool of money – earn more than you spend

For those getting started, increase your earnings by increasing your skills and experience, build your qualifications and your reputation and grow your networks and contacts so you are in high demand. Complete a personal budget so you know where your money is going and set yourself some good savings targets. Decide how much you can save a week or fortnight, and get this direct debited from your pay before you see it. Do not use credit cards or hire purchase – if you can't pay cash for something then don't get it.

For those already in business, drive a strong cash flow and profit to grow the business. Understand the key principles of a highly successful pasture based farming system, focused on profit, generated by maximising pasture growth and utilisation via cows of high genetic merit. Get very, very good at budgeting and have an annual budget and monthly cashflow, and monitor monthly

Educate yourself

Once you have started building a pool of money, the next step is to start learning how to get that money working for you. Spend time learning how to get on the +15% investment pathway. Study successful people who have travelled the +15% investment pathway before you. Ask them what they have done, how they got started and what recommendations they would give you. Some keys tips include building your knowledge, developing your financial capability to evaluate opportunities, build a successful support team around you including an accountant, bank manager, farm consultant, and a team of superb farmers and friends and read extensively.

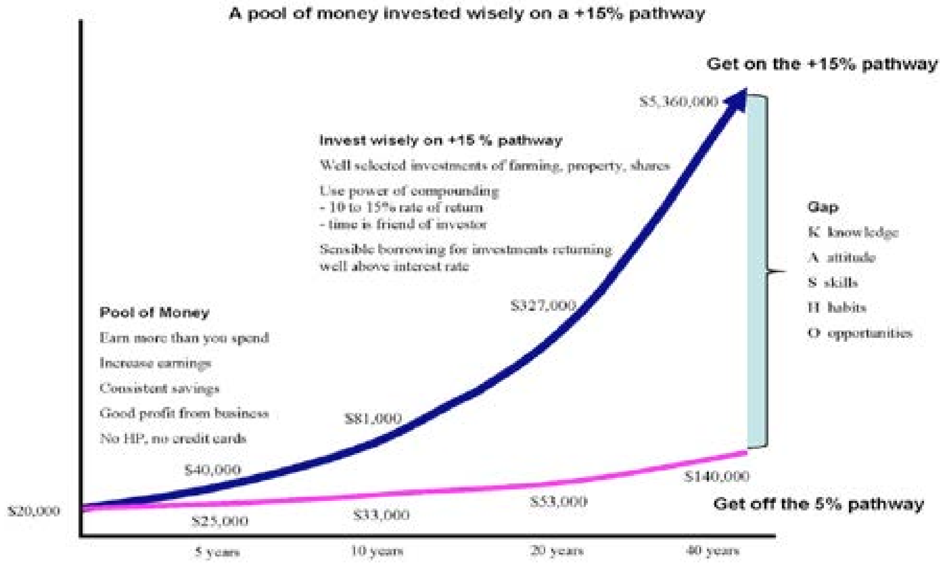


Figure 1. *Wealth creation pathway – compounding at work*

Invest your money well – get on the +15% Wealth Creation pathway

You want to get your money growing for you on the +15% investment pathway, and off the 'going nowhere' five per cent pathway. The Wealth Creation Pathway diagram shows the power of compounding. A lump sum of €20,000 will compound to €5.36 million over a working lifetime of 40 years if invested at 15%, compared with a meagre €140,000 if left on the 'going nowhere' five per cent pathway. The two keys are getting a good rate of return, eg 10-15%, and having time for the investment to grow. The power of compounding takes time to snowball even after ten years there is not a huge difference in the amount invested, but the differences become enormous after 20 years.

In the Wealth Creation Pathway (Figure 1), the gap between the pathways is determined by how you position yourself or the strategy you take. This is determined by the knowledge, attitude, skills, habits and opportunities that you choose to build. Learn to invest wisely on the +15% pathway. Invest in appreciating assets or good businesses such as rearing calves or share milking cows. Money spent on machinery, cars, sound systems or the latest mobile phone is not an investment. These are depreciating items and they lose value.

Magnify your returns by sensible borrowing

If you can find an investment where the rate of return is consistently greater than the interest rate, then it might be a great idea to borrow money to invest. Then you have a bigger pool of money at work for you.

Conclusion

In summary, build a pool of money and get it growing on a sensible wealth creation pathway i.e. within a highly profitable farming business.

Efficient work practices: A people perspective

Dr. Nollaig Heffernan
Independent Management Consultant.

Summary

- There is an increasing need to work smarter not harder, whether through the farmer improving personal work practices or engaging with staff more effectively.
- Writing procedures for each task in a step-by-step fashion not only highlights inefficiencies in the system and potentially in your own work practices but also generates useful documents which can be made available for new and existing employees.
- A simple and very effective approach to planning is to use a yearly wall planner as a simple representation of the year from January to December.

Introduction

With the abolition of milk quotas and the prevailing ambition to expand in Ireland, there is an increasing need to work smarter not harder, whether through the farmer improving personal work practices or engaging with staff more effectively.

To improve personal work practices, it is necessary to assess how well you run your business. Dairy farming comprises many tasks which are routine and individual peculiarities often creep into the execution of these tasks. It should be established whether these peculiarities are a help, a hindrance or redundant habits that you have held onto over the years. *Writing procedures* for each task in a step-by-step fashion not only highlights inefficiencies in the system and potentially in your own work practices but also generates useful documents which can be made available for new and existing employees. Although tedious, this is a relatively cheap exercise that can lead to astonishing gains and will also help to answer the critical question of whether your business requires additional staff. It may be that by streamlining your own work habits there isn't a current need to take on somebody else.

If, however, your business has the capacity to employ staff, *people management* is a *learnable skillset* and multi-billion-dollar industry which should not be feared, as there is a wealth of information available online, in books and through courses. Many *discussion groups* are already tackling this area by inviting speakers along to discuss the various aspects of people management. An excellent starting place in the meantime, is the effective *planning* of what needs to be accomplished on a daily, weekly and monthly basis. This eliminates many of the *issues* that provoke frustration and tension in the employer/employee dyad by creating *role clarity* and *job expectation*.

Planning

Planning is often considered a formal exercise that only needs to be carried out once a year. However, it is at its most powerful when it is *incorporated* into the everyday running of the farm, progress is regularly *reviewed* and actions *modified* to ensure the most cost effective and efficient completion of tasks. A simple and very effective approach to planning is to use a yearly wall planner. At its simplest, it is a visible representation of the year from January to December.

- Start by marking off all the '*set play*', such as the expected duration of the calving block and breeding season, silage, public holidays, vaccinating and herd testing, etc. and make sure that these are the *focused* use of your energy in that time.

GOLDEN RULE NUMBER 1. *Never put tasks that need to be done at the mercy of those that don't need to be done then or at all*

- Next, dates such as staff holidays, discussion group days, family events and any other *agreed discretionary uses of time* are marked onto the planner.
- In addition to these seasonal tasks are the *routine* tasks of milking, feeding, calf rearing, maintenance, etc. When viewed like this, it soon becomes clear how quickly time is *consumed* on farm.
- The next step is to work the planner to *relieve pressure* on the anticipated stressed periods. For example, decide what actions would help to improve next year's calving block and mark on the planner when you will complete them, e.g. speak to Teagasc adviser regarding disease control w/c 1st September, repair calving cubicles and design agreed disease control strategy 10th – 25th September, etc.

GOLDEN RULE NUMBER 2. *Never find yourself in the middle of an annually stressed period e.g. calving, wishing you had put known strategies in place to make it less stressful.*

- Place the planner in a common area where it can be *viewed, discussed* and *modified*. In this way, the planner becomes a powerful *communication* and *time management* tool for everyone, creating clear expectations and generating momentum.

The following is an example of what this planner might look like after step 1 and 2 have been completed:

January	February	March	April	May	June	July	August	September	October	November	December
Pub Hol			1	Pub Hol	1	1	Pub Hol	1		1	1
			2		2	2	Family	2		2	2
			3		3	3	Holiday	3		3	3
Family	6 week calving block		4		4	4		4	Staff	4	4
Holiday			5		5	5	5	5	Holidays	5	5
			6		6	6	6	6		6	6
			7				7	7	John	7	7
			8				8	8		8	8
9			9			Staff	9	9		9	9
10			10			Holidays	10	10		10	10
11			11				11	11		11	11
12			12			Mary	12	12		12	12
13			Pub Hol		Silage		13	13		13	13
14					Window		14	14		14	14
15						15	15	15	15	15	15
16						16	16	16	16	16	16
17		Pub Hol	Breeding Block			17	17	17	17	17	17
18		18				18	18	18	18	18	18
19		19				19	19	19	19	19	19
20		20				20	20	20	20	20	20
21		21				21	21		21	21	21
22		22			22		22	Staff	22	22	22
23		23			23		23	Holidays	23	23	23
24		24			24		24		24	24	24
25		25			25		25		25	25	Pub Hol
26		26			26	Family	26	Sean	26	26	26
27		27			27	Holiday	27		27	27	27
28		28			28		28		28	28	28
29		29			29		29		29	29	29
30		30			30		30		30	30	30
31		31					31		Pub Hol		31

(Pub Hol – Public Holiday)

By planning the year so clearly in advance, there is **universal certainty** about what needs to be done and by when. The planner is further strengthened if individuals are **assigned** to the allotted tasks in advance. When planning the following year, the yearly planner can be **reviewed** to assess whether time allocation was accurate, where the bottlenecks occurred and to inform **future** procedure.

Conclusion

For improved on farm efficiency:

- work on yourself first.
- learn to work with others.
- plan your own and your staff's time.

Labour efficiency on dairy farms

Justine Deming, David Gleeson and Bernadette O'Brien
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Summary

- Overall labour demand increased as herd size increased.
- Efficiency improved significantly as herd size increased above 250 cows.
- The most labour efficient farms used contractors to perform some tasks.

Introduction

Traditionally, the average herd size on Irish dairy farms has been small relative to some international scenarios like Australia and New Zealand. Dairy farms had an average size of 68 cows in 2015, and could be largely managed by the owner and family members. Since EU milk quota abolition in 2015, the Irish dairy sector has been growing and is expected to grow by up to 50% by 2020. Second to feed costs, labour has been identified as one of the highest costs on dairy farms. Compared to other EU countries, Ireland has historically had low milk production per labour unit and this situation is now exacerbated by the growth in the industry. Thus optimising labour efficiency is a critical factor in increasing farm profitability and maintaining the sustainability of the dairy farm. Intensive research on Irish dairy farm labour efficiency was last conducted in the early 2000's while under the constraints of the European milk quota regime. That study, recorded a labour input of 41.4 hours/cow/year for an average herd size of 77 cows. That level of labour input per cow is not sustainable as herd size increases. With current and projected cow numbers, this presents a challenging scenario for labour supply on farms. In order to optimise work/life balance and maintain profitability when and if hired labour is necessary, an examination of the labour issue on-farm was required to identify the factors affecting both the absolute labour input required and also the efficiency of labour use, together with the influence of facilities and practices on farms.

Current work

The objective of this study was to quantify levels of labour input on labour efficient, spring-calving Irish dairy farms (identified by Teagasc advisory). These farms participated in discussion groups and operated a grass based milk production system. Labour input relating to a range of dairy farm tasks over a 1-year period were recorded. Thirty-eight farms were ultimately enrolled in the study with herd sizes ranging from 79 to 533 cows. A phone app was developed to allow farmers to record labour data in real-time by starting and stopping the app's stopwatch to record designated tasks on-farm. Farmers were asked to record their labour data including the labour input for employed and family members on three consecutive days of each month for 12-15 months. A short online survey was also developed and applied on a monthly basis to capture the other factors contributing to labour data on farm. Additionally, a once-off phone survey was conducted with each farmer to establish their farm facilities and practices.

Average total farm labour input was 4,629 hours per year with an average herd size of 191 cows. Farm labour input was 26.3 hours/cow/year. While there were farms with high efficiency on smaller herd sizes (80-150 cows), farms above 250 cows were, on average, the most efficient with an average input of 19.5 hours/cow/year. It was observed that as labour efficiency improved, the proportion of machinery work performed on farm by contractors increased. Milking, and its associated tasks of herding pre- and post-milking and washing post-milking, accounted for 33% of the total farm labour input over the course of the year. The next most time consuming task, was identified as cow care, at 17%. This task was associated with feeding cows and heifers, winter feeding and tasks associated with baled and pit silage.

Seasonality of dairy farming

The distinct seasonal demand for overall farm labour input can be viewed in Figure 1. The average herd size here was 191 cows and the average hours worked per season were highest in springtime (February, March, April), dropping down and remaining steady throughout the summer (May, June, July) and autumn (August, September, October), and finally dropping off significantly in the winter (November, December, January). The most notable peak in the spring was attributed to milking, calf care and feeding, and calving tasks.

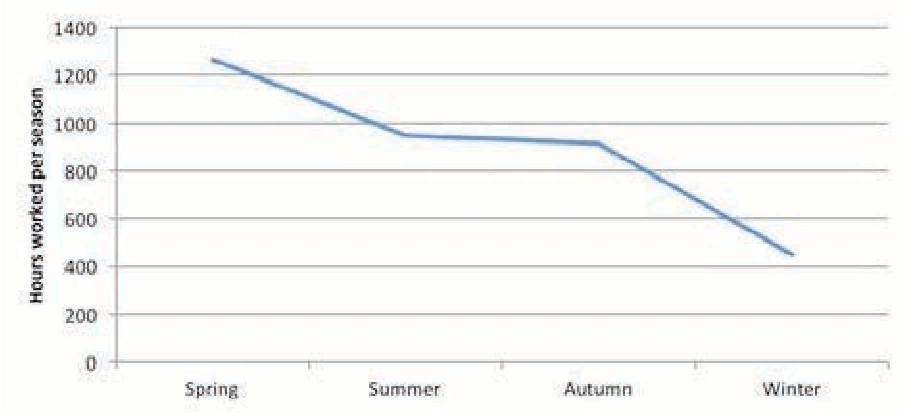

Figure 1. *The seasonality of workload on Irish dairy farms*

Efficient practices

Regardless of herd size, the more efficient farms also had an increased proportion of machinery work performed on-farm by contractors. Farms that were found to be efficient over the entire year were also more efficient in the peak of the spring season. Due to the evident strain on the system during the spring, the most and least efficient farms in this period were investigated further and there were notable differences in facilities and practices which affected labour input for certain tasks. The most efficient farms in springtime were also found to be some of the most efficient at the milking tasks. The most efficient farms with regard to milking efficiency averaged nine rows of cows for milking while the least efficient farms averaged 12 rows. On the more efficient farms, exit gates from the parlour and drafting facilities could be managed from the pit and cows could go directly to paddocks from the milking parlour.

Conclusions

Excellent examples of labour efficiency were observed across herd sizes in this study. While this small sample is not representative of the current industry benchmark, it represents what is achievable on Irish dairy farms and highlights where farms can make adjustments and improvements to help optimise labour efficiency and ultimately the work/life balance, particularly during the peak months in spring.

Contract rearing dairy replacements - A rearer's perspective

Tom Coll

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Summary

- The increase in popularity of contract rearing is driven mainly by expanding dairy herds and farmers who want to streamline labour at their current scale.
- As with any collaborative farming structure, there are benefits and risks for both parties involved.
- Dry stock farmers view contract rearing as a means of increasing stocking rate with little capital outlay, to grow gross output and the overall profitability of their holdings
- A detailed contract agreement specific to the farms involved should be put in place and agreed including a herd health plan and target weights at arrival and return.

Introduction

Contract rearing of dairy heifers has become more popular in recent years. The increase in popularity is driven mainly by expanding dairy herds but also by dairy farmers who want to streamline labour at their current scale. As with any collaborative farming structure, there are benefits and risks for both parties involved. It is perhaps fair to say that the majority of information published to date has focussed on the issues at hand for the dairy producer. However, this paper will outline the pros and cons of contract rearing from the rearer's perspective, using the collective experiences of farmers in a dedicated contract rearing discussion group based in the Sligo/Leitrim region.

Contract rearing in practice

In November 2015, a number of drystock farmers in the Sligo/Leitrim area came together to investigate the potential of contract rearing dairy heifers as a means of increasing stocking rate and increasing the profitability of their farms. An initial meeting was held on a farm that had been successfully contract rearing heifers since 2010. The Sligo/Leitrim contract rearers discussion group was duly formed and now consists of contract rearers and farmers who intend to contract rear in the near future. To look firstly at the farmers in the group, they were all relatively good grassland managers, some are on the PastureBase grassland measurement system, and all had the ability to make high quality silage. They all looked on contract rearing as a means of increasing stocking rate with little capital outlay, to grow gross output and the overall profitability of their holdings. Group members were asked to list the benefits associated with contract rearing from their perspective and those are outlined hereunder

- A means of increasing stocking rate with immediate effect, making better use of available land and buildings without the requirement to invest in stock.
- Allows for a clear direction in farm planning as the risk associated with market and price fluctuations is eliminated with an agreed contract price per day established.
- It is good for cash flow as the rearer gets paid on a monthly basis by direct debit.
- Guidelines regarding target weights and pregnancy rates to keep the rearer focused.
- A means of building a long term trustworthy relationship with the dairy farmer with each farmer focused on how the relationship will benefit both.

- Contract rearing has substantially increased the profitability of farms involved either as a sole enterprise or in combination with an existing enterprise on the farm.

Group members were also asked to list the negatives and associated risks

- It takes time to build trust and form a working relationship with the dairy farmer - the first bump on the road and how it is dealt with is vital.
- Heifers arriving on the rearers farm under target weight for age was one of the main problems. These animals will be the ones that the rearer will continually struggle with to meet the targets and the ones that will reduce farm profitability. Dairy farmers need to ensure that all heifers sent out for rearing are on target.
- Heifers arriving on the farm sick will also have a huge effect on their potential to reach targets. The dairy farmer and rearer need to draw up a health plan with a veterinary surgeon to manage the health status of the animals leaving both farms.
- The initial contract is difficult to get up and running with some dairy farmers pulling out at the last minute and leaving the rearer without stock.
- The contract rearer needs to be technically efficient, an excellent grassland manager and aware of the benefits of reaching target weights.
- There is a cost associated with changing the annual herd test date to earlier in the year to allow enough time for retesting stock in the case of a TB outbreak. The rearer should liaise with his local DVO prior to entering into an agreement.
- There is a disease risk when stock are taken onto the farm especially where there are existing animals on the farm.

Finally, group members were asked to advise on some key factors and targets that should be put in place and agreed upon between dairy farmer and rearer in advance of the first animals arriving on farm:

- A detailed contract agreement specific to the farms involved put in place and agreed including a herd health plan, target weights at arrival and return and a breeding plan.
- Regular weighing of stock should be undertaken to identify under-performing animals for timely corrective action. The ICBF weight recording link will allow the dairy farm to view weighings and monitor heifer performance.
- In the first year of the contract agreement, both parties found it beneficial for the dairy farmer to hold onto a percentage of the heifers and rear them himself as a means of comparison. This can be used as an aid in the trust building process.
- The use of heat synchronisation and tail paint/patches as an aid to heat detection to ensure pregnancy rate targets are reached and reduce workload on the rearer.
- The use of an intermediary person appointed by both parties to dissolve disputes and find solutions when things don’t go to plan.
- To continue to meet as a discussion group sharing experiences and acquiring additional knowledge to reduce the cost of heifer rearing and ensure targets are met.

Conclusions

Contract rearing is a win-win for dairy and dry stock farmers. The dairy farmer has the use of the contract rearers land, labour and buildings which should reduce his own labour requirement and need to invest in additional building for heifer rearing. The drystock farmer, who is technically efficient, a good grassland manager and makes excellent quality silage, will meet the dairy heifer rearing targets and generate a viable farm income. The Sligo/Leitrim contract rearers group are focused on farm income and want to build long term contracts with suitable dairy farmers. They treat the heifers as their own and take pride in reaching targets. I would say that the heifers reared by group members far exceed the performance of heifers reared on dairy farms nationally.

Farmer attributes predictive of farm profitability

Niall O'Leary
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Summary

- Variation in manager attributes and behaviours are predictive of variation in performance in most sectors.
- This is also the case in dairy farming and certain farmer attributes and behaviours are strongly associated with farm business performance.
- Large associations with profitability were found for Detail Conscious, Leadership and Growth Mindset (continuous learning behaviour).
- Assessing and developing beneficial attributes and behaviours is likely to lead to improved farm business profitability.

Introduction

Insights from other sectors are becoming more relevant within agriculture. For example, developing employee and manager attributes and behaviours associated with higher performance can result in increased performance and it is common in some sectors to assess employee and manager attributes during hiring and training.

Two studies of dairy farmers have shown that farmer attributes and behaviour also predict farm profitability. Farm profitability is likely to be increased by a systematic approach to hiring and staff development. Development and training of farmers and future farmers may also be guided by these findings. Both studies were of dairy farmers in Britain but are likely to be just as relevant in Ireland.

Study 1: Attitudes and beliefs association with farm profitability

A study of 80 dairy farmers in Britain found that responses to eight questions were strongly associated with profitability. These are presented in Table 1 with the percentage of profitability predicted by the responses. The cumulative percentage of profitability predicted by the first six questions alone was 40% - a large effect. Most of the findings are not surprising but the percentage size of the associations is of interest. However, there were two findings that were counterintuitive.

Farmers indicating they learned a lot about farm management when aged 11 – 15 and agreeing that content cows are a source of pride were less profitable. More profitable farmers may take content cows for granted and not see it as an achievement. Farmers that keep learning and developing are likely to be more profitable and may be less likely to say they knew a lot at the age of 15. They are also likely to have continued to learn in the intervening period demonstrating a 'Growth Mindset'. The importance of a 'Growth Mindset' is supported by profit's correlation with training provision and believing staff entering the industry need more skills (Table 1).

Table 1. Farmer responses to statements predictive of farm profitability

Statement	Predicted profit %
My farm is completely orientated towards maximising profit	+10%
How much insight into farm management did you gain between the ages of 11 & 15 (Growth Mindset – reversed)	-8%
When things go wrong I sometimes lose my cool and don't salvage the situation as well as possible	-8%
Staff entering the industry lack important skills and knowledge (Growth Mindset)	+5%
Content cows are a major source of pride	-6%
I buy in bulk when possible to get the best prices	+9%
People think I work too hard	-9%
Amount of training provided to staff (Growth Mindset)	+8%

Study 2: Personality and behaviour predictive of farm profitability

In a study of 40 dairy farmers in England and Wales, three personality measures cumulatively predicted 40% of variation in profitability (Table 2). Individual associations were larger than in Study 1. The largest effect was that 24% of variation in profitability was predicted by Detail Conscious Behaviour. A high scorer 'focuses on detail, likes being methodical, organised and systematic'. A low scorer is 'unlikely to become preoccupied with detail, less organised and systematic, dislikes tasks involving detail'.

Table 2 shows what a one point change on a 10 point scale predicted for profitability. All else being equal, if one farmer scored one point higher on Detail Conscious, a difference in profit of 1p per litre or £71.84 per cow was predicted.

Similar but smaller effects were found for Leadership and Relaxed. Leadership is described as 'Inspiring and guiding individuals and group. Leading by example and arousing enthusiasm for a shared vision'. A high scorer on the Relaxed 'finds it easy to relax, rarely feels tense, generally calm and untroubled'. A low scorer for relaxed 'tends to feel tense, finds it difficult to relax, can find it hard to unwind after work'. Relaxed was negatively associated with profitability.

Table 2. Profit variation explained

	Pence per litre	Profit per cow	Predicted profit
Detail conscious	1.00p	£71.84	24%
Leadership	0.79p	£54.67	21%
Relaxed	-0.61p	£-48.72	12%

Conclusions

Variation in farmer attributes and behaviour is predictive of variation in farm profitability. The findings and their scale are consistent with findings in other sectors. Broadly similar relationships are thus likely to exist amongst Irish farmers. There are practical implications for farmers wishing to increase their own performance, agricultural educators, and for informing the hiring and training of farm staff.

Collaborative farming: Providing sustainable solutions to improve labour availability in Irish dairy farming

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- Partnership:
  - » A registered family partnership is an integral part of succession planning of the family dairy farm.
  - » Partnership provides a sustainable business model for farmers to amalgamate farming businesses.
  - » A business model where young trained farmers can establish a career in dairy farming.
- Contract rearing:
  - » An opportunity for expansion and labour efficiency for the dairy farmer.
  - » A complimentary or alternative enterprise to drystock 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 successor
- Cow leasing:
  - » An opportunity to get a financial return on surplus cows in the short-term.
  - » Can help a young farmer to reduce initial set up costs when entering dairy farming.
- 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.
- Specimen template agreements:
  - » Available from Teagasc for all the collaborative arrangements featured in this article at: https://www.teagasc.ie/rural-economy/farm-management/collaborative-farming/

Registered farm partnerships – family situations

Succession Planning on Irish dairy farms is a vital process to the future of Irish dairy industry. Recent studies show that many farmers have no identified farming successor. However, Irish dairy farmers need to be conscious that succession is happening on the farm every day at some level. The early part of succession is about the next generation learning to do routine tasks on the farm and gaining a greater level of competence for those tasks over time. Where the later stages of succession (Transferring responsibility, decision making) are ignored or not dealt with by a farm family it can stymie the long-term development of the farm business and can also discourage potential successors due to uncertainty around the future. Recent research by Teagasc has highlighted that succession is an on-going process that can begin early in the life of a son or daughter. A registered farm partnership is a central step as part of a succession plan. It is an ideal structure to formally involve the next generation in the farm business and in doing so facilitate the gradual transfer of responsibility and decision making on the farm. The focus moves from farm transfer to farm operation as a team to progress the farm to meet the needs of a changing industry. This is important as in most cases, parents are not immediately in a position to transfer the farm to a son or daughter that has returned home after completing their agricultural education. Firstly, the young person is relatively inexperienced and there are genuine reasons usually linked to concerns about the implications for family income; security for the parents and other family members that still have to be provided for. 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 financial advantages to forming a registered partnership for both the parents and the son or daughter.

Succession farm partnerships are a new structure beginning in 2017, where an annual income tax credit of €5,000 is available for up to five years. To avail of this credit the partnership must complete a business plan in the form of the Teagasc My Farm My Plan booklet and complete a separate legally binding succession agreement in which it is agreed to transfer 80% of the farm assets within 3-10 years.

Registered farm partnership – non-family

A partnership with other farmer(s) offers a superior work-life balance to operating alone through more labour availability. In some situations, it can alleviate the need to rely on hired in labour. While the farm will be still busy, especially at peak times, the fact that there is at least two labour units making an income off the farm and available to carry out the work on the farm on a daily basis is what provides this superior work life balance. A partnership can and must provide to the opportunity for increased scale as the farm will have to sustain two family incomes. The real reward for a good work structure is the ability to have a good lifestyle with adequate time for family and other personal interests. It can provide scale in a sustainable way as the additional labour is built in as part of the partnership. The main advantages include: making use of the existing facilities on farm, which may reduce the level of capital expenditure; a more capable skills mix; greater labour efficiency; and a better lifestyle.

Working in partnership means there is often a better and broader 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. A well thought out work structure leads to labour greater efficiency through having more labour available and also a reduction in the duplication of routine farm operations between two farmers.

Having completed the required formal agricultural education and spending a period of time gaining valuable on-farm experience, a registered farm partnership with an existing dairy farmer is a business model that can facilitate the entry of young trained farmers to the Irish dairy industry.

The key challenge for any farmer considering partnership or any collaborative arrangement is to develop and nurture a strong working relationship with other people in the agreement. This is the single most important factor in the success of any arrangement. It involves a change of mind-set on the part of the farmer to think in terms of us/we rather than I/me. The relationship must be built on strong core values such as trust, respect, understanding, and above all excellent communication.

Share farming

The key feature distinguishing share farming from a partnership is that two completely separate farming businesses operate on one farm. Firstly, the business of the landowner, and secondly, the business of the share farmer. All receipts and payments are split between both people as set out in their written agreement. They both calculate their own separate profits from the arrangement. The concept remains the same across all enterprises including dairy farming.

The starting point for this arrangement is a financial budget to cover potential income and expenditure from the enterprise. Each person must then complete a financial budget and cash flow plan for their own respective businesses to make sure the venture makes financial sense for them in their own right. Share farming as a structure could suit a situation where the landowner no longer wants to be involved in the day to day running of the farm but will retain an interest in the financial performance of the farm. The share farmer generally provides all of the labour and in some cases, the livestock and/or machinery. The landowner provides the land and the facilities required for the dairy enterprise to be successful.

Long-term land leasing

Long-term leasing is a growing feature of Irish farming due mainly to the income tax incentives available to the owner of the land who leases it out for more than five years. Other changes in relation to Capital Acquisitions tax have also helped to make land available to active farmers under lease rather than the inheritor farming it themselves. Leasing is an attractive option to established farmers as they can better justify any required investment in the land in order to get a financial return.

Benefits to lessors

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.

Table 1. Tax incentives for long-term land leasing

Term of lease (years)	Max tax free income/year
5 - 7 years	€18,000
7 - 10years	€22,500
10 - 15 years	€30,000
> 15 years	€40,000

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%. This is a very valuable relief to farmers and other land owners when transferring land.

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.

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 between 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.

Since 2015, the scheme includes the disposal of an entire fragmented farm and its replacement with another farm that is less fragmented, subject to meeting the original criteria of the scheme.

Conclusion

Collaborative farming has wide ranging benefits for the farmers who get involved. The key to long-term success is mutual benefits to all members of the arrangement. Some of the benefits include: new opportunities for existing farmers; better work-life balance through greater labour availability; better decision making through greater skills mix and opportunities for young trained farmers with experience to begin their career in dairy farming. The challenge for many dairy farmers in Ireland is a change of mind-set and the establishment of a strong working relationship with their fellow collaborating farmers.

Farm succession planning

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Summary

- Every farm family encounters the issues of succession and inheritance in the lifetime of the farm.
- Planning for succession is one of the most important aspects in the life of the farm business.
- Planning for and carrying through on succession can be a complex process but needs to be done at an early stage to ensure that the process is successful.
- Communication is one of the most important factors which contribute to a successful succession and inheritance process and there should be open discussion with all family members.

Introduction

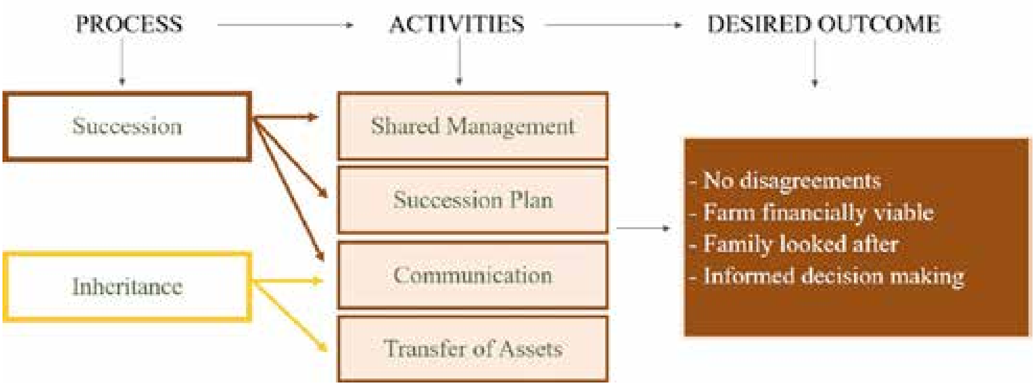
The issue of transferring the family farm is one which every farm family encounters during the life of the farm. A lot of farmers do not like to talk about succession and inheritance as it can be a sensitive subject as farmers' feel it marks the end of their farming career. It is important to understand that within farm transfer is the two processes of succession and inheritance.

- **Succession** is defined as the gradual transfer of management of the farm from one generation to the next.
- **Inheritance** is defined as the legal transfer of the farm assets from one generation to the next.

Planning for succession is critical to ensure that the process occurs without issue and that all members involved in the family are happy with the outcome.

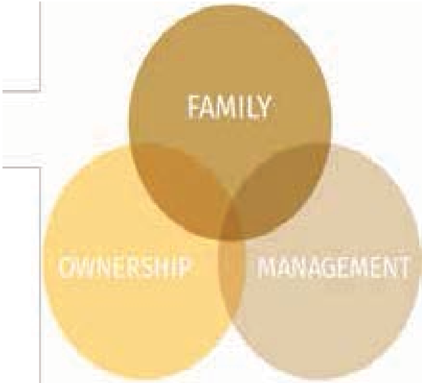
Succession planning

Succession is very important for the farm business as it gives an incentive to expand or change the farm and it also provides the resources, labour and skills to carry the plan through. It is important to note that succession is not a single event but a process which occurs over a period of time. Succession planning can be difficult and complex as the farmer tries to maintain a viable farm business for the next generation, treat all of their children fairly and provide financial security for their own retirement. Planning early for succession allows for a lot of the main issues to be addressed and resolved and ensures that all family members are happy with the proposed outcome for the farm. A key starting point to this is establishing the needs, expectations and fears of all family members in regards to the farm business.



Communication

Effective communication is the key ingredient to successful succession planning as it allows for family members to share concerns, decide on options available and what actions to take. It also allows for effective planning and helps prevent disputes, misunderstandings and unnecessary anger. Typically, when it comes to discussions around succession and inheritance, farmers are "passive" communicators meaning that there is a lot of assumptions around who is getting the farm and the plans for the future but these are not always explicitly communicated to the people involved. When communicating on succession and inheritance it is important to include all family members in the conversation considering the three key aspects of family, ownership and management in any discussion. When planning any discussion on succession the following should be considered:



- Who should be involved in the discussion?
- What needs to be discussed?
- When and where to meet?
- What life stage are the children at?

Conclusions

Communication is key to effective succession planning but it is important to have the discussion early and with all family members to avoid any disagreements and ensure that all family members have had the opportunity to discuss their needs, fears and requirements about the farm business.

DAIRY FARM INFRASTRUCTURE

Efficient milking facilities

John Upton[1] and Tom Ryan[2]

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Summary

- Milking facilities should be designed so that the milker can carry out the complete milking without leaving the pit. Aim to complete milking in under 90 minutes.
- Appropriate animal handling facilities are required to achieve this goal, including good cow flow into and out of the parlour.
- Drafting facilities save time, provide gentle cow treatment, and maximum cow traffic speed through the parlour.
- Adjust the milking routine as lactation progresses to avoid over milking. Over milking causes discomfort for the cow and increases the new mastitis infection risk.
- Cluster removers eliminate over milking and provide consistency of milk-out.

Introduction

Milking is the main chore on dairy farms and typically consumes over 30% of total labour input. In the past, most dairy farmers focused on having about ten cows per milking unit and space for additional units was in many cases omitted. In the future, apart from restricted land resources, labour is likely to be the most important factor limiting herd size. Hence, having a parlour with a large output in terms of kg's of milk produced per person per hour will be necessary. The number of milking units an operator can safely handle is now a major issue, and all forms of automation are now being considered by farmers as labour demand in milking parlours is now a priority. Herd sizes will continue to grow in Ireland, driven by the abolition of the quota regime in 2015. Against this background, many farmers are milking in unsuitable parlours and need to invest in a new parlour to suit their needs. With high labour costs and problems accessing skilled labour, the recent trend has been to install milking parlours with a greater number of units to be handled by one operator. Installing a new parlour is an expensive, once in a generation investment and should be planned carefully.

Output of milking parlours

- The choice of milking systems should be directly related to the number of cows currently being milked and the herd size envisaged for the future. Plan to allow for milking an expanded herd in no more than 1 hour 30 minutes.
- Larger herd sizes will lead to a greater focus on time, working conditions and ergonomics associated with milking. It is important that maximum potential milking performance be achieved either from new milking installations or from changes to the existing milking parlour size and design.
- The particular requirements of the individual dairying enterprise and the cost of hired labour must dictate the level of automation decided on. The capital, maintenance and running costs of the automation must be carefully considered also. If a high level of automation is installed, then it must be ensured that it is reliable and dependable and can be operated by a person of reasonable skill.
- Generally it is better to focus on having adequate milking units at the expense of high levels of automation.

Automatic cluster removers (ACRs)

- While cluster removers are often considered unnecessary in smaller parlours (less than 14 units), they offer great flexibility in larger parlours. The installation of ACRs can help cows' health by eliminating the risk of over-milking.
- Cluster removers ensure consistency around the end-point of milking, which is beneficial if the milking task is carried out by a number of different people.
- Analysis of on-farm data shows that herds without cluster removers are prone to over milking towards the end of lactation. During the over milking period, short milk tube vacuum can approach system vacuum causing congestion (or swelling) of the teat tissue and hence delayed closure of the teat canal after milking. This delayed closure of the teat canal allows a window for mastitis causing bacteria to enter the udder.
- Swing arms are usually required for correct operation, i.e. to prevent clusters getting dirty and swinging free across the pit when detached, and to support the rams for cluster removers and also to support the long milk tube.
- If planning for the installation of cluster removers at a later date, swing arms should be installed making the fitting of cluster removers easier in the future.

Bailing systems

The installation of bailing systems allows cows to be located conveniently for proper operation of ACRs. The main advantage with bailing systems is that cows are controlled and positioned better for easy and safer cluster attachment and removal, compared to having a straight-breast rail or angled mangers. When there is a large variety of cow sizes in the herd (e.g. if there is a large number of 1st lactation animals), extra cows can fit into the row unless there is a suitable cow positioning system. This causes poor cow position and may double the row time

Well-designed drafting facilities at exit from the parlour will:

- Save time, provide gentle cow treatment, and maximum cow traffic speed through the parlour.
- Cows can be accurately drafted and normal cow flows are not disrupted.
- A system that funnels cows into a single file on exit from the parlour and into a chute is required. This can then widen after drafting to allow for rapid cow exiting.
- A short self-closing drafting gate can be opened across the race from the pit via a rope and pulley system. It is important when cows are being drafted that they have adequate space in front so that they do not hesitate at the drafting gate passage.
- A secure holding pen should be of adequate size, e.g. hold 10% of the herd, should have a gate to guide animals towards a crush, and provide shelter where cows are held for long periods.

Conclusions

Efficient milking involves successful interactions between the cow, milker and the milking facilities. Investment in key technologies such as those described in this paper can contribute to achieving the goal of efficient milking. Choice of technologies will be farm specific but should be prioritised in order of time saved during the milking process.

Energy and water use efficiency on dairy farms

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Summary

- Benchmark your farms energy costs against other farms. The average cost of electricity usage on Irish dairy farms is €5 per 1,000 litres milk produced.
- Check the electricity unit cost against the best unit rates using a cost comparison website.
- Use night rate electricity for water heating and the morning milking. Night rate hours are from 11pm to 8am during winter time and 12 midnight to 9am for summer time.
- Efficient recycling strategies for plate cooler water (e.g. for wash-down or stock drinking) is important to reduce water use while maintaining energy efficiency.

Introduction

The average cost of electricity usage on Irish dairy farms is €5 per 1,000 litres milk produced. There is a large variation in that figure – from €2.60 to €8.70 per 1,000 litres produced, or from €15 to €45 per cow per year. These figures suggest that there is potential for many farmers to reduce their electricity usage by making some changes to how they produce milk. Teagasc estimates that the average farm could save €1,800 per year through altered management strategies and the use of energy efficient technologies. These costs exclude VAT and network charges. The main drivers of energy consumption on dairy farms are milk cooling (31%), the milking machine (20%) and water heating (23%). A more detailed breakdown of energy consumption is illustrated in Figure 1.

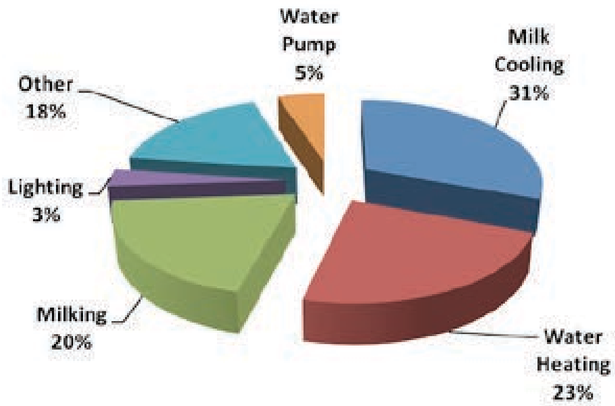

Figure 1. *Average component consumption on 60 commercial dairy farms*

Calculate your energy costs

A simple calculation can be made to approximate on-farm electricity costs. Firstly, add up the total electricity charges over a year excluding standing charges, VAT and PSO levy; these figures can be found on the electricity bill. Multiply by 100 to convert from euro to cents. Next add up the total number of litres of milk sold to the processor over the same period. Dividing the electricity cost in cents by the number litres will give the cost in cent per litre. The average three bedroom house in Ireland uses approximately 5,000 units of electricity per year. This can be deducted to account for domestic usage if the dwelling house is on the same meter as the farm.

Night rate Vs day rate electricity

Night rate is charged at ~€0.08 per KWh, and day rate is charged at ~€0.16 per KWh; exact costs vary by the electricity supplier. Checking your pricing and tariff structure against the best available rates can also yield significant savings. The cheapest supplier could be 20% less than the most expensive supplier.

A price check can be carried out using a pricing comparison website such as www.bonkers.ie. All you need is information about your present tariff, annual usage and night rate usage in order to make comparisons and calculate possible savings. If you decide to switch suppliers, it is important to read the small print. Check the standing charges and termination charges.

Key points about night rate electricity

- Night rate hours are from 11pm to 8am during winter time and 12 midnight to 9am for summer time.
- Where appliances are required to operate during night rate hours (e.g., electrical water heaters), digital time clocks with battery backup should be used.
- Analogue timers without battery back-up will become out of sync in power failures.
- Note: There is no charge from ESB networks to install a night rate meter. The meter standing charges increase from approx. €0.46 per day to €0.60 per day after moving to night rate electricity. This means that a minimum of 1.5 units of electricity would need to be used each night to offset the extra charges.
- A typical dairy water heater uses approx. 1.5 units of electricity per hour and takes about six hours to reach full temperature.

Water use on dairy farms

In a study of 25 Irish commercial farms that were monitored for a 12 month period, the average volume of water consumed per litre of milk produced was 6.4 litres. Consumption by livestock and other miscellaneous use accounted for two thirds of water use on farms. The second largest use of water was the plate cooler (1.69 L/L). An efficient recycling strategy for this plate cooler water is important to reduce water use while maintaining energy efficiency. Plate cooler water can be collected and reused for wash-down procedures and animal drinking water (provided the bacterial load of the source is low). Maintenance of water systems was identified as a key aspect of efficient water use. Leaks can add to the pumping cost of water, with leaks of 10L/min costing up to €526/annum in pumping costs.

Conclusions

Calculating the energy costs of your farm in cents per litre of milk produced is a useful exercise to benchmark efficiencies against national averages. Farms with energy costs of greater than €8 per 1,000 litres milk produced will benefit from in energy efficient technologies (such as plate cooling), whereas farms below the average electricity spend of less than €5 per 1,000 litres would benefit from cost reducing measures such as moving consumption to night rate electricity (e.g. for water heating and morning milking) and moving to the least cost supplier.

Energy efficient methods for dairy farm water heating

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Summary

- Water heating is among the largest electricity consumers on dairy farms, and therefore energy efficient methods to reduce water heating costs should be explored.
- Solar panels and heat recovery units are two energy efficient options that were tested for their ability to provide a positive return on investment on dairy farms of three different sizes.
- Results showed that, under the conditions examined, the return on investment for solar panels ranged from -19% to -22% and the return on investment for heat recovery ranged from -4% to -23%.

Introduction

Water heating is a major consumer of electricity on dairy farms in Ireland, accounting for approximately 23% of farm electricity costs. This makes water heating the second largest consumer of electricity after milk cooling. Further information is required to enable farmers to make informed business decisions around the most appropriate investments in water heating technology. Solar panels and heat recovery units provide "free" hot water, as solar panels use energy from the sun and heat recovery systems use waste heat extracted from the milk cooling process. While these two technologies may provide significant reductions in water heating costs, it is necessary to investigate whether this long term financial saving on water heating is outweighed by the systems' initial capital outlay.

Hot water use on dairy farms

Hot water may be used on a dairy farm for wash-down of the milking machine, bulk tank and parlour. The volume of water required for milking machines is typically in the region of 10 litres of hot water per milking unit, while the volume required for bulk tank wash-down varies depending on the frequency of milk collection i.e. if milk is collected every second day the hot water used to wash the bulk tank will be half of that used during every day collection. Hot water temperatures between 70 and 80 degrees Celsius are required for washing the milking machine and between 60 and 70 degrees Celsius for washing the bulk tank.

Energy efficient water heating methods

Solar panels (SP) provide heat to the water by means of a coil contained within the water tank. This coil contains a fluid (glycol) which is heated by being passed through the solar collector to absorb energy from the sun. This energy then heats the water via the coil. Heat recovery (HR) units supply heat to the water by recycling heat extracted from milk during the cooling process. Rather than expelling the milk's heat to the outside air, a heat exchanger is used to transfer this heat to the water. Up to 60% of the heat extracted from the milk may be transferred to the water, with particularly high percentages observed at the beginning of the cooling process when the milk is at its warmest.

Testing

A series of experiments were carried out at Teagasc Moorepark in 2016 to provide an insight into the economic performance of the two energy efficient water heating technologies mentioned above (SP and HR). Two sizes of SP were tested ($6m^2$ and $10m^2$) under a variety of weather conditions. The HR was tested separately, taking both precooled and non-precooled milk into account. These technologies were compared with a basic system using night rate electricity alone.

Results

Having acquired the data from these experiments, the economic potential of SP and HR was assessed for three dairy farms of different sizes.

- The first dairy farm (Small) consisted of a 50 cow herd, a milking machine with eight milking units, direct expansion (DX) milk cooling, twice-a-day milking and once-a-day hot-wash, with annual milk yield of 250,000 litres.
- The second dairy farm (Medium) consisted of a 100 cow herd, a milking machine with 14 milking units, direct expansion (DX) milk cooling, twice-a-day milking and once-a-day hot-wash, with annual milk yield of 500,000 litres.
- The third dairy farm (Large) consisted of a 200 cow herd, a milking machine with 24 milking units, direct expansion (DX) milk cooling, twice-a-day milking and once-a-day hot-wash, with annual milk yield of 1,000,000 litres.
- For all three farms, two precooling scenarios - with and without precooling – were considered.

Results are provided in Table 1 below. For each of the dairy farm scenarios mentioned, the percentage return on investment (ROI) over a 10 year period was calculated for separate investments in both SP and HR (compared with a basic system using night rate electricity alone). It was assumed that the initial SP installation cost for the small and medium farm was €4,500 ($6m^2$ array), and for the large farm was €7,500 ($10\ m^2$ array). The initial HR installation cost was assumed to be €3,600, with the farm having been provided grant aid of 40% on the system (i.e. total cost without grant = €6,000).

For the three dairy farms described above, neither SP nor HR appear financially feasible at present, with negative ROI values for all scenarios investigated. The most promising results were attained for HR systems on large dairy farms, with ROI values of -10% and -4% under a precooling and no precooling scenario, respectively.

Table 1. Ten year percentage return on investment for Solar panels and heat recovery systems on three dairy farms, under two precooling scenarios

Farm Size	Precooling level	ROI for solar panels	ROI for heat recovery
Small	Precooling	-19%	-23%
	No precooling	-19%	-17%
Medium	Precooling	-19%	-16%
	No precooling	-19%	-12%
Large	Precooling	-22%	-10%
	No precooling	-22%	-4%

Conclusions

Experimental results indicate that, under the specific scenarios investigated, solar panels and heat recovery systems were not financially beneficial for farmers over the 10 year period examined in this study.

Key points for appropriate grazing infrastructure

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Summary

- The grazing infrastructure will need to be changed for increased herd sizes. Adjust paddock sizes, ideally for three grazings.
- Ensure the farm roadway network is appropriate for the herd size and the soil type.
- Upgrade the water supply to paddocks. Achieve a good flow rate to troughs with large pipe bores and "full flow" type ballcocks.
- Good fencing is an important aid to grassland management.

Paddocks

Paddock sizes will have to be changed as the herd size increases. The size of the paddock should be based on either two or three grazings of a planned number of cows. From mid-April to August, a three grazing system is preferred, as it maximises pasture intake and milk production. The guideline paddock area is 1.2 ha per 100 cows for 2 grazings and 1.8 ha per 100 cows for three grazings (with a target pre-grazing cover of 1,400 kg DM/ha). For a 21 day rotation in mid-summer, this means that 21 or 14 such paddocks are required. Additional grazing area will be available before and after silage is harvested. Ideally paddocks should be square to rectangular in shape, with the depth no more than three times the width. As a general rule, the distance from the roadway to the back of the paddock should be between 70 - 100 metres on heavy land, 100 - 170 metres in medium land and 170 - 250 metres on light land. The upper limits are more applicable to larger herds. Provide a few small paddocks near the parlour for lame/sick cows. Use multiple gateways to paddocks on heavy land and during wet weather.

Calculating paddock size:

- Establish cow numbers (plan for the long-term).
- Establish daily demand, e.g., 100 cows x 17 kg DM = 1,700 kg DM for 24 hours.
- Ideal pre-grazing yield is 1,400 kg DM/ha in mid-season.
- To calculate paddock size, divide herd demand by ideal pre-grazing yield.
    - » Two grazings: 1,700/1,400 = 1.2 ha for 100 cows in 24 hours (3 acres); 21 paddocks required.
    - » Three grazings: 1,700 x 1.5 days/1,400 = 1.8 ha. for 100 cows in 36 hours (4.5 acres); 14 paddocks required.
- The remaining area is normally closed for silage during this period. It could also be divided into similar paddocks.

Roadways

Design, construction and maintenance of farm roadways have a big impact on cow flow, walking speed and lameness. Does your current farm roadway system service all of the potential grazing area and is it in good condition? If the current roadway system is inadequate, it needs to be upgraded and/or extended. Essential elements of a good roadway are adequate width, a smooth surface, a crossfall, raised above the grazing area and sweeping bends at corners and adequate junctions. The main roadway should be wide enough for good cow flow (e.g. 100 cows - 4 metres wide; 200 cows – 5-5.5 metres wide).

New farm roadways must be laid in good weather in dry soil conditions. Construction costs can vary, from €18 to €30/m, depending on the cost of materials, the width, depth of material and the construction method. Cow tracks (spur roadways) are a cost effective way (€8 to €11 per metre) to improve access, particularly on heavy land and to long paddocks. Cows like to walk with their heads down to see where to put their front feet. The hind foot is also placed on ground that the cow has seen. When cows cannot place their feet safely, they will slow down. They also slow down due to a poor roadway surface or if forced to move on from behind. If forced to move on from behind, cows become bunched and stressed and they lift up their heads and shorten their stride. Now they cannot see where to put their front feet and they lose control of where to put their hind feet. A cow that is left to move along quietly will seldom misplace a foot, even on a poor surface.

Water system

Assess your current water supply to the paddocks:

- Are pipe sizes adequate?
- Are ballcocks restricting flow?
- Are water troughs big enough and correctly located?
- What water flow rate is needed for your herd?

A flow rate of 0.2 litres per cow per minute and a trough volume of about 5-7 litres per cow are generally recommended. For example, a flow rate of 20 litres per minute and 680 litre troughs per 100 cows. Don't be tempted to solve water supply problems with very big troughs; focus on flow rates and larger pipe sizes instead. Excessive trough sizes markedly increase installation costs. Farms are very different in terms of cow numbers, pipe length, farmyard location and topography, so take all these factors into account when deciding on pipe size and system layout. The aim is to minimise pressure loss due to friction in water pipes so that enough pressure is available to overcome lift and maintain a good flow rate in troughs. Err on the high side with pipe size bore. A ring main (loop system) is a cost effective way to enhance water flow rates and ensure an even flow rate to troughs. Main pipe size bores should typically be 25 mm, 32 mm or 40 mm and branch pipe bores to individual troughs would be 20 mm, 25 mm or 32 mm. Use "full flow" type ballcocks in all new troughs. These ballcocks typically have 9-12 mm jets providing a good flow rate even with low pressures at the ballcock. A standard high pressure ballcock jet (3 mm diameter) is very restrictive even where pressure at the ballcock is high. Position troughs to minimise walking distances to water and to avoid unnecessary smearing of grass. Keep troughs away from gaps and hollows. Troughs should be level and have no leaks. Where leaks do occur, they should be promptly located and repaired. Troughs on roadways will slow cow movement and make roadways dirty. Allow trough space for at least five per cent of the herd to drink at once. Costs can amount to €275/ha for new installations.

Paddock fencing

Good fencing is an essential element of any paddock grazing system. A specialised fencing contractor will be more skilled and better equipped to erect top quality fencing. Plan the location of fences carefully based on a paddock plan on the farm map. Clearly determine the extent of the work. Some paddocks may need two strands for calves and farmers in Glas need to have these fences right. Get itemised quotations in advance. Plan the system to aid grassland management. It should be easy to setup the access to paddocks between grazings. The fence should be designed so there is no danger that the fence is off if gateways are left open. Good maintenance is essential.

Land drainage design and installation

Pat Tuohy[1], Owen Fenton[2] and James O Loughlin[1]

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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.

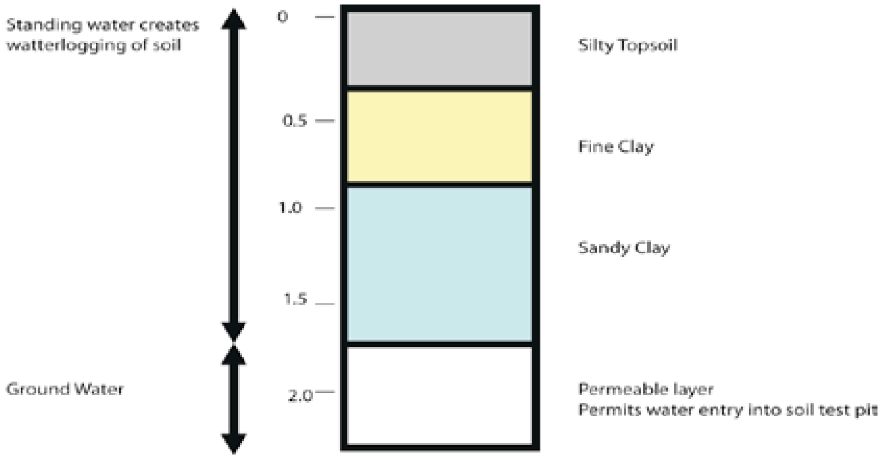

Figure 1. *A typical heavy soil profile. If a free draining layer (called "permeable layer" here) is present at any depth then a groundwater drainage system is the most appropriate solution, if not then a shallow drainage system is required*

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 type of 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. Where layers with high permeability are deeper than this, however, deeper drains are required. Deep field drains are usually installed at a depth of 1.5-2.5 m 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 via the Teagasc website, www.teagasc.ie/publications. Search “Teagasc Manuals”. A freely downloadable practical guidebook to land drainage is available via the Teagasc website, www.teagasc.ie/publications. Search “Land Drainage”.

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.
- 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, excellent herd fertility, optimum soil fertility, and capacity to build silage reserves are essential. Teagasc launched a heavy soils programme in 2011, and has a number of detailed studies on-going on seven commercial dairy farms located in Macroom, Kiskeam, Castleisland, Listowel, Athea, Rossmore and Doonbeg. A beef farm in Crossmolina joined the programme in 2014 and two dairy farms in Stradone and Swans Cross joined the programme in 2016.

Farm performance

The performance of the seven dairy farms on the programme between 2011 and 2016 is summarized in Table 1. A marked increase in costs in 2012 (high rainfall year) was caused by reduced grass production, and poor milk price is reflected in the 2016 data. There has been a steady growth in herd size and stocking rate on the milking platforms, which is reflected in increased milk solid production per hectare.

Table 1. Heavy Soils Programme farm physical performance 2011-2016

	Herd size	Stocking rate (LU/Ha)		6 week calving (%)	Milk solids/ ha (kg)	Grass grown (T DM/Ha)	Net margin	
		Farm	Milking platform				€/Ha	c/litre
2011	77	1.7	2.12	72	850	10	1,512	15.3
2012	85	1.71	2.27	68	869	6.8	1,067	10.7
2013	83	1.69	2.24	76	940	8.9	1,494	14.6
2014	85	1.85	2.3	74	935	11	1,727	16.7
2015	95	1.81	2.45	74	1,091	11.3	1,228	11.2
2016	101	1.83	2.58	79	1,132	11.4	995	9.9

Soil fertility

Soil data from the original seven farms on the Heavy Soils Programme are summarized in Table 2. Average pH has increased from 5.8 to 6.3. Soil pH has increased on all farms. The farms continued to apply lime in 2016 to bring all paddocks to target pH of 6.3. No noticeable change in soil trafficability has been observed by the farmers, largely due to limiting application rates to two tonnes per acre in any one application. Phosphorus (P) status increased in five farms, with the overall P status declining in Doonbeg and Listowel. Higher P off-take and high soil P fixation capacity remain the key factors preventing improved soil P status on these farms. Potassium (K) status remained static between 2015 and 2016, with only two farms recording an improvement in K status. Soil analysis shows that K removed in surplus round bale silage needs to be replaced.

Table 2. Soil fertility status Heavy Soils Programme farms 2014 - 2016

Year	K-Morgan	K index	P-Morgan	P index	pH
2014	123	3	7.2	3	5.8
2015	102	3	5.9	3	6.1
2016	102	3	5.8	3	6.3
Target	101-150	3	5.1 - 8	3	6.3

Grazing blueprint

The Heavy Soils Programme has identified key actions to maximise grass utilisation:

- Build high quality silage reserve (+0.5 tonnes DM/cow).
- Compact calving is essential as grazing season is shorter.
- Have a flexible approach to grazing.
- Introduce high quality silage when grazing conditions deteriorate.
- Excellent grazing infrastructure with spur roads for paddock access is vital.

Table 3. Grazing year-key benchmarks

Autumn	Spring	Summer
Start building cover 10th Aug	Mean calving date – 1st Mar.	Milking block-cows only
Peak cover – 1,000 kg DM/ha	Graze 40% - 17th Mar. & 100% - 10th Apr.	18 – 21 day rotation
Start closing late Sept	On-off grazing	180-200 Kg DM cover/cow
80% + closed – 31st Oct	1st Apr. -60 units N/acre (2 splits)	Make 2½ bales/cow on MP
Closing cover – 650 kg DM/ha	1st May -100 units N	Measure grass every five days

Conclusions

Increased productivity on heavy soils requires continued focus on soil fertility. The Heavy Soils Programme farms have improved soil pH and grass production through greater lime application. 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 or 2.5 bales/cow). Stocking rates must be matched to the grass growth and the grass utilisation capacity of the farm. It is vital to establish a good grazing infrastructure and to have a flexible approach to grazing challenges at different times of the year.

Maintaining and enhancing water quality

Daire Ó hUallacháín

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Summary

- Water Quality is a primary environmental indicator of sustainable agricultural systems. Ireland must achieve 'good' status in all watercourses by 2021.
- Existing farmland habitats and landscape features play an important role in improving water quality by intercepting the flow of nutrients and sediment.
- Appropriately managed targeted buffer strips help ensure bank stability, intercept nutrient, improve water quality, whilst also providing a habitat for biodiversity.

Introduction

River regulation, alteration of stream habitats and degradation of water quality have had significant impacts on freshwater ecosystems throughout the world. Nutrient enrichment (and subsequent eutrophication), along with excess sediment inputs are the primary water quality issues for most freshwater ecosystems. In Ireland, the two main threats to water quality are municipal (point source) and agriculture (diffuse sources).

The Water Framework Directive was established as an overarching approach to protect waterbodies in Europe. It requires Member States to achieve at least 'Good' ecological and chemical status in all waters and maintain 'High' status where it occurs, by 2021.

Evaluating water quality

The standard method for monitoring freshwater quality in Ireland is the Q-Value method, employed by the Environmental Protection Agency (EPA). This is a rating system from Q1 (Bad) to Q5 (High) and is based on a combination of water chemistry and water ecology parameters.

Assessing water chemistry is relatively straightforward. It is limited, however, in that it only gives a snapshot of the water chemistry on the day of sampling, and does not necessarily indicate recent changes or fluctuations in water chemistry condition.

Assessing water ecology can give a better indication of background river conditions. Rivers and streams support a rich and diverse community of animals including fish, insects, snails etc. Insects vary from species that are highly sensitive to different chemical and physical conditions, to those that are tolerant. Therefore, if a river or stream supports a large and diverse community of pollution sensitive species (e.g. mayfly and stonefly larva), this would indicate that the river has 'good' or 'high' water quality, with little indication of excess nutrients or sediment. Alternatively, if a stream contains large numbers of pollution tolerant species (e.g. midge larva) with no mayfly or stonefly larva, this would indicate excessive nutrients and 'poor' or 'bad' water quality. The insect community can therefore be used as an indicator of the health of the waterbody.

Impact of excess nutrients and sediment

The loss of nutrients (nitrogen and phosphorus) and sediment from grassland systems to water has been highlighted as one of the main threats to water quality in Ireland. Agricultural pressures predominantly originate from diffuse sources of nutrient such as the spreading of organic and inorganic fertilisers. In addition to diffuse sources of nutrients, agricultural activities can also give rise to point sources of nutrients, sediments and pathogens.

Elevated levels of nutrients pose direct toxicity difficulties for freshwater animals, but they can also result in eutrophication which impacts on the ecological community. Excessive addition of sediment to rivers for example can result in clogging of coarse river gravels, causing deoxygenation and resulting in the degradation of important habitat types that support native species such as salmonids and the Freshwater Pearl Mussel.

Trends in water quality

The most recent assessment on water quality (2012-2015) by the EPA indicates that approximately 70% of rivers and streams are achieving 'Good' water quality, with the remaining 30% being less than good. This trend has remained relatively stable over the last two decades, with an obligation to achieve good status in 100% of waterbodies by 2021. Measures under Cross Compliance (e.g. SM1), help protect watercourses from excessive nutrients. Additionally, optional measures under GLAS also aim to maintain or enhance water quality (e.g. establishment of riparian buffer strips, or exclusion of cattle from watercourses).

Teagasc freshwater ecology research

Teagasc studies are assessing the impact of existing and potential measures to enhance water quality and improve aquatic ecosystems.

- Research has highlighted that improved targeting of mitigation measures such as buffer strips to specific areas with enhanced overland flow (containing phosphorus or sediment) can reduce the costs of implementation by up to 90%, thus improving the cost-effectiveness of measures.
- Additional studies highlight the importance of existing landscape features and semi-natural habitats (Image 1) in intercepting the flow of sediment from source to river.

Image 1. *Targeted riparian buffer strips can play an important role in improving water quality, whilst also providing a habitat for biodiversity*

Conclusions

Water quality is a primary environmental indicator of sustainable agricultural systems. Effective methods are required to maintain and enhance water quality, as part of the development of sustainable agri-production systems.

KEEPING YOURSELF SAFE ON DAIRY FARMS

Health and Safety management for Dairy farms

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Summary

- Health and Safety management is crucial to prevent accidents and ill health associated with working on dairy farms. Poor standards result in tragedy, pain and suffering, and potentially impact on both lifestyle and livelihood.
- Currently in 2017, farm workplace deaths levels are twice the average levels. A study by ERSI has shown that dairy farms have a 35% higher level of accidents compared to non-dairy enterprise farms.
- All farms have a legal duty to manage health and safety by completing, updating and implementing a Risk Assessment document, or if more than three persons are employed, preparing a Safety Statement.
- Farmers, on average, have an inferior health status compared to other occupational groups. Accordingly, promotion of health practices is warranted to motivate and assist farmers to improve health status.

Introduction

Farming is one of the most dangerous work sectors in Ireland. Typically about a third of all workplace deaths occur in the agriculture sector. On average about 19 fatal farm accidents occur on Irish farms each year. This year, to the 31st May, 12 farm deaths have occurred, with eight of these involving tractors and machinery. Childhood deaths are particularly tragic, and in recent years there has been a significant increase in the occurrence of these fatalities. Farm accidents causing serious injury occur at the high level of 2,500 per year. A recent study by ERSI indicates that dairy farms have a 35% higher level of accidents than non-dairy enterprise farms. An accident can lead to permanent disability and interfere with a person's capacity to farm effectively. Thus, all farmers are advised to give health and safety management particular attention.

Legal duties

The Safety, Health and Welfare at Work Act, 2005 and related Regulations govern safety, health and welfare at work (SHWW) in all workplaces including farms. Under law, employers hold the predominant duties to protect the SHWW of all persons at work and anyone else affected by work activity. These duties include: providing and maintaining: a safe place to work; safe plant and equipment and safe systems and organisation of work. Employees have duties to comply with SHWW legislation by co-operating with their employer, taking care to avoid injury or ill-health; reporting any defects that might be dangerous and using all items in a safe manner.

Revised standards for agricultural vehicles for public road use

The new revised standards for Agricultural Vehicles, which includes trailers and attached machines, became law on 1st January 2016. A demonstration of the standards required took place at Moorepark 2017, and a booklet on the revised standards was available. This booklet can be downloaded from the RSA website.

Quads (ATV's)

An ATV is a valuable machine on dairy farms for travel and undertake certain tasks, but they have a high risk of serious injury and death if miss-used.

PTO covering

PTO and machine entanglement injuries cause fatal and gruesome injuries. All PTO shafts should be properly covered.

Completing a farm Risk Assessment

It is a legal requirement to complete, implement and revise a Risk Assessment. A farm Risk Assessment document is available from Teagasc and the Health and Safety Authority (www.hsa.ie). The Risk Assessment document fulfils the legal requirement to complete a Safety Statement for farms with three or fewer employees. The Risk Assessment can also be completed and revised electronically by logging on to www.farmsafely.com. A format for a farm Safety Statement is available on the H.S.A. website. Evaluations show that farmers who implement health and safety controls and make regular safety checks have better farm health and safety standards.

Work organisation

There is an increased risk of farm accidents when a farmer or farm staff are working long hours, are tired or when work is done in a hurry or under stress. The discipline of work organisation allows matching of facilities, equipment and available labour to meet the farm workload, so that the optimum combination can be used on a particular farm. Capital can substitute for labour on dairy farms to some extent. In an expanding dairy sector, more hired labour will be required. Teagasc has recently published a manual on Managing Labour on Dairy Farms, and is available from Teagasc Offices**.**

Farmer health

Personal health: There is a belief that farming is a 'healthy occupation' because of its outdoor nature. In fact, farmers, on average, have a poor health profile when compared to other occupations. Prevention of ill health includes such measures as undergoing a regular health check along with undertaking health promoting activities (physical activity; diet, weight and alcohol control, sun protection, not smoking and stress control). High accident risk is associated with both poor health and stress.

Musculo-skeletal disorders (MSD's): are the greatest cause of dairy farmer occupational ill health, with 56% of farmers affected annually. The main body parts affected are: back (37%); neck/shoulder (25%), knee (9%), hand-elbow-wrist (9%), ankle/foot (9%) and hip (8%). Prevention is achieved by avoiding heavy lifting, over-reaching and twisting ones' spine and by having a tidy farm. Infections from animals and contaminated material and inhalation of dusts and spores are also sources of ill health.

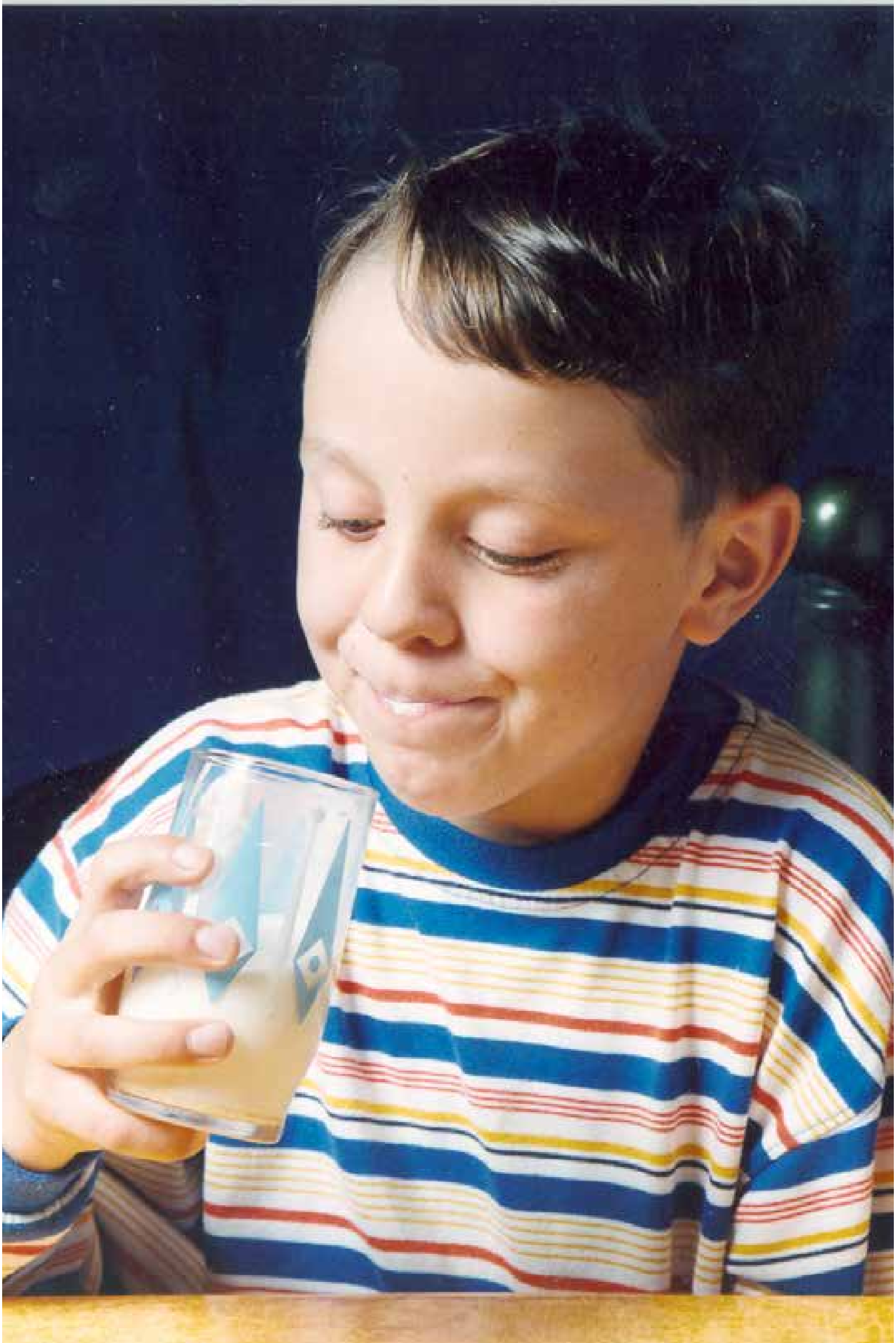
Health and safety exhibit at Moorepark 2017

The health and safety exhibit at Moorepark 2017 was interactive and demonstrated the occurrence of 'blind spots' around tractors and machinery, covering of PTO guards and standard required for road vehicle use. H.S.A staff were on hand to take queries on the practical application of safety, health and welfare at work legislation. Nurses and a dietician were on hand to promote health including blood pressure checking and advice on diet and weight issues. Dealing with an on-farm medical emergency was also demonstrated.

Conclusions

All dairy farmers need to actively manage farm health and safety to protect themselves, their family and any staff working on the farm.

TEAGASC FOOD RESEARCH PROGRAMME



A pasture-based diet improves nutritional composition and quality measures of milk, butter and Cheddar cheese

Tom O'Callaghan[1], Deirdre Hennessy[2], Stephen McAuliffe[2], Diarmuid Sheehan[1], Kieran Kilcawley[1], Pat Dillon[2], Paul Ross[3] and Catherine Stanton[1]

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Summary

- A study was conducted to compare milk derived from cows fed different diets based on grazed grass, grazed grass plus clover or an indoor total mixed ration (TMR).
- Milk from pasture-based systems had higher fat and protein content and improved protein quality compared with milk from the TMR system.
- The fatty acid composition of milk from the pasture-based systems was nutritionally superior, and resulted in butter and Cheddar cheese with more favourable thrombogenicity scores.
- Sensory analysis revealed a preference for the dairy products derived from the pasture-based system compared with the TMR based system. The preference was based on a combination of appearance, flavour and colour.
- The study highlighted the possibility of using milk fatty acid profiling to distinguish between milk derived from a pasture-based diet and milk derived from TMR-based diet.

Introduction

There are many diverse dairy production systems used throughout the world, influenced by geographical factors such as climate, land usage and availability of feed/forage. Ireland has a somewhat unique low input pasture-based dairy system. Our temperate climate and soil type provide ideal conditions for grass growth, and Irish cows spend the majority of their lactation grazing outdoors. Only 10% of global milk production originates from pasture-based systems of production similar to traditional Irish systems. The use of a high-input confinement total mixed ration (TMR) feeding system is widely used in the US, parts of Europe and the southern hemisphere. The TMR diet typically includes a formulated mix of forages, grains, by-products, minerals and vitamins, and is designed to enable the cow to achieve high dry matter intake and high milk yield. By its nature, however, a TMR system is an expensive and high-input enterprise, requiring specialised machinery and housing. While TMR feeding results in increased milk yield, it does not necessarily improve the nutritional composition of the milk. *Profiling Milk from Grass* is a Teagasc-funded, multidisciplinary, collaborative project between Teagasc Food Research Centre, the Teagasc Animal and Grassland Research and Innovation Centre, and the APC Microbiome Institute. The aim of the project is to compare the compositional, functional, and processing characteristics of milk and dairy products derived from 1) a pasture-based feeding system of perennial ryegrass; 2) a perennial ryegrass/white clover mixed sward; and 3) a TMR-feeding system. An additional aim of the study is to identify potential biomarkers that can distinguish different milk and milk products on the basis of the feeding systems used.

Experimental design

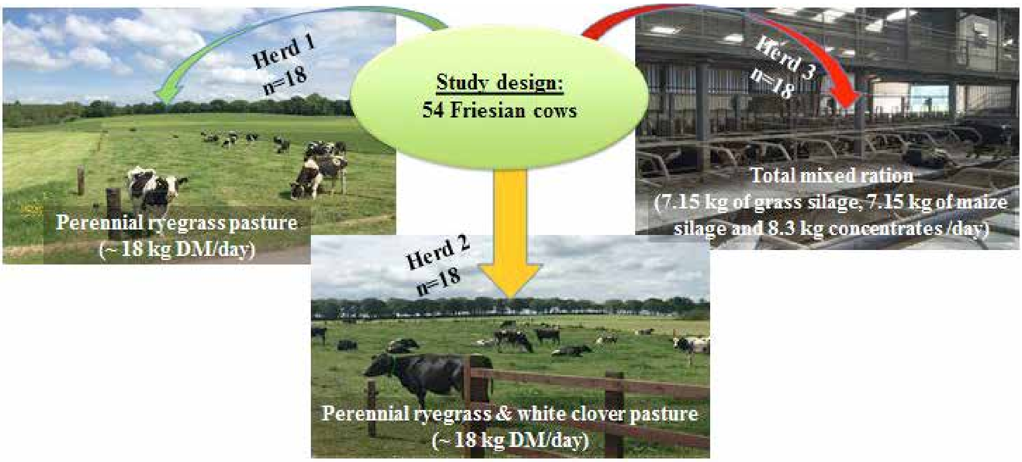

Figure 1. *Experimental design and herd allocation*

Fifty four spring calving Holstein-Friesian cows were allocated to three groups (n=18 each) at the Moorepark Research Farm. Three feeding systems were compared over a full lactation: Treatment 1 was housed indoors and fed a total mixed ration diet (TMR); Treatment 2 was maintained outdoors on perennial ryegrass pasture only (GRS); and Treatment 3 was maintained outdoors on a perennial ryegrass/white clover pasture (CLV). Cows on the TMR diet were offered, on a dry matter basis (DM), 7.15 kg of grass silage, 7.15 kg of maize silage and 8.3 kg concentrates daily. Cows on the pasture-based systems were offered ~18 kg DM/day (>4 cm; Figure 1). The annual average CLV sward white clover content was approximately 23%. In order to obtain a representative sample of milk, the cows in each of the three feeding systems were milked separately into designated 5,000 L refrigerated tanks. The evening milk was stored at 4°C overnight, the morning milk was then added, and the milk was agitated before collection. Bulk milk samples were collected after the morning milking weekly throughout lactation and stored at 4°C until analysis. Bulk milk samples were also collected to produce mid-lactation sweet cream butter and mid-late lactation Cheddar cheese.

Effects of feeding system on raw milk composition

The GRS feeding system produced milk with higher concentrations of fat (4.65% versus 4.39%) and protein (3.65% versus 3.38%) compared to the TMR system (Figure 2). Moreover, the GRS feeding system produced milk with better quality protein with increased true protein concentrations compared to the TMR system (3.46% versus 3.19%). The inclusion of CLV produced milk with comparable composition to that of GRS. The feeding system also had a direct effect on milk fatty acid composition. GRS feeding beneficially altered the nutritional status of milk, with a greater than two-fold increase in the total concentration of CLA, and particularly the health benefiting isomer CLAc9t11. This supports previous studies that revealed greater milk CLA concentrations in cows consuming fresh grass. Pasture feeding systems resulted in significantly higher contents of Omega-3 fatty acids and significantly lower contents of Omega-6 fatty acids than milk derived from the TMR feeding system. Of note, milk derived from the TMR system had a significantly higher thrombogenic index than the milk derived from the GRS or CLV systems. Finally, milk fatty acid profiling was capable of distinguishing pasture milk from TMR milk.

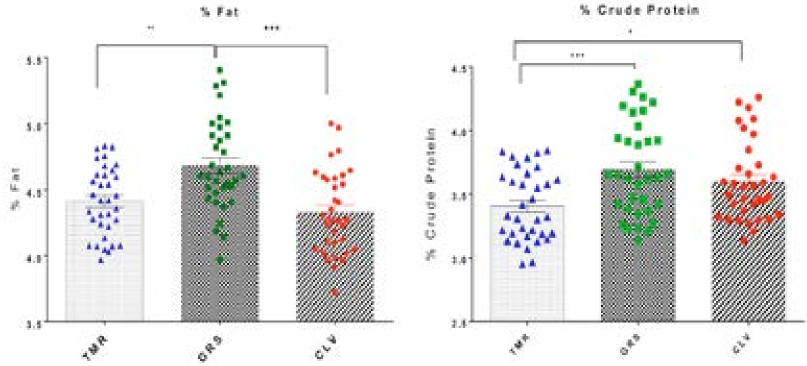

Figure 2. *Average fat and protein contents of raw milk throughout lactation from cows on TMR, GRS and CLV feeding systems. Each point represents weekly samples between March and October 2015*

Effects of feeding system on sweet cream butter

This study evaluated the effects of cow feeding system on the characteristics, quality and consumer perception of butter. Feeding system resulted in significant differences in fatty acid composition. These differences contributed to significant differences in textural, thermal, sensory and volatile properties of the butter produced. Pasture-derived (GRS and CLV) milk produced butter with improved nutritional characteristics, including lower thrombogenicity scores and significantly higher concentrations of CLAc9t11 and β-carotene. Sensory panellist data revealed that GRS derived butter achieved significantly higher scores for several attributes including "liking" of appearance, flavour and colour (Figure 3). Volatile analysis of butter derived from the different feeding systems by GC-MS identified 25 different compounds. Of these, five differed significantly based on feeding regimen, including acetone, 2-butanone, 1-pentenol, toluene and β-pinene. Finally, FA profiling coupled with multivariate data analysis indicated clear separation of butter derived from grazed pasture diets versus butter derived from TMR systems.

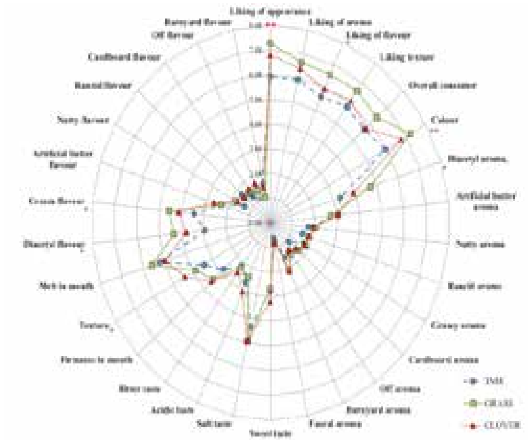

Figure 3. *Sensory analysis of sweet cream mid-lactation butter produced from cows on TMR, GRS and CLV feeding systems. Sensory panellists were required to score each butter on a scale from 0-10 in terms of preference or intensity of attribute; 0 (none) to 10 (extreme). Points shown are the average results of a twenty six person sensory panel for butter produced from each feeding system,*indicates attributes which were significantly different*

Effects of feeding system on Cheddar cheese

The nutritional composition of Cheddar cheese was improved on the pasture-based feeding systems (GRS or CLV), with significantly lower thrombogenicity index scores and a greater than two-fold increase in the concentration of vaccenic acid and CLA c9t11, whereas TMR derived cheeses had significantly higher palmitic acid content. Pasture derived Cheddar cheese was shown to have significantly higher Omega-3 fatty acid content, while TMR cheese had significantly higher Omega-6 fatty acid content. The consumption of CLA has been proposed to have several potential health benefits, with a recommended intake of between 0.8 and 3.2 g of CLA/d based on animal models of therapeutic doses. 100 g of Cheddar cheese produced using milk derived from TMR, CLV and GRS systems would provide 0.15 g, 0.35 g and 0.44 g of CLAc9t11, respectively.

Fatty acid profiling of the cheese produced from the different feeding systems coupled with multivariate analysis showed clear separation of Cheddar cheese derived from pasture-based diets versus a TMR system. These alterations in the fatty acid profile resulted in pasture derived cheese having reduced hardness scores at room temperature (Figure 4). Feeding system had a significant effect on the volatile and sensory profile of the Cheddar cheese. Pasture derived cheese had significantly higher concentrations of the hydrocarbon toluene, while TMR derived Cheddar cheese had significantly higher concentration of 2,3-butanediol. In conclusion, this study demonstrated the benefits of pasture-based feeding systems for production of Cheddar cheese with enhanced nutritional and rheological quality compared with a TMR feeding system.

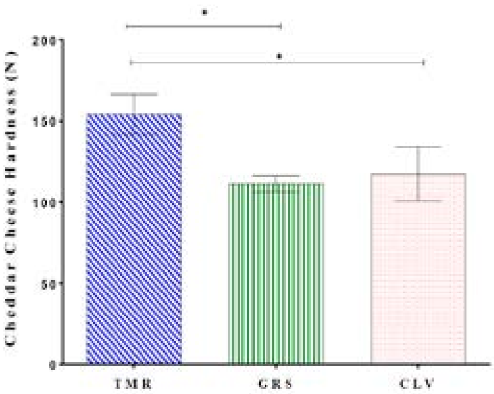

Figure 4. *Hardness of Cheddar cheese at room temperature after 270 day ripening from TMR, GRS and CLV feeding systems*

Conclusions

The results of the current study demonstrate the superior nutritional quality of milk produced from pasture-based systems versus TMR systems of milk production in terms of fatty acid and macronutrient composition. Additionally, more favourable thrombogenicity scores and higher scores for a combination of appearance, flavour and colour were recorded for butter and Cheddar cheese manufactured using milk derived from pasture-based systems versus a TMR system. The study also highlighted the possibility of using milk fatty acid profiling to distinguish milk and different dairy products derived from a pasture versus a TMR-based diet.

Infant milk formula research at Teagasc

Eoin Murphy, Noel McCarthy, Sean Hogan and Mark Fenelon
Teagasc, Food Research Centre, Moorepark, Fermoy, Co. Cork

Summary

- A significant proportion of Irish milk is used for the production of infant milk formula (IMF), and around 10% of global IMF exports are made in Ireland.
- In 2015, exports of IMF reached a value of €1.5 billion, with exports to China constituting approximately 25% of total exports. Ireland is now the second largest exporter of infant formula to China after the Netherlands.
- Teagasc Moorepark has recently undertaken a number of research projects focusing on IMF, with a view to supporting the Irish IMF and dairy ingredients sectors.

IMF formulation

The target for IMF manufacturers is to replicate as close as possible the composition of human milk (Table 1). Human milk is the 'gold standard' in neonatal nutrition and provides all the nutrients and physiologically active substances required. The protein, fat and carbohydrate content of cow's milk is not ideal for new-borns, and therefore the primary phase of IMF manufacture is re-formulating cow's milk to match the compositional profile of human milk.

Table 1. Composition of IMF, human and bovine milk (IMF figures based on European Standard)

	IMF	Human	Bovine
	per 100 mL		
Energy (kcal)	60 - 70	71	69
Total protein (g)	1.2 - 2.0	0.9	3.3
Casein	*	0.3	2.6
Whey	*	0.6	0.7
Fat (g)	2.9 – 3.9	3.8	3.7
Carbohydrate (g)	5.9 – 9.1	7	4.8

** not specified by European Standard*

Cow's milk is skimmed to remove fat, as cow's milk fat is made up of different fatty acids (FA) compared to human milk fat. This fat is generally replaced by blends of vegetable oils, which more closely resemble the FA composition of human milk. In addition to differences in composition, the molecular organisation of cow's milk fat is also significantly different. Therefore, the molecular organisation of vegetable oil blends is often modified in order to improve digestion. These re-organised vegetable oil blends are called structured lipids.

The protein content of cow's milk is much higher than required by the new-born baby. In addition, the balance of amino acids (AAs – the building blocks that make up protein) is significantly different to human milk. Therefore, whey protein is added to cow's milk in order to match as closely as possible the AA profile of human milk. In recent years, it has become more common to replicate the individual types of protein present in human milk. This has resulted in infant formulations being supplemented with α-lactalbumin (the main human milk whey protein) and, less commonly, β-casein (the main human milk casein).

Novel manufacturing processes for infant formula

Recent innovations in membrane processing developed at Teagasc Moorepark can provide protein rich streams that are closer to the protein profile of human milk than traditional ingredients (e.g. skimmed milk, demineralised cheese whey etc.). This novel approach resulted in a significant enrichment in β-casein, which is the main casein in human milk (Figure 1). In addition, the IMF protein fraction is generated in one processing step, as opposed to typical production where whey is added to skim milk to meet AA requirements.

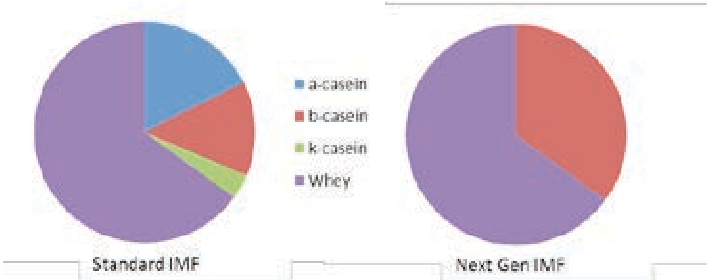

Figure 1. *Protein composition of Standard IMF vs Next-Gen IMF*

New milk fat based ingredient

Producing cost-effective fat ingredients that closely resemble the composition and molecular organisation of human milk fat is a priority for the IMF industry. In human milk fat, the majority of the main unsaturated FA, palmitic acid, is located in a position where it cannot be easily accessed by enzymes during digestion. In contrast, the molecular organisation of cow's milk fat allows these enzymes to "attack" and liberate higher amounts of palmitic acid. Liberated palmitic acid can combine with calcium to form calcium soaps, which can have negative impacts on calcium absorption and cause problems such as stool hardness, constipation and digestive discomfort. Hence, it is desirable to provide a product with more palmitic acid that is protected against enzymatic attack compared to cow's milk fat. A product based on a blend of vegetable oil and cow's milk fat with up to 20% more protected palmitic acid was produced, which compares very favourably with commercially available vegetable oil-based structured lipids. Furthermore, the inclusion of 50% cow's milk fat in the novel product represents a value-added application for Irish dairy fat.

Innovative heating solutions for infant formula

The interaction between process technology and composition in the manufacture of IMF is an active area of research. In particular, the type of heating technology applied directly affects the viscosity of IMF concentrates before spray drying. Utilisation of shockwave steam injection as a heating technology resulted in a reduction of viscosity before spray drying. This finding is of particular interest to the dairy industry, as viscosity of concentrates is a limiting factor during processing and, in particular, spray drying.

Conclusion

This brief summary of research carried out at Teagasc Moorepark highlights paths available to Irish milk processors for adding value their products through innovative IMF processing and products.

Making cheese from dairy ingredients using the Teagasc 'Cheese 2030 – New Technology Platform'

Tim Guinee

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Summary

- The platform, developed at Teagasc Food Research Centre Moorepark (TFRCM), enables the manufacture of cheeses from reassembled milks formulated from dairy proteins and other ingredients.
- The technology involves; manufacture of high protein dairy powders; preparation of reassembled milks, or liquid pre-cheese, by dispersion of the powders, milk fat and other ingredients in water-salt solutions; gelation of reassembled milk using rennet, starter culture and/or organic acids.
- The resultant cheese products are formed by filling the rennet-treated reassembled milk directly into the final mould/package.
- The main advantages of the platform over conventional cheese manufacture include the absence of a 'whey release' step, the complete retention of any materials such as colours and flavours; and a greater opportunity to innovate characteristics such as flavour, texture, and form.

Introduction

World cheese production was ~19×10^6 tonnes in 2014, and has increased at an average annual rate of three per cent over the past 20 years. The growth in production is driven by the increase in consumption of cheese globally, even in regions where cheese has traditionally been scarcely consumed, if at all. The popularity of cheese is enhanced by its relatively high levels of protein and calcium, healthy and positive image, the variety of cheese available, and its functionality, which makes it very compatible with modern trends for convenience and the consumption of prepared consumer foods. In these foods, which are frequently supplied through food service, cheese is required to perform functionally. Pertinent functionalities of unheated cheese include appearance, colour, crumbliness, sliceability, spreadability, shreddability and/or gratability. For heated cheese, functionalities include overall appearance, flavour, and extent of flow, stringiness, fluidity, opacity, oiling-off and heat stability.

The increase in global demand for cheese provides an excellent opportunity for the Irish dairy industry to export milk solids, protein and fat. Far-distant markets with high ambient temperatures can challenge cheese quality maintenance and transport logistics. An alternative approach is to export dried dairy ingredients, which reduces transport costs and the risk of product spoilage, and reassemble the dried ingredients into cheese in the target market.

Conventional cheese manufacture

At its simplest, conventional cheese manufacture may be described as a three-step process: (1) gelation/coagulation of milk by added rennet and/or acid; (2) dehydration of the gel to a curd with the simultaneous expression of whey; and (3) maturation/ripening of the curd. The weight of curd and whey typically account for 10% and 90%, respectively, of the total milk.

There are a number of limitations of conventional cheesemaking technology:

- expression of a large volume of whey (~90% of milk volume);
- contamination of whey with various materials solubilised and/or expressed during cheesemaking, including fat, bacteria, acid, and solubilised minerals;
- loss of materials added to milk to improve nutritional status (e.g., bioactive peptides, prebiotic materials such as β-glucans), yield/component recoveries, and/or or physical (functional)/biochemical properties of the resultant cheese (e.g., hydrocolloids, enzymes, flavours);
- few opportunities to include new functional ingredients in cheese;
- restricted scope to evolve cheese from its original status (calcium-phosphate gel modified by superimposed operations).

Considering these limitations, and the requirements of an expanding ingredient cheese market, the question arose: can cheese be made in a new way? The idea of reversing conventional cheese manufacture occurred: concentration before dehydration, as opposed to dehydration followed by gelation and whey expression.

Moving cheese technology forward: New Cheese Technology Platform (NCTP)

The NCTP is a novel approach to cheese manufacture based on the gelation of concentrated reassembled milk with the same dry matter content of the finished cheese. The reassembled milk is prepared by dispersing fat and specialised dairy proteins in water-salt solutions. The dairy protein ingredients, including milk protein concentrate and micellar casein powders, are manufactured using membrane filtration and designed with the requisite functionalities that facilitate their subsequent conversion to cheese with the desired quality. The protein ingredients have a number of important characteristics: ability to disperse easily to form high protein dispersions (up to 40% protein-in-moisture), ability to undergo acid- or rennet-induced gelation, and ability to confer the resultant cheese with quintessential 'cheesy' characteristics, clean flavour, and opaque colour. Such characteristics are designed by manipulation of the membrane conditions during manufacture to control the ionic strength, calcium phosphate content, casein-to-whey protein ratio, and lactose content of the final powder.

The current status of the Platform

A patent application on the Platform concept was filed in June 2008. Research on the NCTP began in May 2008 with a project entitled 'Cheese 2030 – New Technology Platform for engineering cheese structure and function in model systems', funded by Enterprise Ireland under the Commercialisation Fund: Technology Development Phase 2007.

Ornua licenced the NCTP in 2012 for the development of a suite of white cheeses for the Middle-East and North Africa (MENA) region. A research team was put in place at the Ornua Innovation Centre on the Moorepark Campus to work in tandem with researchers at TFRCM to refine and optimize the technology for that cheese suite, using the pilot-plant facilities at Moorepark Technology Limited. Ornua now produces the products in the Kingdom of Saudi Arabia in a new €20 million state-of-the art plant, which was officially opened in 2016. In a statement Ornua declared "The investment will further strengthen our position in the Saudi Arabian market, the fifth largest dairy importer in the world, as well as providing a central hub to access the important dairy growth markets in the MENA region."

The NCTP is also currently being adapted by another company, based in Moorepark Technology Limited, to develop natural, high calcium, high-protein cheese aimed at the children's market.

Notes


Help for the fingers that work the soil

Ulster Bank

Ulster Bank Competition - 4th July 2017, Moorpark

Terms and Conditions

1. The competition is open to all residents in the Republic of Ireland aged 18 or over. The competition is not open to anyone employed by Ulster Bank Group (including contract workers), their families or anyone associated with the competition.

2. In the event that an employee of Ulster Bank Group, their families or anyone associated with the competition wins the competition the prize will immediately become null and void and another winner will be selected from the remaining entrants.

3. The Promoter is Ulster Bank Ireland DAC, Georges Quay, Dublin 2 ("the Promoter").

4. Only one entry is permitted per person. Completed entries must be submitted to the Ulster Bank stand at the Moorpark Open Day and must be received by 4pm on 4th of July 2017. Entries submitted after that time will not be accepted.

5. The completed entry forms and the copyright in them are the property of the Promoter.

6. Entries not submitted in accordance with these rules, delayed, damaged, incomplete, altered or illegible entries will be disqualified. No responsibility is accepted for entries lost, delayed or damaged for any reason whatsoever. Proof of posting will not be accepted as proof of entry.

7. The prize is subject to availability and any terms and conditions governing the prize itself. The Promoter is not responsible for any matter arising from or relating to the prize.

8. The entrant's estimations will be based on an eyeball assessment.

9. The plots will be independently measured by Teagasc.

10. There will be one winner of the competition. The entrants who answers all three questions within 200 kg dm of the correct measurement for all three plots will be placed together and one winner will be drawn at random.

11. The prize is non transferable and no cash alternative is available. The judge's decision is final and no correspondence will be entered into.

12. The winner will be notified by telephone before 5pm on 10th July. The winner agrees to take part in publicity in connection with this competition.

13. Unless otherwise agreed, the entrant's personal data will be used for the purposes of this competition only.

14. If a prize is unclaimed after reasonable efforts have been made to contact the winner the Promoter will be entitled to dispose of the prize as it sees fit without any liability to the winner for having done so.

15. The Promoter reserves the right to alter, amend or terminate the promotion without prior notice.

16. Entry into the competition shall be deemed to be a full and unconditional acceptance of these terms and conditions.

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National Development Plan 2007 - 2013

Agriculture and Food Development Authority