Animal & Grassland **Research and Innovation** Centre

Moorepark

Irish Dairying

Growing Sustainably Wednesday 3rd July, 2019





AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY







Wednesday 3rd July, 2019

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

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Introduction: Recent success — new challenges Pat Dillon

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Recent success

The Irish dairy industry has been transformed since the abolition of milk quotas in 2015. Exports of Irish dairy products and ingredients have increased from €1.84 billion for the average of 2007 to 2009 to over €4 billion in 2018. The top five markets for Irish dairy products are UK, China, the Netherlands, Germany and the United states. Currently 26%, 34% and 41% of Irish dairy exports go to UK, other EU destinations and destinations outside the EU, respectively. China now accounts for 10% of total Irish dairy exports. The value of butter exports reached €1 billion for the first time in 2018. Of equal importance the expansion has improved the profitability of family farms and brought more money into the rural economy. Rabobank predicts that increases in global production of dairy products will be slower than the growth in global demand; therefore, the supply/demand for dairy produce should be positive in the coming years.

Increase in milk production

Milk production in Ireland has increased from an average of 4.93 billion litres (average of 2007 to 2009) to 7.57 billion litres in 2018. This is equivalent to a 54% increase in milk production or a 64% increase in milk fat and protein production. This exceeds the 50% increase two years ahead of schedule forecasted by Food Harvest 2020 strategy document. Current indications are that milk production in 2019 could reach 8 billion litres. In 2018, cow numbers had increased by 367,400 (34%) when compared to the average of 2007 to 2009 (1,057,583). Milk production per cow increased by 14%; increasing from 4,666 litres/ cow (average of 2007 to 2009) to 5,316 litres in 2018, whereas yield of milk fat and protein per cow increased by 21% from 334 kg to 405 kg. Therefore, over this time period 54.5% of the increase in milk fat and protein production came from an increase in cow numbers with the remaining 45.5% coming from increased milk solids production per cow.

Improved competitiveness

During the period 2008 to 2017, direct costs increased by 0.4 c/litre while overhead costs reduced by 1.9 c/litre. One of the key drivers of reducing overhead costs was a big increase in milk production from a very modest increase in debt; farm debt increasing by €7,000 on average between 2008 and 2015 to €75,000. This small increase in debt relative to a big increase in farm production means that debt repayments per kilo of milk solids actually reduced during dairy expansion. Considering both direct and overhead costs, there was a reduction in total costs of 1.5 c/litre and an increase in net margin of 6.8 c/litre. The CSO Agricultural price index for total agricultural inputs reduced by 2.5% between 2008 and 2017 (www.cso.ie/statistics/), whereas total costs for specialist milk production decreased by 13.9%. This indicates an efficiency gain of 11.4% over a nine-year period. The results show that base milk price in nominal terms increased by 2.1 c/litre over the period from 2008 to 2017; however, actual milk price increased by 4.1 c/litre, reflecting the value of improving milk fat (+0.26%) and protein (+0.14%). The CSO Agricultural price index for total agricultural (output) prices increased by 11.2% between 2008 and 2017, which was mostly driven by beef prices; milk prices for specialist milk production increased by 6.1% (base milk price). Costs in 2018 at farm level will have increased due to the difficult weather conditions in relation to the below normal temperatures in spring and below normal rainfall in summer.

Adoption of key technologies

Over the last ten year period (2008 to 2017), mean calving interval has reduced from 391 days to 381 days, pregnancy rate to first service has increased from 46% to 54%, six-week calving rate has increased from 61% to 72%, and mean calving date has advanced from the 11th to the 3rd of March. The proportion of cows calving in the months of January to April has increased from 74% in 2008 to 84% in 2018. This indicates that Irish dairy farmers are highly focussed on achieving a compact calving pattern in the spring with the objective of maximising pasture utilisation. Average grass utilisation on Irish dairy farms has increased from 6,728 kg DM/ha in 2008 to 7,796 in 2015; this was associated with an increase in whole farm stocking rate from 1.71 LU/ha to 1.93 LU/ha. The average EBI per cow calving increased from -€12 in 2000 to €98 in 2017 or an increase of €6.6 per year. An analysis of farm data indicates that each one unit increase in EBI resulted in an increase of €2 in net margin per cow per lactation.

New challenges

The Irish dairy industry is currently facing a number of key challenges: climate change; water quality; remaining competitive; access to markets; and availability of skilled labour.

Climate change

Ireland's target under the EU Effort Sharing Decision (Decision 406/2009/EU) for sectors outside the Emission Trading Scheme (non-ETS) is to reduce Greenhouse Gas Emissions (GHG) by 20% relative to 2005 levels by 2020. Agriculture accounted for 32% of Irish total greenhouse gas emissions in 2016 and 47% of non-ETS emissions. Greenhouse gas emission in 2017 was estimated to be 20.2 Mt CO_2 eq compared to 19.8 Mt CO_2 eq in 2016. The main reasons for the increase in greenhouse gas emissions are the increase in dairy cow numbers and increase in nitrogen fertilizer use. The latest projections estimate that non-ETS emissions in 2020 will (at best) be 11% below 2005 levels compared to the 20% reduction target. Ireland has among the lowest GHG fluxes in milk production (kg CO₂eq/kg cow's milk) of EU-27 countries. The Origin Green Sustainability Report indicated that the average carbon footprint (CO_2 eq/kg of fat and protein corrected milk) has reduced from 1.21 in 2014 to 1.14 in 2016. Therefore, reducing emissions levels to the 2005 reference period by 2020 will be very challenging. Environmental objectives could be satisfied through restrictions on dairy cow numbers, but this would conflict with other national policy objectives set out in Food Harvest 2020 and FoodWise 2025. Teagasc have produced guidelines for the dairy sector, identifying key actions that need to be undertaken to reduce the industry's environmental footprint.

Maintaining water quality

Good water quality is vital to the well-being of society, the economy and the environment. The 2010–2015 Environment Protection Agency report indicated that the quality of Irish surface waters has remained relatively static since 2007-2009, and the improvements expected under the first River Basin Management Plan have not been achieved. Nationally, 91% of groundwater bodies, 57% of rivers, 46% of lakes, 31% of transitional (estuarine) waters and 79% of coastal waters are achieving either good or high status under the Water Framework Directive. The New River Basin Management Plan (2018–2021) is taking a new approach to protect the environment, including a collaborative Agricultural Sustainability Support and Advisory Programme (ASSAP). This partnership between the State and the dairy industry consists of 30 Sustainability Advisers promoting best farming practice in 190 areas chosen for action (reaching up to 5,000 farmers). Positive results from this initiative would help Ireland secure a future Nitrates Derogation, which is of crucial importance to the dairy sector. Increased stocking rates in pasture-based systems are associated with increased chemical fertilizer and supplementary feed importation, increased nutrient surpluses and reduced nutrient use efficiency resulting in increased losses to ground water and the general environment. Where feed and fertilizer use is held constant and

additional pasture utilisation is achieved to support extra stock, the risks of nutrient loss during intensification are much reduced. A recent longitudinal study of changes in groundwater quality as a result of farm management changes on an intensive grazing dairy farm reported that the concentration of N in groundwater declined over an 11-year period despite a 20% increase in stocking rate. In more intensive pasture-based systems, several changes to management practices are required to maintain low levels of nutrient losses: increased grazed pasture utilisation; greater use of organic manures to replace chemical fertilizer; more strategic use of chemical N; reduced cultivation reseeding methodologies; improved grazing management and nutrient budgeting; and preferential management of higher risk farm areas.

Maintaining competitiveness

Over the period 2009 to 2013, Ireland had the third lowest cash costs as a percentage of market based output in the EU (65%); with the lowest being Italy and Belgium. Ireland fell to the bottom of the ranking for total economic costs (included an imputed cost for family labour, equity capital and owned land) at 111% of output. When the analysis was carried out in terms of costs per kg of milk solids, however, only Belgium had lower costs, and in terms of total economic costs, Ireland remained the fourth lowest in the EU. The Irish dairy sector response following quota abolition has been to expand milk production and this increase in scale has lowered total costs. Future dairy expansion may require more investment due to reduced availability of unpaid labour (family labour) and increased feed costs due to higher stocking rates resulting in reduced competitiveness. This occurred in New Zealand between 2002 and 2013, where milk production increased by 48%, but farm working expenses increased from \$2.53 per kg of milk solids to \$4.33, and interest plus rent increased from \$0.81 per kg of milk solids to \$1.29 (from various DairyNZ Economic Survey reports). Analysis of farm data indicates that increases in purchased feed in pasture based systems resulted in increases in other non-feed related costs, eroding the profit from this management strategy. Hence, it is essential that Ireland maintains its primary focus on producing milk from pasture. Continued support of programmes and policy that improve land mobility will help to maintain cost competitiveness, as improved land access will enable Irish farmers to increase cow numbers without increasing stocking rate and increasing supplementary feed. Maintaining cost competitiveness is essential to managing the challenge of milk price volatility, which is likely to continue in the years ahead.

Availability of skilled labour

One of the main challenges common to all dairy systems implementing best practice management is the availability of skilled operatives to implement effective tactical decisions in a timely manner. This is particularly evident in expanding dairy industries. Although the average herd size in Ireland was 76 cows in 2016 and is relatively small compared with an average of 419 cows in New Zealand (2015/2016) and 262 cows in Australia (2016/2017), it has increased significantly in recent years and will continue to increase in the years ahead. The 'People in Dairy Project' estimated that the Irish dairy industry will require approximately 6,300 new entrants over the next decade to replace retirees (4,000) and meet the requirements of expanding herds (2,300). The People in Dairy Action Plan identified six key initiatives that required attention:

- implementation of measures at national level to alleviate the immediate shortage of labour on dairy farms.
- the provision of excellent formal, informal and on-farm placement training programmes.
- increase the adoption of labour efficient practices on dairy farms.
- provision of continuous professional development programmes for dairy farmers to increase their reputation for retaining and developing their employees.

- provide career progression pathways for experienced dairy employees to become business managers; and
- promotion of dairy farming as an attractive career.

These actions were devised after a review of international studies on dairy farm labour availability to identify key actions.

Reputation

Irish pasture-based production offers natural competitive advantage for Irish dairy products on the world market, including cost efficiency, animal health and welfare, food safety and naturalness. Bord Bia estimate that only 2% of Irish population is vegan, however research from the NDC indicate that 30% of young men and 41% of young women are limiting the amount of dairy they consume. Dairy alternatives are often fortified with nutrients such as calcium and vitamin B1; however dairy is a natural source of a much wider matrix of other nutrients. Additionally, the form of calcium in many fortified drinks is different to that naturally provided in dairy and it's uncertain that the calcium in fortified drinks is absorbed and metabolised in the same way. Irish cows are considered to experience high levels of animal welfare because of our pasture-based system of milk production. Additionally as a result of increase EBI, SCC has reduced, reproductive performance has increased, longevity is increasing and ease of calving has increased. However there is a requirement for a proactive approach to welfare issues of both cows and young stock as a result of increase herd size in recent years and to protect the strong positive image of Irish dairying held by consumers of Irish dairy products both at home and abroad.

Conclusions

The structure of the Irish dairy industry has changed significantly in the years immediately before and after EU milk quota abolition. This expansion has increased the competitiveness of Irish dairy farmers, as they are now producing more milk and at a lower cost, significantly increasing profitability. The Food Harvest 2020 and FoodWise 2025 strategy provided clear targets and effective communication channels to all stakeholders that facilitated co-ordinated multi-actor action in a variety of programmes. The application of key technologies in relation to farm system, grazing management and use of high EBI genetics were critical to achieving profitable expansion at farm level, as were the different policies and programmes that Food Harvest 2020 initiated. Challenges in the future relate to climate change, water quality, maintaining cost competitiveness, access to markets, and availability of an adequate supply of skilled labour. In order to address these challenges as effectively as the Irish dairy industry managed the challenge of milk quota removal, it is necessary to re-examine the Food Harvest 2020 and FoodWise 2025 plan and develop a new 2030 plan. It is critical that a new forward-looking plan gains strong industry support to ensure that it is delivered, thereby securing the successful future of the Irish dairy industry.

2019 is the 60th anniversary of the establishment of Moorepark. Most experts would agree that over the past 60-years Moorepark has made a significant contribution to the development of the Irish dairy industry. This would not have been possible without the excellent commitment of Moorepark staff and support obtained from key stakeholders in the dairy industry. The financial support from state grants and the Dairy Research Trust is gratefully acknowledged.

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Taking stock of sustainable growth Laurence Shalloo and Padraig French

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Summary

- The Irish dairy sector has just gone through a very successful period of expansion, with milk output increasing by 64% and dairy farm income by 70%. The carbon footprint and farm debt per kg milk have reduced compared with the period 2007–2009.
- Success in the past doesn't automatically mean success in the future. We must reevaluate and refine the industry strategy for the future.
- Refocus efforts on profitable grass based milk production systems (the only competitive/ comparative advantage for the Irish dairy industry), with significant opportunities to further increase efficiencies.
- Expansion of milk production using extra imported feed will generate a poor return, expose the farm to more risk and increase the environmental footprint.
- Continued expansion for some farmers is the right thing to do if based on increased grass utilisation and dairy farm conversions with low capital cost infrastructure.
- The recent expansion of the Irish dairy industry has reduced the global footprint of milk production by approximately 4.0 million tonnes of CO₂e, assuming that Irish milk displaced milk with a global average carbon footprint.
- Ireland is uniquely positioned to exploit the growing demand for grass fed dairy products.

Introduction

The Irish dairy sector has gone through a transformational change over the past 10 years with a 64% increase in milk output and 367,000 additional cows. Debt has not increased dramatically, and has actually reduced per unit of output quiet substantially, and farm profitability has markedly increased (circa 70% comparing 07–09 versus 16–18). This has coincided with the removal of the EU milk quota regime, which created stagnation within the industry and exposed a generation of farmers to the full impacts of the cost-price squeeze with limited tools to reduce exposure. Despite reductions in greenhouse gas (GHG) emissions intensities, total emissions have increased, which was inevitable in light of the increase in dairy cow numbers. The rapid expansion has been associated with a bottleneck of labour availability, at least partly because it coincided with the country reaching almost full employment. Within this paper, we evaluate the industry growth with reference to the Food Harvest 2020 targets, re-affirm the drivers of efficiency within pasture-based systems and finally discuss the future direction of the industry.

Expansion in the Industry

Ever since the first signals that milk quotas would be removed and that expansion would be possible, dairy farmers had flagged their intent by increasing the numbers of dairy heifer calves born, followed by replacement heifers and then the dairy cow herd increasing since 2008 (Table 1). There were 367,000 extra cows in Ireland in 2018 when compared to the Food Harvest 2020 reference period (2007–2009). During that same period, milk solids output has increased by 64%, and milk volume by 55%. Of this increased milk output, 45% was achieved through increased yield per cow and 55% by increased cow numbers. All of this expansion has been associated with relatively small increases in farm debt. Over the period, costs of milk production increased up to 2013 and then reduced with the increased output leaving an increasing margin. The value of milk has increased as a result of improved milk solids

concentration; protein content increased from 3.33 to 3.48%, and fat content increased from 3.84 to 4.14%. Average grass utilisation has increased by 1.3 t/ha (excluding 2018), and the fertility performance measured through six week calving rate has increased by almost 10%.

With reduced costs, increased output and increased value of output, there has been a substantial increase in family farm income on dairy farms (70% 07–09 versus 16–18). It has also led to increased demand for dairy farm labour; >4,500 herds have a herd size greater than 100 cows compared to 1,500 herds a decade earlier. This is putting pressure on the availability of labour, and in particular hired labour as family labour is unlikely to fully meet the requirements because of the scale involved. The increase in cow numbers has also increased GHG and ammonia emissions, for which Ireland has national emission reduction commitments. With an expanding industry and onerous targets, it will be necessary to invest in strategies to reduce ammonia and GHG emissions both on-farm and across the wider industry.



Table 1. National cow	inventory	and milk	productio	on statisti	cs betwee	n 2007 an	id 2018					
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cow numbers (*000)	1,054	1,060	1,060	1,039	1,076	1,101	1,123	1,177	1,268	1,347	1,388	1,425
Replacement heifers born	255,777	267,735	306,200	317,924	364,097	367,562	380,018	370,113	381,546	398,250	378,254	387,288
Milk Output (million L)	5,074	4,943	4,785	5,173	5,377	5,232	5,423	5,649	6,395	6,654	7,263	7,585
Fat %	3.79	3.82	3.83	3.85	3.89	3.94	3.94	3.98	4.03	4.10	4.09	4.14
Protein %	3.32	3.34	3.33	3.37	3.37	3.36	3.39	3.43	3.5	3.45	3.48	3.48
Milk solids tonnes	371,483	364,445	352,811	384,613	401,964	393,310	409,289	430,985	495,861	517,282	566,100	595,143

Table 2. Indicators of	physical a	nd financ	ial farm p	erforman	ce betwee	en 2007 ar	nd 2018					
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cow numbers/farm	51	54	57	56	66	67	68	69	70	74	75	83
SR (LU/ha)	1.82	1.83	1.86	1.85	1.89	1.89	1.94	1.98	2.01	2.04	2.09	2.09
Grass utilisation (tDM/ha)	6,550	6,728	7,282	6,657	7,107	6,811	6,802	7,210	7,796	8,000	8,100	7,500
Concentrate feeding (kg/cow)		1,115	895	995	881	1,022	1,158	968	931	943	1,038	1,300
Debt levels (€/farm)	40,363	62,169	57,619	59,078	63,768	67,708	66,907	68,482	75,040	60,718	62,241	71,646
Net margin (€/ha)	1,134	964	221	830	1,297	805	1,290	1,390	1,165	792	1,730	1,049
Farm Income (€)	51,000	45,732	23,684	50,192	67,036	49,750	62,936	66,762	63,931	54,035	88,829	61,273

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Drivers of efficiency

Teagasc has set a target of achieving €2,500 net profit per hectare of owned land including full labour costs at a base milk price of 29c/l plus vat. The future target farm system is based on maximising the performance from the existing platform, while at the same time ensuring that the number of unproductive livestock on the farm is minimal. Achieving a net profit of €2,500/ha requires paying attention to detail across all of the components of the farm business. The rewards are huge, however, and place the business in a very positive position when dealing with milk price volatility, and realising returns from the business comparable with some of the best possible investments (on or off farm). Whether you are achieving the future target, are close to the future target or are a long way from the target, the direction of travel should be the same for the business. The future targets will be outlined in this paper under physical and financial headings, and compared to the national average performance during the period 2014 to 2016, assuming a base milk price of €0.29/l at 3.3% protein and 3.6% fat. Labour costs are included at €15/hr and all other costs are included based on the most up to date costs and prices. It is assumed that the farm operates contract rearing in the future target system and that calves leave the farm at two weeks of age, while it is assumed that calves are reared on the farm in the national average system.

Table 3 summarizes the physical farm performance on both the current national average and the future target performance systems. The physical performance required to achieve the target system include >13.0 t DM/ha of grass utilised, milk solids output of 1,344 kg/ ha, while feeding <500 kg concentrate per cow. In order to achieve these targets, excellent herd fertility performance is required, with a low replacement rate (\leq 18%), high six week calving rate (\geq 90%), and a herd mean calving date of mid-February. High levels of labour efficiency are essential, where the focus is on cows and grass, thus facilitating these achievements with total labour input of <16 hours/cow/year. Within the future target system, there is an increase in stocking rate based on increased grass growth, but there is also a change in enterprise as all replacement stock are moved off the milking platform to a contract rearing enterprise. It is also assumed that the target system uses increased fertiliser inputs, and a greater proportion of the farm is reseeded annually.

Table 3. Physical performance of national av	erage and target syst	ems
	National average	Future target
Milk yield kg MS sold/cow	405	480
Milk yield kg/cow	5,409	5,800
Milk protein %	3.45	3.70
Milk fat %	4.06	4.60
Milk kg/ha	11,090	16,820
Milk solids kg/ha	825	1,344
Calving interval days	394	365
Mean calving date	6 th March	14 th Feb
Six week calving Rate %	64	90
Replacement rate %	23	18
Labour hrs/cow	30	16
SR cows/ha	2.05	2.80
Concentrate feeding kg/cow	933	500
Herbage utilised T/ha	8.0	13.0

Financial

Table 4 provides a breakdown of the financial performance of a farm that is achieving the physical outputs outlined in Table 3 for both the national average and the future target systems for a 36 ha farm. The analysis is completed for the farm as a whole, and also per kg MS and per hectare farmed basis. The differences in financial performance between the national average and the future target systems are quite stark. The farm that is operating the future target system is achieving 4.2 times more profit. Is this profitability possible? It is only possible if the physical performance outlined in Table 3 is possible. If that physical performance is achieved, then the financial performance differences are real and are tangible. Analysis of data from both the EProfit Monitor and the National Farm Survey indicates that the magnitude of performance difference between farms operating at the top and bottom levels of efficiency is huge.

In order to understand the differences between the different categories of farms, it is important to evaluate where the differences are coming from in Table 4. The major change in performance is due to differences in output. Gross output increased by 78%, derived from 63% greater livestock sales and 78% greater milk receipts. The increased milk output is based on higher value milk, higher milk yield per cow and the farm carrying a higher stocking rate. Importantly, the higher stocking rate is facilitated by increased grass growth and utilisation.

On the cost side, there are increases in overall costs per farm and per hectare (~26%), but there is a marked reduction in costs per unit of output (~28%). Therefore, the increase in milk output in the future target system occurred in tandem with a reduction in costs per unit of output, resulting in substantial increases in profitability. This mirrors what has happened in the dairy industry since the removal of milk quotas (Hanrahan et al., 2018). The major cost categories with reductions include concentrate feed and labour costs, while other cost category reductions were based on the growth in output per cow and per hectare and the removal of heifer rearing costs from each of the cost categories. Contract rearing costs for heifers had the opposite effect, as this was included as a new category. In reality, however, the total costs for heifer rearing have not changed markedly between the average and future target situations, because contract rearing provides a cost saving on the existing milking platform. A substantial increase in labour efficiency is assumed in the model, and some of this increase is based on the removal of heifer rearing from the labour requirements on the farm. Recent research has highlighted substantial differences in labour efficiency across farms, with more labour efficient farmers tending to be larger, using the contractor more, less likely to be rearing calves and more likely to have appropriate facilities (Deming et al., 2017). Ultimately the financial performance of the farm in relation to net profit has increased substantially across all of the metrics shown, with net profit for the farm, per hectare and per kg MS increasing by 419%, 418% and 203%, respectively.

Table 4. Financ	ial performance	of the na	tional av	erage and	l target fa	rms	
	F	National average			Roa	d-map ta	rget
		Farm €	Per kg MS €	Per ha €	Farm €	Per kg MS €	Per ha €
Receipts	Milk	113,819	4.21	3,197	204,033	4.31	5,728
	Livestock	13,620	0.50	383	22,219	0.47	623
Gross Output		127,438	4.72	3,580	226,252	4.78	6,352
Costs	Concentrate	17,552	0.65	493	9,919	0.21	278
	Fert/reseeding	10,056	0.37	282	13,967	0.29	392
	Contract heifer	-	-	-	19,624	0.41	551
	Contractor other	1,275	0.05	36	4,595	0.097	129
	Contractor silage	6,195	0.23	174	5,062	0.11	142
	Vet/AI	8,006	0.30	225	10,733	0.23	301
	Elect/phone/ car	6,747	0.25	190	7,469	0.16	210
	Hired labour	27,126	1.00	762	23,034	0.49	647
	Other	33,658	1.24	946	44,521	0.94	1,250
	Total	110,617	4.09	3,107	138,924	2.93	3,900
Net Profit		16,821	0.62	473	87,328	1.84	2,452

All of the improvements in financial performance are based on different components of the farm system that can be changed within the farm gate, at least to some extent. There are some circumstances where physical farm constraints (e.g. soil type, climatic conditions) will prevent the full achievement of the targets, but there is potential to make changes to increase key performance indicators on all farms. The focus should be on investing in the right areas on the farm to achieve those targets, and ensuring that the direction of travel is correct for the farm and not about the distance to travel. There are very few farmers that are achieving all of the metrics for the target system. Therefore, it is imperative that we continue to remind ourselves of the potential to increase profitability from investment in basic technologies at farm level. Prioritise investment in these technologies (especially when milk price is high) to reap long-term dividends (especially when milk price is low). Table 5 summarizes the net financial benefit from achieving improvements in different aspects of technical efficiency across the farm.

Table 5. Potential farm benefits from increasing efficiency on a dairy farm					
	TT 1. 1	Financial benefit			
	Unit change	Farm €	€/kg MS		
Increasing fat concentration	0.1%	1,195	0.04		
Increasing protein concentration	0.1%	2,530	0.09		
Increasing milk volume — from grass	100L	2,027	0.06		
Increasing grass utilisation	1t DM/ha	4,840	0.1		
Reducing replacement rate	1%	1,218	0.035		
Reducing calving interval	1 day	247	0.009		
Total		12,057	0.34		

Take an example of a farm with 36.0 ha that makes a five year plan to improve technical efficiency. Over the five year period, grass utilisation increased by 3 t DM/ha, milk fat concentration increased from 4.05% to 4.25%, milk protein concentration increased from 3.45% to 3.65%, replacement rate declined from 23% to 20% and mean calving date advanced by one week. Collectively, these improvements will increase net profit on the farm by over €27,353, profit per kg MS by €0.71 and profit per ha by €768.

Future direction

After the initial period of growth following 31 years of stagnation, where should the industry go from here? When asking this question, one must be cognisant of the potential for further growth, environmental policy constraints, international demand for Irish grass fed dairy products and the economic considerations around enterprise shift into dairying. But most importantly, we must be cognisant of the farmer's ambition for growth, the sustainability of the system, the risks associated with further growth and the physical potential for growth.

The average stocking rate on dairy farms is just over two cows per hectare at present. As described in this paper the target system will operate at 2.8 LU/ha. There is significant potential to further intensify on existing dairy farms, by focusing on increased grass growth, investment in soil fertility, sward renewal and grazing management. This will result in significant increases in profitability at farm level and should be the focus for farmers considering further expansion. Nationally, grass utilisation is just over 8 t DM/ha, but there is potential for up to 13 t DM/ha, highlighting that further expansion is realistic and achievable. The focus of this group of farmers should be on improving efficiency of grass growth and utilisation. For farms that are currently operating at high levels of grass utilisation and efficiency, however, additional expansion using this strategy is no longer possible, and they must find an alternative strategy.

Expansion beyond the farms carrying capacity including >10% of the diet originating from bought in feed has been consistently shown to not be profitable. It is potentially the biggest risk to the Irish dairy industry and should not be considered. It might look marginally profitable, when owned labour is not included in the calculations, but when full costs are included, expansion based on additional imported feed is generally not profitable, increases risk and environmental footprint and ultimately results in the dairy farmer working a lot harder for little gain. Internationally, many industries have fallen into this trap and the Irish dairy industry must be careful to ensure that it does not follow suit. Ensuring capital costs are minimised and that the metrics affecting profitability rather than production are the focal points will ensure that we do not fall into this trap.

For the group of farmers that are currently operating at high levels of grass utilisation and efficiency, if further expansion is desired, the focus should be on replicating what they are doing on larger blocks of land, increasing the land area available for dairy cows by having heifers contract reared, trying to access land adjoining their existing operation or development of second units. This will involve the movement of land from its current enterprise (e.g. beef, tillage, sheep) into dairying through a long term lease or some other land movement structure that allows land to move to efficient progressive enterprises that are capable of being profitable when all costs are included. The family farm income achieved from dairying, beef, sheep and tillage between 2010 and 2018 is summarized in Table 6. It is apparent that dairying is substantially more profitable than all of the other enterprises. For an individual landowner that is not a dairy farmer and who wishes to have a long term future in agriculture in a full time capacity, serious consideration should be given to evaluating the potential for that land to move into dairy farming in one form or another.

Factors outside the farm gate may also impact the feasibility of expansion. Environmental policy is likely to affect agriculture in the coming years. There is considerable debate about the impacts of agriculture in areas of climate change policy, nitrates directive, ammonia emissions ceilings and biodiversity. These are all areas that require greater focus within the farm gate. On a positive note, the grass based system provides an advantage over high input/TMR based systems. For example a recent FAO report has highlighted that the average carbon footprint of global milk is 2.5 kg of CO_2e for each litre of fat and protein corrected milk produced. The corresponding figure for Ireland is ~1 kg of CO₂e per litre of fat and protein corrected milk when carbon sequestration is included. This does not take from the point that there is an urgent need for focus on reducing the various footprints, but in reality, if Irish or EU policy prevents sustainable dairy expansion from grass, there will be a marked increase in global emissions. The expansion of the Irish dairy industry, producing additional low (1 kg CO₂e) emission intensity milk, has reduced the global footprint of milk production by circa 4.0 million tonnes of CO_2e based on the assumption that it displaced milk from the market that would have been produced with the average emission intensity globally. While the initial starting point in Ireland from an emissions perspective is good, there needs to be a focus on continued improvement on all the environmental concerns. Luckily most of the technologies that increase efficiency and profitability will also reduce emissions. The future target system has a substantially lower carbon footprint than the current system.

Table 6. Family farm income from differing enterprises between 2010 and 2018										
	Dairy		Cattle Rearing		Cattle Other		Sheep		Tillage	
	FFI €	FFI €⁄ha	FFI €	FFI €/ha	FFI €	FFI €/ha	FFI €	FFI €⁄ha	FFI €	FFI €/ha
2010	44,432	953	7,023	246	9,676	319	12,269	311	36,759	615
2011	68,570	1,282	10,453	367	14,573	454	16,805	419	35,296	559
2012	49,672	887	12,180	348	17,716	412	18,375	375	37,184	581
2013	62,994	1,137	9,576	250	15,667	389	11,731	220	28,797	460
2014	67,595	1,229	10,374	266	13,320	333	15,066	279	29,016	468
2015	62,141	1,112	12,660	329	16,319	424	16,137	323	34,303	546
2016	51,968	928	12,672	352	16,909	457	15,657	307	30,619	457
2017	86,069	1,562	12,529	358	17,199	464	16,586	325	37,020	617
2018	61,273	1,049	8,318	269	14,408	387	13,769	281	42,678	697
Average	56,703	1,127	10,643	309	15,087	404	15,155	316	34,630	556

There is a significant debate on the role that livestock will take in future food systems. Feed-food competition is said to occur if crop and land-area is used for livestock feed rather than more efficient food crop production (for human consumption). It is argued that land used for livestock feed instead of crops for human consumption reduces the global supply of human edible protein. The current ratio of human edible protein efficiency of an Irish cow suggests that for each 1 kg of human edible protein consumed, the average Irish cows produce 4.92 kg of human edible protein. In comparison even if the land used to feed the cow was converted to protein producing crops (where possible) rather than

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producing milk, more edible protein would be produced than consumed by close to 50% by leaving the land under dairy cows. This is not the case with high input and TMR based systems and it is increasingly difficult to justify these systems in the allocation of scarce resources globally.

Consumer interest in the food they consume, including milk and milk products, is ever increasing. This has led to the development of milk brands that require farmers to mainly feed their cows grass (e.g. Organic Valley's Grassmilk in the USA). These dairy products are in high demand in many countries, and are sold at a market premium price. The sustained market interest in grass-based dairy products is leading to greater consumer interest to know the typical quantities of grazed pasture and forage in a dairy cow's diet. Ireland has developed a methodology to quantify the proportion of grass in the diet that is being implemented within the SDAS system. There is scope to build on this development and further develop brands and credentials to satisfy the growing market demand through producing dairy products from grass in a sustainable and efficient manner. Ireland can grow this potential further, ultimately adding value to dairy products, increasing the returns to the primary producers and satisfying the demand of consumers by producing grass-fed high value product. Ireland is uniquely positioned to capitalise on the grass fed narrative, but must continue to focus on grass based systems.

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Future systems: growing sustainably Brendan Horan¹, Donal O'Brien^{1,2} and David Wall²

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Summary

- The sustainable intensification of Irish pasture-based dairy systems is achievable, but requires improved management practices and additional technology adoption on dairy farms.
- Future systems will continue to rely primarily on efficient ruminants fed on highly productive pastures. Substantial additional gains in both farm profitability and environmental efficiency can be achieved.
- The incorporation of white clover into grassland swards coupled with the use of protected urea fertilisers and low emissions slurry application methods can further enhance the sustainability of dairy systems.

Introduction

The stellar performance of the Irish dairy sector over the last five years has been unparalleled, both in terms of other indigenous sectors of the Irish economy or other international dairy industries. At the core of this success story are 18,000 family-owned dairy farms, producing approximately 7.6 billion litres of milk and supporting 60,000 jobs across the rural economy. Economic activity in the sector produces a far greater multiplier effect than other traded sectors. Every $\in 1$ of additional dairy exports corresponds to an additional $\in 0.90$ spend in the wider domestic economy. The unique nutritional quality and character of pasture-fed dairy products has been a cornerstone of the growing demand for Irish dairy products in 110 premium markets worldwide. The value of Irish dairy exports exceeded $\in 4$ billion for the first time in 2018, and accounted for 30% of total food and drink exports. With current production running 15 to 20% ahead of 2018, total production is expected to exceed 8 billion litres for the first time in 2019, resulting in additional jobs, investment and export earnings.

This success has been achieved against a backdrop of increased global pressures to realign increasing food demand with more environmentally efficient production systems to meet climate change targets. The concept of sustainable intensification has recently been developed to increase productivity (as distinct from increasing volume of production), while reducing environmental impacts. This means increasing yields per unit of inputs (including nutrients, water, energy, capital and land) as well as per unit of undesirable outputs (such as gaseous emissions, nutrient leakage or biodiversity loss). Globally, grassland is the most important agroecosystem; it is capable of efficiently feeding ruminants with human inedible feeds, increasing soil carbon (C) storage and maintaining high quality biodiversity. However, the competition for land use from arable food and fuel production is reaching unprecedented levels, and many international studies report increasing land degradation, biodiversity loss, food security risks and water scarcity arising from climate change. Increasing public awareness of the impacts of agriculture on land use and climate change highlight the need for greater efficiency and sustainability in all aspects of agricultural production across the globe. On-farm production systems are at the centre of many of the challenges we face, and need to adapt to these changing circumstances. This paper sets out both the challenges faced by the Irish dairy industry, and thereafter, describes the targets for future Irish dairy production systems including new research technologies that will assist farmers to realise these targets.

Why should Irish dairy farmers be concerned with sustainability?

In the context of an expanding, export-dependent agri-food sector, the sustainability of Ireland's dairy industry is now very much in focus. Customers, both at home and abroad, have become more engaged in the provenance, nutritive value and sustainability credentials of the food they consume. The business case for improving the environmental performance of dairy farms is compelling, as efficiencies gained also enhance the economic performance of a farm. At farm level, environmental sustainability comes down to minimising the amount of resources used (e.g., nutrients, electricity, feed, water, etc.) to produce each kg of output. Indicators of sustainable intensification are essential to verify the comparative advantage of Irish pasture-based food production systems. Even under current regulations, Irish agriculture faces significant environmental constraints in terms of water quality, ammonia (NH₃) and greenhouse gas (GHG) emissions and biodiversity loss which may result in EU fines (NH₃) and the necessity for Ireland to purchase credits (GHG's) for exceeding target levels in the future. There is a national ceiling on NH₃ emissions; as agriculture produces more than 90% of total NH₃ emissions, this is a de facto ceiling for agriculture. In comparison with intensive agriculture in other countries, Irish farming is not particularly intensive. Nevertheless, the EPA estimates that agriculture, principally cattle, contributed approximately a third of Ireland's GHG's in 2017, whereas the corresponding average for the EU was just over 10%. As Ireland has recently declared a national climate emergency, the Irish government is currently formulating targets for each sector to achieve a low carbon, climate-resilient and environmentally sustainable economy by 2050. As part of this national plan, agriculture (and land-use including forestry) will be required to reduce total emissions without compromising our capacity for sustainable food production. Irish dairy farmers need to be aware of, and proactive in, adapting dairy production systems to these new requirements.

What are the important sustainability metrics?

The environmental metrics that are of most concern in Ireland include air quality, water quality, energy use and biodiversity. Air quality measures of foremost importance include both GHG and NH₃ emissions, both per hectare and per kg of fat and protein corrected milk (FPCM). At the farm scale, N and P surplus (defined as the excess of N and P inputs in feeds and fertilisers less N and P exports in milk) and N and P use efficiency (defined as the amount of milk N and P produced relative to total N and P inputs) are commonly used as overall measures of the efficiency of nutrient use to minimise nutrient loss to water. Energy efficiency is measured as kiloWatt hours per 1,000 litres of milk sold (kWh/1,000 L). Biodiversity is measured in terms of the proportion of farming area with hedgerows and high value ecosystems. Although Irish pasture-based dairy systems have been widely heralded for our lower intensity of food production, the rapid expansion in the sector has increased total agricultural contributions across each of the metrics. The increase in Irish dairy production over the past five years has been possible due to a 26% increase in the size of the national dairy herd, from 1.1 to 1.4 million dairy cows. Using data compiled through its national farm survey, the recently published Teagasc National Farm Survey 2017 Sustainability Report report tracked the performance of Irish farms in terms of environmental sustainability and sets out the challenge for a growing dairy industry. The report highlighted that farm level GHG and NH₃ emissions efficiency (per unit of product produced) has been improving, and Ireland is among the lowest in terms of emissions intensity when compared against international dairy industries. The recent expansion in animal numbers and area per farm, however, has resulted in increasing total emissions and stable nutrient surpluses on Irish farms (Figure 1 and 2).



Figure 1. Recent trends in a) Green House Gas (GHG) and b) Ammonia (NH_3) emissions on Irish dairy farms (Teagasc National Farm Survey Sustainability Report, 2017)

So how does Ireland compare with other countries?

Although there are few studies that make international comparisons across countries, there are an increasing number of studies that investigate the greenhouse gas (GHG) emissions associated with individual farming systems, or which make comparisons between systems (for example, grass-fed versus feedlot or conventional versus organic systems). The comparison of different industries is also complicated by the various methodologies employed. In terms of emissions, some sources are based on activity-based emissions, which only consider emissions which are directly associated with the within farm activity, whereas an alternative approach, called a life cycle assessment (LCA), not only includes direct emissions from animals, but also emissions of feed and fertilisers both within and outside the country in addition to C sequestration rates related to feed production (including grassland and grazing). Teagasc research has shown that, including total emissions using LCA, the C efficiency of grazing is superior more typical confinement dairy systems.



Figure 2. Recent trends in a) Nitrogen (N) and b) Phosphorus (P) surplus and use efficiency on Irish dairy farms (Teagasc National Farm Survey Sustainability Report, 2017)

The EU Commission's Joint Research Centre (JRC) report on EU emissions was published in 2010 based on 2004 data and shows that Ireland (, together with Austria,) is the most C-efficient producer of milk in the EU at approximately 1 kg CO₂ eq./kg milk (Figure 3). The results

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observed are similar to those reported for pasture-based systems in New Zealand (Basset-Mens *et al.*, 2009) and well below comparable estimates from more intensive confinement systems in other EU countries (Cederberg and Mattsson, 2000; Thomassen *et al.*, 2008).



Figure 3. European Union Joint Research Centre report on EU emissions from dairy production in various member states (EU JRC, 2010; Ireland: IR)

From a water quality perspective, the quality of Irish groundwater and surface waters is among the best in Europe. Under the Water Framework Directive (WFD), the Environmental Protection Agency (EPA) reports show that overall levels of pollution remain relatively constant since the beginning of the 1990's. Some improvements have been made with the length of seriously polluted channel being reduced to just over 6 km in the 2013 to 2015, period compared with 17 km between 2010 and 2012 and 53 km between 2007 and 2009. The most recent report has however, highlighted a 3% decline in river water quality since 2015, with a decline in the number of pristine sites. The most recent report (EPA, 2018) also shows that nitrate and phosphate levels in rivers are relatively stable over time. In terms of relative agriculture pressures on water resources, the EU gross N and P balances provide an indication of the potential nutrient surpluses on agricultural land (kg N and P per ha per year) between countries over time.





The most recent analysis (2015) indicates that Ireland has a national N and P surplus of 42 kg of N and 5 kg P/ha respectively, which is below average for member states (Figure 4, Eurostat, 2019) and indicative of the comparatively extensive nature of Irish agriculture.

Beginning with the end in mind

Sustainability is not just confined to environmental considerations, but also encompasses the economic well-being of those involved in farming, the quality of food produced and the welfare of animals. There is a growing understanding of the role of pasture-based food production in efficiently converting human inedible grazed forage to high quality human edible nutrients with a low environmental footprint. In contrast, protein deficient confinement dairy systems use a large proportion of maize silage as the forage, which must be balanced by imported protein-rich feedstuffs. In effect, this outsources a considerable proportion of the environmental impacts to South America, where the expansion in soybean cultivation has been a major environmental concern. Permanent pastures also provide an important biological filter to reduce nutrient and chemical losses, conserve soils and store carbon, while also supporting high levels of biodiversity (particularly avifauna). In a European context, improving the efficiency of grazing production systems is recognised as the primary opportunity for sustainable intensification of food production for the future.

Core principles of efficient pasture-based grazing systems

Future pasture-based dairy systems will continue to be dependent on highly productive pastures combined with efficient ruminants (Table 1). Substantial additional gains in farm profitability can be achieved on most farms through refinement of Irish grazing systems. The greatest gains will come from increasing pasture production and utilisation followed by conversion to milk fat plus protein (milk solids; MS), and this will provide the primary avenue to improved environmental efficiency over the next two decades. Research modelling results indicate that for each 1 t DM/ha increase in pasture utilisation on dairy farms, GHG emission intensity is reduced by 4% and net farm profit is increased by €173/ ha. Further improvements in pasture productivity can be realised by improving grazing management, reseeding unproductive swards and improving soil fertility to optimum levels. Optimising the soil pH to \geq 6.3 through application of lime on acidic mineral grassland soils is vital to ensure efficient use of applied nutrients. Teagasc data indicates that a 10 day increase in grazing season length increases annual farm profitability by €30/ cow, and reduced GHG emissions by 2% per annum. In addition, where soils are maintained within the optimum soil pH range, productive grass and clover persist for longer, resulting in reduced cultivation and increased C sequestration.

The selection of more efficient dairy cows is also of paramount importance. From an animal breeding standpoint, there are two key improvement goals: firstly, extend the lifespan of each animal and reduce the requirement for replacements; and secondly, to further increase individual animal performance from grazed pasture. Increasing herd Economic Breeding Index (EBI) by €10 per year increases annual farm profitability (by €20/cow/yr) and reduces GHG emissions by 2% per annum. In addition, selection of dairy cows that are capable of achieving large intakes of forage, relative to their size and genetic potential for milk production, increases feed efficiency and also reduces nutrient losses. Efficient grazing animals should produce in excess of 90% of bodyweight in annual milk solids production to increase N use efficiency. On that basis, dairy farmers should aggressively select on EBI and use milk recording to eliminate inefficient animals to further advance both the economic and environmental efficiency of Irish dairy herds.

systems					
	NFS1	Top 10%	Future target		
Net profit (€/ha incl. full labour)	473	1,032	2,500		
Dairy economic breeding Index (€)²	86	122	150		
Herd maturity (No. calvings/cow) ²	3.4	4.1	4.5+		
Calving rate (% calved in 42 days) ²	64	85	90		
Optimum soil fertility (% farm area)	10	75	100		
Fertiliser N (kg chemical N/ha)	180	250	150–250*		
Grazing season length (No. days/cow)	235	265	280		
Stocking rate (LU/ha)	2.1	2.3	2.8		
Pasture utilised (t DM/ha)	7.3	9.6	13.0		
Supplement (kg DM/cow)	1,050	910	500		
Fat plus protein (kg sold/ ha)	825	1,021	1,350		
Total GHG emissions (t CO₂ eq./ha)	9.2	13.9	12.6		
GHG intensity (kg CO2 eq./kg FPC milk)	1.14	1.00	0.71		
Total ammonia emissions (kg NH₃ eq./ha)	46.9	65.1	46.2		
Ammonia intensity (kg NH₃ eq./'000 kg FPC milk)	6.2	4.8	2.6		
Nitrogen/phosphorus surplus (kg N or P/ha)	164/10	225/9	160/10		
Nitrogen /phosphorus use efficiency (%)	25/62	26/70	35/85		
Energy use (kWh/1,000L milk sold)	59	42	30		
Biodiversity cover (% habitat area)	7	5–10	10+		

Table 1. Performance indicators for current average, top performing and future dairy systems

¹NFS: National Farm Survey (2015 to 2017), ²ICBF (2018).

*Where an overall sward white clover content of 25% is achieved, chemical N can be reduced to 150 kg/ha

Identifying the appropriate stocking rate (SR) is the key strategic decision for pasturebased dairy farms. This is generally defined as the number of animals allocated to an area of land (i.e., cows/ha). Although the beneficial impacts of SR on grazing system productivity have been widely reported, the impact of SR on environmental efficiency must also be considered. Previous studies have indicated that increased SR was associated with increased chemical fertiliser and supplementary feed importation, greater nutrient surpluses and reduced nutrient-use efficiency, resulting in increased losses to ground water and the general environment. Currently, the average Irish dairy farm has a SR of 2.1 livestock units (LU) per hectare. Hence, any increase in farm SR needs to occur without greater usage of chemical fertiliser, and without an increase in concentrate supplementation per cow. Based on improved grazing management and soil fertility, increasing overall farm SR will result in increased pasture utilisation and improved farm profitability and environmental efficiency in the future. As a component of the sustainable intensification of dairy production, improved management practices are required to maintain low levels of nutrient loss within more intensive pasture-based systems, including greater use of organic manures to replace chemical fertiliser, more strategic use of chemical N, reduced cultivation reseeding, improved nutrient budgeting, and, importantly, the preferential management of higher risk farm areas. Previous studies have also reported that the C footprint of milk production will be reduced by maximising the use of grazed pasture at an appropriate overall SR. The optimum SR for farms that produce different amounts of pasture and feed different amounts of supplement is defined in Table 2 below.

Table 2. Stocking rate (cows/ha) that optimises profit on farms growing different amounts of grass and feeding different amounts of supplement/cow					
	Grass grown, t DM/ha				
Kg supplement DM/cow	10	12	14	16	
500	1.8	2.2	2.5	3.0	
1,000	2.0	2.4	2.9	3.2	

Farming for the future - new practices for intensive dairy farms

Irish dairy farmers have been enthusiastic innovators during the last decade, which has contributed greatly to improvements in productivity within the sector. The adoption of the following research practices on intensive dairy farms can further reduce both emissions and nutrient losses, and facilitate the achievement of the future industry targets as set out in Table 1 above.

Grass clover swards

Traditionally, white clover was included in perennial ryegrass mixtures to improve sward nutritive value and reduce N fertiliser use. The availability of cheap N fertiliser, however, reduced the variability in pasture production during spring and increased overall pasture production. This led to a reduction in the use of white clover, with declining levels reported in temperate grazing regions such as Western Europe and New Zealand. Managing grassland with less mineral N fertiliser inputs and with greater reliance on biological N fixation from clover can reduce costs, reduce GHG emissions (industrial synthesis of mineral N fertiliser is energy intensive) and increase the digestibility of herbage. Data was compiled from multiple studies to quantify the milk production response associated with the introduction of clover into perennial ryegrass swards. At a mean sward clover content of 32%, mean daily milk and milk solids yield per cow were increased by 1.4 and 0.12 kg/day, respectively, compared with grass only swards. The same studies indicated that there is potential to replace up to 100 kg fertiliser N/ha, while maintaining output and profitability on intensive dairy farms where white clover content exceeds 25% of the sward biomass. Ongoing analysis of trial results indicate that the combined animal performance gains and cost saving from reduced N fertiliser use in ryegrass plus white clover pastures could increase annual farm profitability by €450/ha, while also reducing GHG emissions by up to 10%.

There are however, challenges with the adoption of white clover on dairy farms. The use of white clover is not widespread (on derogation farms or on farms in general), and may be problematic on wetland soils. The yield stability of white clover in intensively managed pastures remains problematic and the limited range of clover friendly grassland herbicides and risk of bloat in grazing livestock have discouraged some farmers. While research has shown the possibilities for overcoming these obstacles through improved grazing management, over-sowing swards and the use of bloat prevention technologies, further work is required to increase the stability and persistency of white clover and more generally encourage greater adoption.

Low emissions slurry spreading (LESS)

Slurry is an important source of nutrients (N, P & K) and application to grassland must be properly timed to maximise the efficiency of nutrient capture and replenish soil fertility levels. The targeted application of slurry in spring, based on soil test results, will ensure the most efficient use of slurry nutrients for grass production and minimise potential NH₃ losses. Slurry N losses in the form of NH₃ emissions are potentially the largest loss of reactive N on Irish farms, with manure spreading responsible for a quarter of all NH₃ losses in Ireland. Using LESS methods, such as trailing shoe or band spreaders, has a large effect on N losses and increases slurry N value by 10%, thereby increasing pasture productivity and further reducing chemical N requirements.

Protected urea fertiliser

There is a strong yield response from ryegrass swards to supplemental N addition, including from mineral fertilisers. Loss of N, via NH₃ and nitrous oxide (N₂O) emissions and N leaching, however, must be reduced. Recent studies have shown that protecting urea with a urease inhibitor reduces loss of NH₃ to the environment by 80%. Furthermore, protected urea reduces N₂O losses by 71% compared with ammonium nitrate, without compromising productivity. Results from several studies indicate that protecting 50 kg/ha of urea-N will save 6 kg N/ha, which can increase the value of grass growth by up to €40/ha per yr. Protected urea can also help reduce N losses to water by holding N in ammonium form, which is more stable in soil particularly during wet conditions.

Reducing concentrate crude protein content

On average, Irish dairy cows have a requirement for a diet with a Crude Protein (CP) content of 15 to 17%. In general, high quality grazed pasture has a CP content in excess of 18% during the grazing season. Therefore, grazed grass more than adequately meets animal requirements for crude protein. Several studies have been completed during the last 10 years showing no benefit from feeding rations with high CP content at pasture. Indeed, feeding high CP content concentrates during the grazing season provide excess CP to the dairy cow, who must then expend energy to excrete the excess N. From an environmental perspective, reducing concentrate CP content will reduce N surplus and loss to the environment. A 1% reduction in CP of dairy concentrates reduces N excretion by 1% and also results in a 5% reduction in GHG and NH_3 emissions. On that basis, using concentrates with a CP content of 12–14% is recommended when animals are at pasture.

Protecting biodiversity

Biodiversity is an important primary environmental indicator of sustainable agricultural systems. Although extensively managed farmland will always provide the highest quality ecosystems, improving biodiversity on intensively-managed farms can also play an important role in halting the decline of farmland biodiversity and maintaining soil C. Pasture-based farming systems are uniquely well positioned to support wildlife within the landscape; it is estimated that natural habitats constitute 12–14% of the area of grassland farms in Ireland. Greater efforts are required to improve both the area and quality of high biodiversity habitats. Examples include maintaining and managing existing habitats such as hedgerows and field margins, and the inclusion of watercourse buffer strips.

Energy and water efficiency

Although average electricity costs on Irish dairy farms are \in 5 per 1,000 litres of milk produced, large variation exists between farms (from \notin 2.60 to \notin 8.70). The main energy uses are for milk cooling (31%), milking (20%) and water heating (23%). Teagasc research suggests that it is possible to reduce on-farm electricity consumption, and related CO₂ emissions, by up to 60% and save over \notin 2,500 (100 cow herd) by installing an effective milk pre-cooler (e.g. plate cooler), variable speed drives on the vacuum and milk pumps and solar photovoltaic systems.

Future opportunities - Methane reducing feed additives

Methane from the cow's digestive system is the main source of GHG/C emission from milk production. Numerous additives have been fed to cows to reduce methane emissions, but most are not effective or their effect weakens after a short period i.e. 8 weeks. Moreover, some additives have a negative effect on animal production or the environment (e.g., the ozone layer). New research in the USA and Europe, however, indicates that mixing the inhibitor 3-NOP (3-nitrooxypropanol) into the feed ration or feeding plant extracts (e.g., Mootral[™]) can persistently reduce cow methane by up to 30% without any significant adverse effects, and may improve cow productivity. These additives are likely to be required

to meet long term (2050) emission and food targets, but further testing is required to determine if these additives reduce emissions in grazing dairy cows.

Conclusions

Improved efficiency in dairy systems is a significant challenge for the future. The world demand for food will increase further in the coming decades, but intensive milk production systems must become more sustainable with lower nutrient surpluses and increased emissions efficiency. Irish dairy farm systems can grow sustainably based on highly productive swards and genetically elite dairy cattle consuming a predominantly pasture diet. Considerable gains in both farm profitability and environmental efficiency can be achieved through incorporation of white clover into grassland swards coupled with the use of protected urea fertilisers and low emissions slurry application methods.

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Grazing management: areas for improvement on dairy farms

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Summary

- The optimal stocking rate for your farm should be aligned with the average annual grass grown of your farm over a number of years.
- Every farm should have a target figure for grass growth and number of grazings achieved to support the farm stocking rate.
- Farms using PastureBase Ireland to routinely measure and record grass growth have grown on average 13.2t DM/ha over the past five years with a difference of 7.1 t DM/ ha between the top 10% and bottom 10%.
- Autumn closing management and targeting the correct closing cover are vital to ensure adequate spring grass availability.
- Each one day delay in closing (from September 25th) results in 16 kg DM/ha reduced herbage mass in spring.

'If you don't measure it, you cannot improve it' — Peter Drucker, 1954

Introduction

The proportion of dairy farmers in Ireland that are routinely measuring and recording grass growth is approximately 10%. To improve farm performance, key performance indicators (KPI's) need to be measured. Measurement serves two purposes:

- It provides clarity regarding current performance.
- It can provide motivation to improve performance.

Grassland measurement is a hugely important KPI for dairy farm management. The grassland performance dictates the farm stocking rate, concentrate supplementation strategy and fertiliser application program for the farm. Ireland has a great opportunity to continue its grass-based focus by implementing better grassland management. Teagasc data indicates that the increased concentrate feeding during 2018 due to poor pasture growth rates resulted in €650/ha lower farm profit for dairy farmers. This highlights our dependence on grazed grass, and the escalation in costs of production when grass availability is inadequate.

Every farm situation is unique: soil types, local climatic conditions, stocking rates, grazing days and farmer management capabilities are highly variable. Nevertheless, grass production is currently limiting productivity on most Irish farms, with huge scope for improvement. Many Irish farms have increased herd size while at the same time increasing their grass DM production capacity. However, other farms have increased herd size without increasing grass DM production, and instead increased the level of concentrate fed to the herd to compensate for higher herd feed demand. Teagasc Moorepark research indicates that every 10% increase in purchased feed reduces net profit by \notin 97/ha, highlighting the importance of matching any increase in stocking rate to an increase in grass growth. Since the abolition of milk quotas in 2015, greater cow numbers, increased stocking rates and more compact calving have collectively caused an increase in spring feed demand on dairy farms. Increasing grass utilisation can lead to increased farm profits, with each extra tonne DM utilised/ha worth an additional \notin 173 net profit/ha. This paper outlines key areas where Irish dairy farmers can improve annual pasture utilisation through regular

grassland measurement, increased focus in both spring and autumn grazing management and increasing grazing herd performance.

Current Grass DM Production in Ireland

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. A subset of the farmers in PastureBase Ireland (PBI) recorded grass growth data annually over a five year period (2014–2018). Mean grass production was 13,200 kg DM/ ha. The individual year differences in DM production between farms are large (Figure 1), and the variation within farm can be just as large. In 2018, there was a large reduction in grass output across the farms, with a difference of 3,050 kg DM/ha from the average of the previous four years. The year with the greatest difference between the top 10% and bottom 10% of farms was 2015 (8,502 kg DM/ha difference). These DM production differences demonstrate most farmers have potential to increase grass DM production.



Figure 1. Summary of dairy farm grass DM production from 2014–2018 on farms participating in PBI and completing >30 measurements per year. Results are presented for the average of all farms, the top 10% and the bottom 10%

The number of grazings/cuts per paddock provides a good indication of herbage production and grass utilisation. Every additional grazing is equal to an extra 1,386 kg DM/ha herbage grown. On average, the number of grazings/cuts for PBI farms over the five years was 8.2 per paddock. The mean difference between the top and bottom farms was on average 2.1 grazings/cuts, with a range of between 1.6 and 3.2 over the five years. It is clear that some farms are not generating enough grass growth to support the grazing animals. This deficit in grass production results in increased milk production costs (i.e., more imported feed). On the other hand, if a farm is currently producing surplus grass/silage, an opportunity exists to increase farm stocking rate to utilise the surplus grass growth. The capacity to grow grass on the farm should be determined, and stocking rate matched accordingly. A farm growing an annual average of 14 t DM/ha across the whole farm is capable of supporting a stocking rate of 2.5 cows/ha with a concentrate supplementation level of 500 kg DM/cow (Table 1). All farms have different actual and potential grass production. If a farmer wants to increase stock numbers, grass output needs to increase first. The below table summarizes the optimum stocking rates for farms that produce different quantities of grass (from 10 to 16 t DM/ha) and feed different amounts of concentrate (from zero to 0.75 t DM per cow). For example, if a farm can grow 10 t DM/ha on average (similar to national average figures, NFS) and the farmer feeds 500 kg concentrate DM/cow, then the optimum stocking rate is 1.8 LU/ ha. If, on the other hand, the farm is capable of growing 16 t DM/ha and the farmer also feeds 500 kg concentrate DM/cow, then the optimum stocking rate is 3.0 LU/ha.

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Table 1 highlights the appropriate stocking rate for a particular farm based on its grass growth capacity, but it does require that the farmer has accurate knowledge of the grass growth capability on the farm. Identification of the appropriate farm stocking rate is further complicated by farm fragmentation, leading many farmers to increase stocking rate on the milking platform. Farmers with very high milking platform stocking rates are building systems that are dependent on imported feed, particularly in the second half of the year. Based on data available from PBI, only farmers in the top 10% for annual grass growth can support a stocking rate of 3 cows/ha.

Table 1. Stocking rate that optimises profit on farms growing different amounts of pasture and feeding different amounts of concentrate/cow (Roche and Horan, 2013)

Concentrate,	Grass grown, t DM/ha				
t DM/cow	10	12	14	16	
0.00	1.5	2.0	2.3	2.6	
0.25	1.7	2.1	2.4	2.8	
0.50	1.8	2.2	2.5	3.0	
0.75	1.9	2.3	2.7	3.1	

Spring grazing management

Excellent spring grazing management is crucial to reduce costs and increase output. Ireland have experienced two very different spring seasons in the past two years (2018 and 2019), but we are now very much aware of that we must have a silage reserve available (400 kg DM/cow, or two bales per cow) for feeding in spring. Three factors dictate the success of spring grazing: spring fertiliser management, turnout cover and grazing management. The optimum level of N used for early grass will depend on turnout date and grass demand (stocking rate). For most intensive dairy farms in Ireland, the optimum level of N to apply for early spring grass is 30 kg N/ha (23 units/acre) in mid-January to early-February (depending on geographical location) and 56 kg N/ha (46 units/acre) in March, a combination of both chemical fertiliser and slurry available on farm (Table 2), with an average of 88 kg N/ha (70 units/acre) by April 1st. Slurry should be applied using trailing shoe or dribble bar, to ensure the most efficient use of N uptake. Ground with the lowest P and K fertility levels should be targeted with slurry.

In 2016, data from PBI indicated that the majority of farms were applying early spring N fertiliser, with 33 kg/ha (27 units/acre) applied by mid-February, but there was a large variation in quantity (range: 0 to 65 kg/ha; 0 to 52 units/acre). By April 1st, PBI farms had on average 110 kg N/ha (88 units/acre) applied, but again, with a large variation between farms (range: 64 to 167 kg N/ha; 51 to 134 units/acre). Obviously, this variation can have a large impact on grass DM production in the spring period. Farms that had applied at least 88 kg N/ha (70 units/acre) by April 1st grew 24% more DM (275 kg DM/ha) by April 10th compared with farms that had applied less N. Some useful guidelines to aid decision making regarding spring N application are outlined in Table 2.

Table 2. Nitrogen fertilizer application plan for the spring period					
Month	Product	Rate	Area		
¹ January/ February	Slurry	2,500 gal/acre	1/3 of grazing platform (covers <600 kg DM/ha)		
January/February	Urea	23 units/acre (29 kg N/ha)	Remaining 2/3 of grazing platform		
March	Urea	46 units/acre (58 kg N/ha)	Entire grazing platform		
February/March	Slurry	2,000 gals/acre	1/3 of grazing platform (paddocks grazed first)		
Average by 1 st April		70 units/acre² (88 kg N/ha)			

¹Slurry and chemical fertiliser should only be applied once the open period commences; ²Combination of Urea and slurry available on farm

Early spring growth is influenced by the genetic capacity within the sward to respond to the N application. Newly reseeded swards with high perennial ryegrass content have a greater response to N than older swards with more diverse grass species. Soil factors, largely driven by soil texture and weather, will also influence N response. Colder soils are obviously slower to respond; as a rule of thumb, soil temperatures should be 5°C and rising for the first N application. Soil drainage also plays a big role, as land that is more prone to extended periods of waterlogging is less likely to respond to early N. Strategic decisions are required for the spring N application schedule, and may mean that N applications are delayed for some areas of the farm that are less likely to respond, resulting in a split application. It is still important to apply early N fertiliser on fields where a higher response is more likely.

Despite poor growth conditions in spring 2018, data from a trial in Moorepark indicated that there was a response of 9 kg grass DM per kg N applied from the first round of N (late-January), and a response of 11 kg per kg N from the second round of N (mid-March). These responses, albeit achieved under good sward and soil type conditions, are well above the financial break-even rates of 5 kg grass DM per kg N. Based on the responses achieved, 1,200 kg DM/ha was grown by April 10th compared to delaying N application until early April. The same experiment was carried out in spring of 2019. The first harvest (16th March) had a response of 14 kg grass DM per kg N applied in the first round (late-January), a 40% increase on the response obtained in 2018.

Grazing management in the first two months after turnout determines spring grass growth and cumulative growth for the remainder of the year. Data from PBI (n=65 farms) from 2015 and 2016 indicates that, on average, 22% (range 0 to 52%) of the grazing platform was grazed in February, well below the target minimum of 30% grazed by March 1st. The same dataset indicated that for every 1% 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 by April 10th. 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 also has a large impact on spring DM production. Data from PBI indicates that mean spring grass production from January 1st to April 10th was 1,239 kg DM/ha on farms that completed the first grazing rotation on or before April 10th. This 20% difference highlights that some farms are finishing the first rotation too late.

An experiment was established at Teagasc Moorepark to examine the effect of opening farm cover (OFC; high or low) on animal performance in early lactation. Both treatments had the same stocking rate (2.95 LU/ha) and calving pattern. Table 3 summarizes the results for animal performance during the first and second rotation (February 6th to May 1st 2018 and 2019).
performance in early lactation (February 6 to May 1) in 2018 and 2019							
	High OFC	Low OFC	Diff				
Opening farm cover (kg DM/ha)	1,232	621	+611				
Grass allocation (kg DM/cow/day)	12.2	8.5	+3.7				
Pre-grazing herbage mass (kg DM/ha)	1,522	1,028	+494				
Cumulative concentrate feed (kg DM/cow)	260	260	0				
Cumulative silage (kg DM/cow)	150	270	-120				
Post-grazing sward height (cm)	3.8	3.4	+0.4				
Cumulative milk solids (kg/cow)	195	173	+22				
Cumulative milk solids (kg/ha)	574	510	+64				

Commencing grazing with a high opening farm cover resulted in more grass available for lactating cows during the 86 day study period (approx. 320 kg DM per cow). The higher grass allocation resulted in an additional 22 kg MS/cow and 64 kg MS/ha produced by May 1st (12% increase in milk output). An additional 64 kg MS/ha at a value of €4.50/kg MS is worth €288/ha, equating to an additional €11,520 in additional milk sales on a 40 ha dairy farm. Hence, having a greater opening farm cover at the start of calving and achieving greater grass utilization has a significant impact on farm performance (physical and financial). If a high farm cover is achieved in spring (similar to 2019), then farms with lower SR have an opportunity to reduce the level of supplementation (concentrate and silage) offered to lactating dairy cows.

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 during the mid-season is not stocking the farm appropriately to match grass growth. This results in large surpluses (understocked) or large deficits (overstocked) of grass. 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. Excellent pasture quality is required to maximize the potential animal performance from pasture. Grass quality varies across the season, but some of these changes are influenced by management practices. The current best 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 most 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. This has adverse consequences for sward quality, regrowth capacity and animal performance in subsequent rotations.

Maintaining high quality grazed grass during the mid-season can support milk production of 1.7–2.0 kg milk solids/cow per day without concentrate supplementation. For each oneunit increase in organic matter digestibility (OMD), grass DM intake increases by 0.20 kg/ day, which supports an increase of 0.24 kg milk/cow per day. Regrowths on well grazed swards (grazed to 4.0 cm) 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 grass DM intake, so it is imperative that swards are leafy to the base. This can be achieved by good grazing management practices. The proportion of leaf in poorly managed swards (grazed >4.5 cm) can be as low as 65% during the reproductive period, resulting in more stem and reduced overall sward quality.

Autumn grazing management

Autumn closing date is the main management factor influencing the supply of grass in early spring. To ensure that adequate quantities of grass are available at the start of calving on highly stocked farms, an average farm cover of 650–750 kg DM/ha is required at closing (December 1st). Moorepark has developed general recommendations for autumn closing management: commence closing between 5th and 10th October; 60% of the paddocks grazed by 7th November; and 100% grazed by the end of November. Farmers must calculate their own spring grass demand, and implement an autumn closing strategy to facilitate the required opening farm cover in spring. Farmers need to use the autumn planner which allocates the area of ground to be closed from October to November and adapt according to the farm requirements. The final decisions regarding closing strategy also require some consideration of the expected grass growth over the winter period (i.e., average of previous five years).

A study was established at Teagasc Moorepark (Autumn 2016–Spring 2019) examining the effect of autumn closing management on late lactation animal performance, over-winter growth rates and spring grass availability. A standard autumn closing strategy (10th October start closing, 60% of the paddocks grazed by November 1st, and 100% grazed by November 24th) was compared with earlier closing of swards (September 25th start closing, 80% grazed by November 1st and 100% grazed by November 1st and later closing of swards (October 25th start closing, 25% grazed by November 1st and 100% grazed by November 1st and 100% grazed by November 1st.

Extending the grazing season did not result in an improvement in milk production compared to earlier housing, but it lowered the quantity of silage required up to early December compared with animals housed in early- and mid-November (150, 310 and 450 kg DM/cow, respectively). Later closing date did, however, result in a much lower closing farm cover compared to the earlier closed swards (350, 650 and 840 kg DM/ha for the late, normal and earlier closing treatments, respectively). These differences in closing farm cover subsequently resulted in opening farm covers of 630, 860 and 1,100 kg DM/ ha, respectively. Each day delay in closing from late September reduced spring grass availability by 16 kg DM/ha. When planning autumn closing management, the large year to year variation in autumn and over-winter growth rates must be considered. As a result, closing swards based on set dates can result in huge variation in spring grass supply (e.g., spring 2018 vs. 2019). During autumn closing, average farm cover needs to be monitored to ensure that it does not drop too low (<650 kg DM/ha). If this occurs, grazing should cease to ensure grass is available the following spring. On the other hand, if AFC is high (>800 kg DM/ha), grazing can be continued as long as closing farm cover is 650–750 kg DM/ha by December 1st.

Conclusions

All farms can grow more grass through improved grassland management. Not enough dairy farmers are routinely measuring farm grass cover. Managing a farm to produce more grass requires attention to detail and better grazing management. Many farms rely on mechanical correction and using concentrate supplementation to overcome poor grazing management, which ultimately reduces farm efficiency. Farmers that regularly monitor farm cover feed their cows more grass, achieve more grazings per paddock, improve grass production and increase farm profit. In addition, this strategy also makes the farm more resilient to milk price fluctuations. For Irish dairy farms to remain competitive, it is necessary to appropriately match stocking rate to the farms ability to grow grass. The implementation of a long-term sustainable strategy to increase grass production must precede any increase in farm stocking rate.

Sustainable breeding — what are the options? **Donagh Berry, Frank Buckley and Stephen Butler** Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Summary

- The Irish national dairy cow breeding index, the EBI, has delivered a more profitable cow for Irish production systems; the EBI will continue to deliver monetary gains long into the future.
- Selection on EBI is also reducing the environmental hoofprint of Irish dairy cows through a combination of improvements in milk solids output and reproductive performance/survival.
- An economic benefit from crossbreeding with Jersey is still likely via higher production efficiency.
- Sexed semen can be utilised to generate high value female replacements, enabling greater usage of beef semen to reduce the number of low value male dairy calves.
- The recently launched dairy-beef index is a tool to help identify beef bulls for use on dairy females.

Introduction

The Irish Economic Breeding Index (EBI) is a tool to help identify profitable animals. It has been in existence for almost 20 years, and has been widely adopted by Irish farmers. The current makeup of the EBI is illustrated in Figure 1. Milk solids production and fertility/ survival constitute two-thirds of the emphasis within the EBI with the remaining one-third made up by calving performance (calving difficulty, gestation length and calf mortality), cow maintenance requirements (i.e., cow live-weight), beef performance (carcass weight, conformation and fat score), health (somatic cell count, mastitis and lameness) and management traits (temperament and milking duration).





The strong emphasis on milk solids, fertility and survival is to boost milk solids yield per cow, but in an economically and socially responsible and sustainable manner. While direct genetic selection for increased milk solids yield will increase 305-day standardised milk yield, concurrent selection for longer lactations via an early calving date from better fertility cows will further increase lactation yield; this is the justification for the large emphasis on fertility within the EBI. Yield per cow is a function not only of yield per lactation, but also the number of lactations achieved. High replacement rate contributes to a younger herd, which will not therefore achieve its mature potential; a mature cow yields 22% more than a first lactation cow. Hence, improved cow longevity through selection for greater survival helps achieve higher milk solids yield per cow, as well as contributing to a socially responsible and economically sustainable system of milk production.

Two notable examples of the benefits of increasing herd EBI are available: 1) analysis of eProfit Monitor data; and 2) the current Next Generation Herd. Analysis of the eProfit Monitor data revealed that a one unit difference in EBI was associated with a \in 1.94 difference in profit per lactation, which is very close to the expectation of \in 2 difference in profit per lactation. The Next Generation Herd compares Elite EBI Holstein-Friesian cows (top 1%) with cows representing the national average, all managed side-by-side. The elite EBI cows produced more milk solids, commanding both a higher milk price and total milk solids sales; this was complemented by significantly better fertility in the elite EBI cows (92% in calf after 12 weeks of breeding), a trend consistently observed every year since its initiation in 2013.

Genetic trends by year of first calving

The average EBI of heifers entering the Irish dairy herd by year of first calving since 2001 is illustrated in Figure 2; this trend is a good reflection of the rate of genetic gain in Irish herds. The EBI of heifers entering the herd is increasing, on average, by \in 11 per annum over the past 10 years. The rate of gain in profit for the milk sub-index and fertility sub-index over that 10-year period was very similar (\in 4.43 and \in 4.29, respectively), implying balanced genetic gain, and indicating that the improvement in profitability was not from one single factor. Cumulatively, since its introduction in 2001, the EBI of the first calving heifers has increased by \in 143 implying an extra profit of \in 286 per lactation in the modern heifer relative to the heifer of 2001.

All sub-indexes, with the exception of the beef and maintenance sub-index, have been improving year-on-year during the past 10 years. The maintenance sub-index has not changed over this time period, while the reduction in beef merit equates to a loss in profit of only \in 5 over the entire 10-year period. While the EBI, as the name suggests, is economic-based, comparison of the carbon footprint per kg fat and protein corrected milk yield produced by the modern high EBI cow is 14% less than the cow that existed at the introduction of the EBI. This has been achieved through a combination of improved milk solids yield, better reproductive performance and greater longevity. Hence, genetic gain through improving EBI is a major contributor to the abatement of carbon on Irish dairy herds, while also being economically advantageous to Irish farmers.



Figure 2. Average EBI and its component index for Irish heifers by year of first calving

While fertility of the national herd is improving, it is still far from industry targets on the average Irish dairy farm. Based on the Next Generation Herd, under good management, a fertility sub-index of approximately $\notin 100$ is required to achieve reproductive targets. The average fertility sub-index of heifers calving for the first time in 2019 was just $\notin 46$. Hence, considerable emphasis still needs to be placed on fertility within the EBI for the foreseeable future. As reproductive performance improves, however, cows will, on average, live for longer. Hence, the health status of the national herd will become ever-more important. Animal health is under partial genetic control, and thus breeding programs focusing more on animal health are warranted to ensure the sustainability of the breeding program.

Crossbreeding with Jersey — does it still have a role?

Crossbreeding exploits favourable characteristics among contrasting breeds, removes inbreeding depression, and capitalises on heterosis or hybrid vigour. Heterosis occurs in crossbred animals resulting in synergies that mean crossbred animals perform better for certain traits than expected based on the average of their parents. It results in 'nonadditive' genetic improvement, the magnitude of which depends on the genetic distance between the parents. The heterosis effect also varies depending on the trait of interest; for example, the heterosis effect is greater for fertility than milk yield, and is greater for milk yield than milk composition. Heterosis is not directly passed from generation to generation, and reflects the contribution of genetics from different breeds within an individual animal (degree to which the animal is crossbred). For this reason, heterosis is not (and cannot be) included directly in the EBI, but it is included in the COW index.

The Jersey breed has many favourable characteristics for crossbreeding in Ireland: 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. Research has been conducted at Teagasc Moorepark to evaluate the merits of crossbreeding with Jersey since 2006. Five independent studies have been completed, ranging from controlled systems studies in research herds to analyses of commercial farm data. The findings from each study have been entirely consistent with each other and with international research findings. Each has demonstrated that Jersey×Holstein-Friesian cows outperform Holstein-Friesian cows due to a combination of improved fertility and herd productivity. The economic advantage estimated varied between studies, but generally approximated €150 per cow per lactation. The availability of high EBI genomically selected Holstein-Friesian sires has lead people to question if the advantage identified in previous Jersey crossbred research studies still holds true.

The significant and rapid expansion of the dairy industry since 2015 has led to increased supply of very low value dairy bred male calves. This presents a potential image/welfare challenge to the industry. This issue is directly linked to the characteristically compact and seasonal nature of our dairy system. As a result, use of Jersey semen has been targeted for particular criticism due to the poor beef merit associated with the breed.

High EBI purebred Jersey cows were introduced into Teagasc's Next Generation Herd in 2018 to provide a direct comparison with both high EBI (ELITE) and National Average (NA) Holstein-Friesian cows. A simulation to determine the economic and environmental consequence at farm level between the three 'pure' breed groups and two crossbred groups was conducted based on biological data (Table 1). The relative breed differences are consistent with previous research that reported higher milk solids production per ha with Jersey. Improvements in milk constituent values reflect recent favourable genetic progress for milk fat and protein content in both breeds. There are no Jersey×Holstein-Friesian cows in the Next Generation Herd currently. Crossbred performance has been estimated using the breed performance data obtained in the Next Generation study [2018 performance] and heterosis levels determined from previous research at Ballydague. Replacement rate was assumed to be 17% for the ELITE and both crossbred genotypes, 27% for NA and intermediate for the pure Jersey. The performance presented is based on F1 performance, i.e., cows resulting from the mating of Jersey to Holstein-Friesian. These animals would express 100% heterosis. In the longer term, where the breeds are rotationally crossed, expressed heterosis would be reduced to 66%. As indicated in Table 1, it is expected that the performance benefits from crossbreeding with Jersey would be greater where the EBI of the Holstein-Friesian herd is lower (i.e., NA×JE). This is because of the substantial reduction in replacement costs arising from improved fertility and longevity in crossbred cows in addition to the improvements in productivity highlighted. Nevertheless, crossbreeding with Jersey is still expected to result in improved productivity where the EBI of the Holstein-Friesian herd is high (i.e., ELITE×JE). In this case, it is not expected that crossbreeding would markedly improve fertility and longevity (already good in ELITE cows), and is instead driven by expected productivity gains alone (increased value of milk and greater milk solids output per ha). It is important to note that the performance of the crossbred animals in Table 1 are simulated, and not based on recorded biological data. Further investigation is warranted to determine whether the heterosis estimates and extrapolated results for Jersey crossbreds with NA and ELITE Holstein-Friesian genetics would be substantiated in reality.

Table 1. Simulated farm level (40 ha) performance of the National Average (NA),	
ELITE and Jersey (JE) genotypes within Next Generation Herd and anticipated impac	t
of crossbreeding	

	NA	ELITE	NZ JE	NA×JE*	ELITE×JE*
EBI	110	214	185	~150	~200
Stocking rate (cow/ha)	2.63	2.68	3.18	2.73	2.76
Herd size	108	110	133	114	114
Milk yield (kg)	5,649	5,675	4,100	5,325	5,221
Fat (%)	4.17	4.51	5.86	5.03	5.19
Protein (%)	3.52	3.73	4.24	3.90	3.99
Milk solids (kg)	434	468	414	475	479
Body weight (kg)	515	517	390	470	467
Milk solids/kg of body weight	0.84	0.90	1.06	1.01	1.03
Milk solids (kg/ha)	1,141	1,254	1,317	1,297	1,322
Milk price (c/l)	33.9	36.6	44.8	39.6	40.1
Net profit/cow (€)	622	844	564	829	873
Net profit/ha (€)	1,709	2,322	1,868	2,365	2,479

*Extrapolation based on Next Generation Herd data 2018 & Prendiville et al. 2011

Research to objectively quantify the influence of dairy cow genetics on the beef merit of their progeny at slaughter was conducted using data extracted from the national dataset from 2008 to 2018 (Table 2). Progeny sired by Holstein-Friesian sires and Angus sires were evaluated across five different dam genotypes: 100% Holstein-Friesian, 33% Jersey, 50% Jersey, 66% Jersey and 100% Jersey.

The first observation is that the progeny sired by either Holstein-Friesian or Angus out of cows ranging from 33% to 100% Jersey genetics were close in value to the same crosses out of Holstein-Friesian cows. The mean differences ranged from €30 less for progeny from cows with 33% Jersey genetics to €100 less for progeny from cows with 100% Jersey genetics when compared to progeny from cows with 100% Holstein-Friesian genetics. Carcass value was €53 less for both Holstein-Friesian sired and Angus sired progeny out of first-cross dams (50% Jersey) compared to the equivalent progeny from 100% Holstein-Friesian cows. This analysis has quantified the impact of dam Jersey genetics on offspring beef merit and indicates that the deterioration is less of an issue than generally perceived. Importantly, the research also highlights the gain in beef merit and carcass value achieved by crossing beef sires on the Jersey crossbred cow.

Table 2. Average slaughter performance of male progeny sired by either Holstein-Friesian or Angus breed bulls out of dams with varying proportions of Jersey genetics (national data, 2008–2018)

Breed	Jersey proportion of dam	Carcass weight (kg)	Carcass grade (1–15)	Carcass fat (1–15)	Value (€)	Age at slaughter (days)
	0%	323	3.76	6.28	1,101	834
Holstein-	33%	314	3.95	6.39	1,072	836
Friesian	50%	310	3.81	6.45	1,052	838
sire	66%	305	3.82	6.50	1,036	840
	100%	296	3.86	6.58	1,003	843
	0%	327	5.37	7.00	1,179	803
Angus sire	33%	319	5.24	7.11	1,143	806
	50%	314	5.18	7.16	1,126	808
	66%	310	5.12	7.22	1,108	810
	100%	300	5.00	7.32	1,072	814

¹Reference animal is a steer slaughtered at 28 months, except for age at slaughter which is a steer slaughtered at 320 kg of carcass weight and a fat score of 7.

It is, therefore, advised that Jersey genetics be exploited responsibly with consideration given to the use of sexed semen, greater use of high DBI beef sires, more cognisance of required replacement numbers and acceptance that it may be necessary to retain non-replacement calves longer in order to increase saleability in the market place.

Sexed semen

The use of sex-sorted semen allows predetermination of calf sex with ~90% reliability. Despite this benefit, sex-sorted semen currently represents a small percentage of the artificial insemination (AI) market in Ireland. The main barriers to greater uptake are compromised fertility, the price per straw and the EBI of the bulls that are available. In studies comparing conventional semen and sexed semen, the mean conception rate achieved with sexed semen is often expressed as a percentage of the mean conception rate achieved with conventional semen, and is termed the 'relative conception rate'. For example, if the conception rate with conventional semen was 60%, then sexed semen would need to achieve a conception rate of 54% to result in a relative conception rate of 90% (i.e., 54/60 x 100). When AI is conducted once a day after detected heat (as is normal in Ireland), large field studies in 2013 and 2018 demonstrated that sex-sorted semen had poorer conception rates compared with conventional semen in both virgin heifers and lactating cows (76% to 89% relative conception rate). Importantly, bulls that were resident close to the sexed semen lab (all 10 bulls in 2013 trial, four out of 10 bulls in 2018 trial) had mean relative conception rates ≥84%, but the mean relative conception rate for bulls located in Ireland and that had their ejaculates shipped to the sorting lab was ~70%. For now, sexed semen use should be limited to bulls that are located close to the semen sorting lab.

Any reduction in fertility that causes deterioration in calving pattern will reduce the financial benefits from using sexed semen, and usage of sexed semen is unlikely to be profitable in herds with poor fertility. Nevertheless, targeted use of sexed semen can achieve acceptable fertility. The animals selected to be replacement dams should be high EBI, heifers or young cows (parity 1, 2 or 3), calved \geq 60 days on the farm mating start date and in good BCS (\geq 3.00). These are the highest fertility animals on the farm, and are most likely to become pregnant following AI (with conventional or sexed semen). In addition, sexed semen should be used at the start of the breeding period only, and it may be useful to incorporate synchronisation to advance submission as a strategy to mitigate reduced conception rates. In fact, combining synchronisation with sexed semen usage to breed

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eligible cows on the farm mating start date can increase the proportion of early calving cows and improve the compactness of the calving pattern.

The first decision is to decide how many replacement heifer calves are needed. Next, based on fertility performance in previous years in your herd, calculate the expected conception rate of the dams that will receive dairy semen (mix of cows and heifers). The number of conventional semen straws required for a 100-cow herd that needs 25 replacement heifer calves is summarised in Table 3. The expected conception rate has a big impact on the number of straws required (77 straws at 65% conception rate, increasing to 100 straws at 50% conception rate). For the purposes of evaluating the direct costs and receipts arising from AI usage, it was assumed that conventional semen cost was €18 per straw, dairy heifer calves were worth €250, and dairy bull calves were worth €50.

at varying herd conception rates								
	Conve	Conventional semen conception rate						
	65% 60% 55% 50%							
Dairy heifers calves (n)	25	25	25	25				
Dairy bull calves (n)	25	25	25	25				
Beef calves (n)	0	0	0	0				
Conv semen straws required (n)	77	83	91	100				
Semen costs (€)	1,385	1,500	1,636	1,800				
Calf value (€)	7,500	7,500	7,500	7,500				
Net return (€)	6,115	6,000	5,864	5,700				

Table 3. Number of conventional semen straws required to generate 25 heifer calves at varying herd conception rates

What would be the implications of deciding to generate the 25 replacement heifer calves using sexed semen? Again, herd fertility has a big effect, but so too does the expected reduction in conception rate due to sex sorting. In Table 4, sexed semen relative conception rate of 85% is examined, which represents the mean relative conception rate achieved by resident bulls in the 2013 and 2018 field trials. In addition to the assumptions used for Table 3, sexed semen was assumed to cost €45 per straw. It was also assumed that the reduction in conventional dairy semen usage would be displaced by beef semen (€12 per straw), and the resulting beef calves were worth \in 150 (half male, half female). Hence, total straw numbers used for this analysis were the same as each fertility level in Table 3 (77 straws in the best fertility herds, 100 straws in the poorest fertility herds). Using sexed semen caused an increase in expenditure on semen but the value of the subsequent calf crop value was also increased. Reduced conception rates with sexed semen, however, will lead to longer calving intervals. Management options to mitigate this include starting breeding earlier, restricting sexed semen usage to a defined period at the start of the breeding season (first seven to 10 days) and incorporating synchronisation to accelerate the submission of eligible cows.

	Sexed conception rate (85% of Conv)						
	55	51	47	43			
Dairy heifers (n)	25	25	25	25			
Dairy bulls (n)	3	3	3	3			
Beef calves (n)	17	17	17	17			
Sexed semen straws required (n)	50	54	59	65			
Beef straws required (n)	27	29	31	35			
Semen costs (€)	2,582	2,797	3,052	3,357			
Calf value (€)	8,987	8,987	8,987	8,987			
Net (€)	6,405	6,190	5,935	5,630			

Table 4. Number of sexed semen straws required to generate 25 heifer calves at varying herd conception rates

Beef merit of dairy crosses

The expanding dairy herd, coupled with improving reproductive performance, dictates that a greater proportion of slaughtered cattle in Ireland will originate from dairy herds. Hence, a dairy-beef index was required that ranks beef bulls for use on dairy females providing a balance between the desires of the dairy farmer and those of the beef farmer. The dairy-beef index ranks bulls on estimated genetic potential to efficiently produce a high-value carcass, while having minimal repercussions on the milk, health and reproductive performance of the dairy female. Traits included within the dairy-beef index and their relative emphasis are illustrated in Figure 3; two-thirds of the emphasis is on calving performance.





Conclusions

The EBI continues to deliver improved profitability and reduced environmental footprint per unit of milk produced. The benefits can be furthered through crossbreeding with Jersey, even in high EBI herds. This strategy can be complemented by using sexed semen to generate high value female replacements, enabling greater usage of beef semen to reduce the number of low value male dairy calves.

Dairy in the Irish economy!

Ciaran Fitzgerald

Food Economist Consultant

The Irish dairy sector is a huge contributor to growth in economic activity across the rural Irish economy supporting over 60,000 jobs from dairy farming (19,000) to milk processing/ distribution, export marketing and research.

- Ireland exports circa. 90% of dairy output to 120 countries worldwide.
- The value of exports has doubled from €2–4 billion since EU quotas were removed in 2015.
- This growth in export values reflects increased global demand for dairy products and, in particular, increased demand for grass-based sustainable dairy production.
- Ireland's status as the lowest carbon emitting dairy sector in the Northern Hemisphere is recognised across a growing global customer base.
- The additional status of Irish grassland as a huge Carbon sink storing up to 30 million tonnes of CO₂ annually is currently being assessed under IPCC rules.

The overall economic contribution of dairying to the Irish economy has increased significantly in recent years (Table 1). Hugely importantly as detailed in the piece below, Irish economy expenditure by the dairy sector has also doubled since quota abolition to \in 3.8 billion in 2018. Crucially in terms of Irish economy impact, every \in 1 of exports of dairy products represents 90 cent spend within the Irish economy. In contrast, for the Multinational sector the corresponding figure per \in 1 euro exports is 10 cent spend in the Irish economy. Moreover, Dairy's huge Irish economy spend on raw materials wages and services now accounts for almost 10% of spending by all industry (DJEBI, Annual Survey of Expenditure 2017 published February 2019).

Table 1. The economic contribution of the Irish dairy industry (2009–2018)							
2009 to 2013 average 2018							
Milk deliveries	4.8 billion litres	7.6 billion litres					
Value of dairy output	€2.2 billion	€4.5 billion					
Imports	0.4 billion litres	0.75 billion litres					
Value-of output/litre	42 cent/litre	56 cent/litre					
Irish economy spend	€1.8 billion	€3.8 billion					

Expenditure in the Irish economy is a much more real assessment of the impact of industry in the Irish economy than the standard economic accounting figures such as Gross Domestic Product (GDP) or Gross Value Add (GVA). In terms of economic activity, GDP is a completely distorted figure in Ireland's case because of the requirement under GDP convention rules that multinational profits and transfer pricing transactions <u>are included</u> in Ireland's GDP figure, while purchases of milk and other inputs in the Irish economy by the dairy sector for example, <u>are excluded</u>. In gross terms, 130 billion of private multinational company profits annually are included in Ireland's GDP figure, while 3.8 billion worth of Irish economy inputs purchased by the dairy sector (16 billion by the broad agri-food sector annually) are excluded. So very clearly GDP does not measure Irish economy performance.

The Central Statistics Office (CSO), the Department of Jobs, Enterprise and Innovation and Eurostat provide annual analyses that create a much clearer picture. The Eurostat report shows that while Ireland is ranked second in the EU in GDP terms, when transfer pricing is removed, we fall to ninth in the EU (Eurostat AIC V GDP 2017). Irish income levels are 181% of EU average under GDP figures but only 93% of EU average when transfer pricing distortions are removed. The CSO and the Department of Jobs, Enterprise and Innovation

produce annual reports detailing the Irish economy spend on raw materials, people/ salaries and services in Ireland (CSO Census of industrial production, Dept. Jobs Annual survey of Irish Economy Expenditure February 2019). The following statistics provide a clearer picture of the relative economic contributions of various sectors in 2017:

Multinational exports were valued at €200 billion while Irish economy expenditure by multinationals was €20 billion: a 10 cent spends in the Irish economy per euro exported.

- Irish economy expenditure by all Irish indigenous companies was €24 billion while total exports from these companies were €40 billion: 60 cent spends per euro export.
- Irish economy expenditure by the agri-food sector was €15 billion while exports were valued at €13 billion: 1.20 cent/euro export.
- Dairy industry exports were €4.2 billion while Irish economy expenditure was €3.8 billion: 91 cent expenditure in the Irish economy per euro export.

So the Irish dairy sector is a key contributor to growth in economic activity across the rural and regional Irish economy. At the same time, dairy output growth has been extremely climate change efficient. A recent Teagasc report shows that the expansion in the sector has been achieved while reducing the emissions intensity of dairy production to levels well below that of other countries.



Figure 1. GHG emissions per kg FPCM (LCA approach) — three year rolling average weighted by milk supply.

Dairy economy growth comes from a combination of a major surge in global demand for dairy products, particularly in emerging economies, and the ending of supply controls in the EU with the abolition of milk quotas in 2015. Since 2015 Irish dairy output has increased in value by over €2 billon annually and by 60% by volume.

- There are just 19,000 dairy farmers in Ireland (DAFM) producing over 7.5 billion litres of milk annually (CSO, 2018)
- Imports of milk from Northern Ireland represent an additional 800 million litres.
- Employment in milk processing is 7,500 jobs (CSO, 2018). There is an additional 30,000 jobs across the dairy sector in farm supplies and Agri inputs/wholesaling transport, distribution Research and Development (CSO, 2018)
- Total milk processed in the Republic of Ireland is almost 8.3 billion litres. This represents 60% increase on pre-quota levels of an average five billion litres annually.
- The turnover value of the milk processing industry is €4.8 billion. Exports in 2018 were valued at €4.2 billion.
- The unit value of milk production has increased from an average of 42–45c/litre in the

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last years of milk quota to just over 56 cent in 2018.

- Irish economy expenditure by the dairy sector was €3.8 billion in 2018. The Irish dairy sector buys 90% of its inputs and raw materials in the Irish economy.
- The dairy industry accounted for almost 10% of spending by all industry in the Irish economy in 2018. The sector additionally provides around 50% of the raw material for the beef processing sector to a value of €1.2 billion annually.

Since EU milk quotas were abolished in 2015, Irish milk production has increased to 7.6 billion litres in what was a really challenging year for farmers in 2018. Moreover, not only has the volume of milk production increased by almost 50% (as illustrated in Table 1), the ϵ 2 billion in increased expenditure in the Irish economy has ranged from increased farm inputs and services through investment in new processing facilities and in support of an additional 10,000 jobs across the economy from dairy farming right through to manufacturing distribution and research.

Resilience: Fixed price schemes v Price volatility and Return on investment

The transition from a milk quota plus EU market supports based regime to a more, open and volatile world market driven scenario has presented huge challenges in terms of dealing with price and income volatility. It is a testament to the resilience of farmers and the innovation of Irish milk processors led initially by Glanbia with the introduction of robust fixed milk price and business finance schemes, that both the volume growth trajectory and the increase in unit value were sustained throughout the ups and downs of the global milk price cycles (Figure 2).



Figure 2. Global Dairy Trade (GDT) price index (2009–2019). The GDT price index is calculated from the total quantity sold in a trading event across all products, contract periods and sellers.

While some element of the increase in the unit value of dairy output has come from an increase in the price of butter since the middle of 2016, the bigger factor driving the growth in value added would seem to be the move to higher income returns from the Infant formula and Sports Nutrition sectors. In addition to the increased value within the sector, figures from Enterprise Ireland from 2015 showed that, in the two years pre-quota abolition (2013 and 2014), Irish dairy processors invested in 36 projects across the dairy product spectrum, spending €770 million, with a state grant support of €79 million.

Summary and Conclusion

The clear takeaways from the analysis above is that the impacts of dairy expansion have been hugely significant in terms of return on investment (including state support) and even more importantly the huge economy wide impact of dairy expansion across the Irish economy.

PUTTING GRAZING MANAGEMENT INTO PRACTICE



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Pasture Profit Index — choosing the correct varieties for my farm

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Summary

- Key traits in the PPI are seasonal dry matter (DM) yield, grass quality, silage yield and persistency.
- There is a large range in PPI values (€/ha/year) between the highest (€214) and lowest (€66) varieties.
- Farmers should carefully choose varieties appropriate for their requirements when using the PPI.
- Grazing efficiency is a new trait being investigated for incorporation into PPI.

Introduction

Current grass utilisation on dairy farms in Ireland is estimated to be about 8 t grass DM/ha. Data from PastureBase Ireland shows that the top dairy farmers are utilising more than 10 t DM/ha/year, indicating that there is significant potential to increase grass growth and utilisation on most farms. A key management factor used by farmers achieving high levels of grass utilisation is regular reseeding. The Pasture Profit Index (PPI) was introduced to the Irish grassland industry in 2013 after many years of focussed research and refinements to Department of Agriculture, Food and the Marine (DAFM) evaluation protocols. The PPI sets out, in economic terms, the agronomic differences in traits between grass varieties to allow farmers select the most appropriate varieties for their farm.

Using PPI to select grass varieties for your farm

The PPI enables the identification of grass varieties which provide the greatest economic contribution to a ruminant grazing/silage system. The PPI ranks grass varieties based on their economic benefits and will ultimately result in an increase in the use of superior varieties, which means higher profitability for the industry. The key traits in the PPI are seasonal DM yield (spring, summer and autumn), grass quality (DM digestibility), silage yield and persistency. All varieties on the PPI Recommended List are evaluated by DAFM and have a minimum of two years agronomic data generated before the PPI is calculated. The relative emphasis on each trait is as follows: grass DM yield (31%), grass quality (20%), silage yield (15%) and sward persistency (34%). For each trait, varietal performance is expressed relative to the base value for all varieties. Variety performance above or below the base is then multiplied by the economic value for that trait giving the PPI value for that trait. Total PPI for each variety is the sum of all the traits. In 2019, this ranged from €214 to €66/ha/year (Appendix 1). The sub-indices allow farmers select varieties for specific purposes. Desirable traits for each system are displayed in Table 1.

Table 1. Desirable variety traits for grassland systems							
Grazing swards	Silage swards	Mixed swards					
High quality index	High silage index	High quality index					
Good seasonal growth	High spring growth	High silage index					
Good graze out results	Persistency	Good graze out results					
+ Clover							

Grazing efficiency

Grazing efficiency is a new trait currently being evaluated at Teagasc Moorepark. Varieties with good grazing efficiency are desirable as they are grazed tightly by cows, maintain their quality throughout the season and reduce the requirement for topping. At each grazing event, the post grazing residual sward height (PostGSH) achieved of each variety plot was measured with a rising plate meter. To accurately assess grazing efficiency, the PostGSH of each variety was predicted accounting for pre-grazing sward height, grazing interval and year. 'Residual Grazed Height' (RGH) is a measure of varietal grazing efficiency. The PostGSH achieved minus the predicted PostGSH gives us the RGH figure. Varieties with negative RGH values are desirable as they have greater grazing efficiency. This study identified that nearly all tetraploids had negative RGH values indicating that they have improved grazing efficiency over diploids. This work indicates that increased proportions of tetraploid varieties should be sown in grazing swards. Increased levels of OMD and increased leaf proportion are shown to improve the graze out performance of grass swards. Figure 1 shows the level of OMD for each variety trialled at Teagasc Moorepark over the last two years. Grazing efficiency will need to be included as a trait within the PPI in the future.



Figure 1. The relationship between levels of Organic Matter Digestibility (%) and residual grazed height.



Performance of grass varieties and white clover on commercial farms

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Summary

- The evaluation of grass and clover variety performance on commercial farms provides important information in sward evaluation.
- There was a 7.8 t DM/ha difference between perennial ryegrass varieties on commercial farms over a five year period.
- Sward white clover content ranged between 5–22% in 2018, and 8–21% in spring 2019.

Introduction

An evaluation process to identify and promote the use of grass and clover varieties with improved on-farm performance in the areas of production, persistence and quality is economically important for ruminant grazing systems. Since the introduction of Recommended List evaluations to Ireland, the grassland demands of farmers have changed. To overcome the limitations of simulated grazing studies and identify superior grass and clover varieties for grazing systems, on-farm evaluation studies have been established. On-farm evaluation has the ability to influence and direct the breeding of the next generation of grass varieties for intensive grazing systems. This paper presents results from the first five years of a long-term study to assess the life-time performance of grass varieties on commercial farms.

Perennial ryegrass on farm evaluation

This study is being undertaken on 89 farms across Ireland. It includes an array of soil and weather conditions. Over the five years of the study, variety influenced total and grazing DM yield. The highest performing variety for total DM yield was AberGain (14.8 t DM/ha/ year) and the lowest yielding variety was Glenveagh (13.4 t DM/ha/year). A larger range in production was found between paddocks across farms, ranging from approx. 6.5 to 19.5 t DM/ha. The wide range in paddock soil fertility and regional meteorological conditions contributed to the level of variation in on-farm herbage production.

Grazing DM performance indicates how well a variety performs from a grazing perspective, with more frequently grazed swards having greater DM production. The varieties evaluated differed significantly in yield of grazed herbage. The highest yielding variety with respect to grazing DM was AberGain (12.6 t DM/ha/year) and the lowest yielding variety was Dunluce (10.6 t DM/ha/year). AberGain and Astonenergy achieved the highest yield of grazed herbage, combined with recording a low silage yield. Varieties such as AberGain, Drumbo and Twymax appeared to have good yield stability. Other varieties had fluctuations in annual DM production.

White clover cultivar evaluation

In April 2016 and 2017, a study looking at the on farm performance of six white clover (four medium and two small leaf) cultivars was established. Nine farms from across the country were selected based on geographical location, soil type and previous grazing management. White clover was over sown into existing perennial ryegrass swards using an Einbock grass seeder, immediately after swards were grazed, at a seeding rate of 3.7 kg/ha. Between

70% and 80% of the milking platform was over sown with white clover, excluding silage ground. Sward clover contents were determined four times in 2018. Sward clover content averaged 5–22% across the nine farms. In spring 2019, sward white clover contents were determined on all of the nine farms. Sward clover content varied significantly between and within farms. Average sward clover content on the nine farms was between 8% and 21%, and within farms, ranged from 0 to 35%. There was no clear trend in terms of the performance of the white clover cultivars. Farm type, sward condition, soil fertility and grazing management had the largest impact on sward white clover establishment and persistency. The farms and paddocks where white clover established and persisted had high soil fertility for P and K and a high soil pH status, and also generally had high perennial ryegrass sward content.

Table 1. DM yield (T DM/ha) of perennial ryegrass varieties on commercial farms over five years (2013–2017)								
Year	2013	2014	2015	2016	2017	Mean		
AberChoice	13.5	12.5	14.0	14.4	14.6	13.8		
AberGain (T)*	12.8	15.1	15.4	15.1	15.6	14.8		
AberMagic	11.4	13.7	13.2	16.1	16.0	14.1		
Astonenergy (T)	12.8	14.7	15.2	15.1	14.7	14.5		
Drumbo	13.1	15.0	14.2	15.1	15.2	14.6		
Dunluce (T)	11.0	13.5	13.2	14.2	16.0	13.6		
Glenveagh	11.3	13.9	13.5	13.2	14.8	13.4		
Kintyre (T)	13.6	13.4	14.4	13.6	14.3	13.9		
Majestic	12.0	13.8	13.0	13.6	15.6	13.6		
Twymax (T)	12.6	13.8	13.5	14.7	14.7	13.9		
Tryella	12.9	13.2	13.3	13.8	14.4	13.5		

*(T) — indicates a tetraploid variety. All other varieties are diploid.

Conclusions

On average, a difference of 7.8 t DM/ha was observed between perennial ryegrass varieties over a five year period on commercial farms. On-farm white clover evaluation has commenced but no clear results are available to-date. On-farm evaluation helps to identify varieties which maintain production across years in terms of total DM production and grazing DM production. Current and future developments in grass and clover evaluations in Ireland need to result in the delivery of improved varieties suited to intensive grazing environments.



Reseeding grassland swards Deirdre Hennessy¹ and Philip Creighton²

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Summary

- Reseeding is one of the most cost effective on-farm investments.
- There is little difference between reseeding methods once completed correctly.
- There is no loss in grass 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 is important to ensure good establishment.

Introduction

Less than 2% of Ireland's grassland area is reseeded annually despite grass being our dominant feed source. Swards with low perennial ryegrass content are costing farmers up to €300/ha/year due to reduced DM production and reduced nitrogen (N) use efficiency. Reseeding costs approximately €750/ha; however the increased profitability of the new sward would cover the cost in just two years making reseeding one of the most cost effective on-farm investments.

Timing of reseeding

Timing of reseeding depends to a large extent on weather conditions, and grass supply. Generally, total grass production from a spring reseed is as much as, if not more than, old permanent pasture in the establishment year. Establishing clover is more reliable in spring than autumn due to the stability of soil temperatures. Conditions for post-emergence weed control are also more favourable following spring reseeding. While autumn reseeding may make sense from a feed budget perspective, soil conditions deteriorate as autumn progresses; lower soil temperatures can reduce seed germination, and variable weather conditions reduce the opportunity to apply post-emergence spray and to graze the new sward.

Cultivation techniques

The most appropriate cultivation method for a given paddock/farm depends on a number of factors including soil type, 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.

Key points when preparing for reseeding and cultivating

- Soil test and use the results.
- Spray off old sward with glyphosate.
- Graze tightly or mow to remove any herbage on the paddock.
- Choose a cultivation method that suits your farm.
- Apply lime.
- Ensure a firm fine seedbed for good seed to soil contact.
- Roll after sowing.

Cultivar choice

Grass cultivars should be selected from the Teagasc Pasture Profit Index or Irish Recommended List; both provide information on cultivars tested in Irish conditions. Recommended sowing rate is 35 kg seed/ha (14 kg/ac). Include a minimum of 3 kg of each cultivar in a mixture, and no more than three or four cultivars per mix. Keep the heading date range in a mix narrow — no more than seven days.

Establishing white clover swards

Direct Reseeding

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

Over-sowing

Over-sowing is a simple and low cost method of introducing white clover into swards. Success is very much dependent on weather conditions around sowing.

Key steps involved with over-sowing white clover:

- Seed can be broadcast or stitched into a sward using a suitable machine. Over-sow immediately after grazing (< 4 cm post-grazing sward height) or cutting for surplus bales. Over-sowing clover into dedicated silage paddocks is not advised.
- Clover seeding rate of 3.5–5 kg/ha is recommended for over-sowing.
 - » Sow with a P fertilizer, e.g. one bag 0-7-30 or 0-10-20/ac.
 - » Reduce nitrogen fertiliser post over-sowing.
 - » Roll or spread 2,000 gallons/acre of watery slurry to ensure good seed-soil contact.

Management of reseeds

Weeds in new reseeds are best controlled at the seedling stage before the first grazing. Use a clover safe herbicide if there is clover in the sward. If over-sowing, it may be better to control established weeds beforehand. It generally takes around 11 months to fully establish a reseed. Reseeded swards should be grazed as soon as the roots of the new grass plants are strong enough (root stays anchored in the ground when pulled). Early grazing allows light to the base of the plant to encourage tillering and, where relevant, clover establishment.

Conclusions

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 at reseeding or incorporated into existing swards by over-sowing. Post-sowing management has the biggest impact on the establishment and production potential of swards.

Teagasc grass and clover breeding programme Patrick Conaghan

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

Summary

- The Teagasc grass and clover breeding programme breeds new varieties of perennial ryegrass, white clover and red clover for Irish farm systems.
- The breeding programme is supported by Goldcrop Ltd., an Irish seeds and inputs company, that commercialises all new varieties.
- Two new perennial ryegrass varieties were released in 2019: Oakpark and Smile.

History

Forage breeding offers a cost effective and successful means to increase the profitability and sustainability of animal production from grassland. Teagasc has a strong history of forage breeding with the programme initiated in the early 1960's at Oak Park, Carlow. To date, the programme has bred and commercialised 40 grass and clover varieties. The programme is supported by Goldcrop Ltd., an Irish seeds and inputs 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.

Breeding goals

Our emphasis is on breeding improved varieties of perennial ryegrass, white clover and red clover for Irish farm systems. 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 should provide sufficient yield to match the animal feed demand curve over the entire grazing season and also provide additional yield during the mid-season that could be conserved for use during the winter when grazing is not possible. We want a grass variety that heads only once in a compact period of time for seed production. For the rest of the year we want a leafy, high digestible sward. We want a variety that produces a dense sward with no bare ground and that will persist indefinitely. Finally, we want a variety resistant to diseases particularly foliar diseases such as crown rust.

Breeding methods

The release of a new variety is the culmination of a 10–20 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 where the best plants (genotypes) are evaluated, selected and intercrossed to produce a new variety. Plants are selected based on their individual performance, progeny performance or DNA (genomic selection). A new variety is produced by crossing, in all possible combinations, a number of selected plants. The new variety is then independently tested under cutting and grazing by the Department of Agriculture, Food and Marine. If it excels and its botanical characteristics are distinct from other varieties, uniform and stable (DUS), it is added to the Ireland Recommended List. Commercial seed of Teagasc bred varieties are produced and sold under license by Goldcrop Ltd. or DLF-Trifolium.

Varieties

In 2019, farmers may choose among nine 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 2019. Two new, late diploid perennial ryegrass varieties were released in 2019: Oakpark and Smile.

Perennial ryegrass varieties

- Early diploid: Genesis.
- Intermediate tetraploid: Elysium.
- Late diploid: Oakpark, Smile, Glenroyal, Majestic and Kerry.
- Late tetraploid: Kintyre and Solas.

White clover varieties

- Medium leaf size: Buddy, Chieftain and Iona.
- Small leaf size: Coolfin and Galway.
- Large leaf size: Dublin.

Forthcoming Teagasc varieties, currently undergoing seed increase for release in 2020–22, include the late diploid perennial ryegrass varieties Glenmore, Gleneagle, Glenrock, and the red clover variety Fearga.

Fearga is the first ever Irish red clover variety. Red clover is a relatively drought tolerant, deep tap rooting, nitrogen fixating legume primarily used for silage production. It offers high yields of high quality forage with greater animal intakes and performance than grass silage. Fearga was selected for superior yield, persistency and longevity. There are no official red clover trials in Ireland. However, Fearga has completed the UK official trials across Northern Ireland, Scotland, England and Wales where it excelled. Fearga was found to be the highest yielding variety in the UK yielding 22% and 31% more than the control variety Merviot in the second and third harvest years, respectively. Fearga also offered significant improvements in persistency with 54% higher autumn ground cover than Merviot in the third harvest year.

Conclusions

The Teagasc forage breeding programme continues to develop improved varieties of grass and clover for Irish farmers. Farmers may currently choose among nine 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.



Fertiliser planning to improve grass production David Wall and Mark Plunkett

Teagasc, Crops, Environment and Land Use Programme, Johnstown Castle

Summary

- Low soil fertility (e.g. P Index 1) equates to a loss more than 2.0 t grass DM/ha/year, which is worth €275/ha/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 improving grass production.
- Slurry is a valuable resource. Target fields with highest requirement for P & K to help offset expensive fertiliser costs.

Introduction

Well-managed fertile soils are critical for profitable and sustainable grass based dairy systems. Soil quality is the term used to describe the soil's capacity to provide different functions such as grass production, water storage, nutrient recycling, soil organic matter (SOM) build-up and as a habitat for biodiversity, under changing management and climatic conditions. Soil quality also underpins the capacity of our lands to exploit the high yield potential of modern grass and clover varieties in reseeded soils.

Soil quality and soil fertility

The nature of grassland farming, including grazing, soil disturbance during reseeding and grazing events, large offtakes of nutrients in milk, meat and silage, and machinery trafficking puts pressure on soil quality and soil fertility. Soil structure, which refers to the arrangement of sand, silt and clay particles, held together by SOM, is critical for grass and clover to develop adequate root systems to access sufficient nutrients and water to drive herbage yield. Soil biology influences soil physical quality, e.g. earthworms consume up to 20 t soil/ha when tunnelling and burrowing, and chemical quality through the decomposition of grass residues and dung paths and mineralisation of organic matter to release nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and trace elements, etc.

Nutrient cycling in soils

Plant-available forms of macro- and micronutrients are relatively scarce in soil. The cycling of nutrients into and out of SOM is important to minimise the lock up of nutrients in the soil and prevent their loss to the environment. When soil quality is maintained, soils can: 1) safely accept manures and fertilisers, and make maximum use of the nutrients they contain; 2) sustain biological N fixation; 3) match mineralisation of nutrients to seasonal requirements; 4) maximise the recovery of nutrients; and 5) minimise nutrient loss risks. Soil quality and soil fertility levels affect each of these five aspects of nutrient cycling.

Feeding the soil and the grass crop

Fertiliser inputs are critical for high yielding grassland production systems, however, grass yields will be compromised if balanced nutrition cannot be supplied by the soil each day of the growing season. This balance and overall demand for nutrients will change over the course of the growing season due to changing growth rates and soil and weather conditions. For example, P is critical in springtime to drive early grass growth and provide energy for rooting and tillering, N and S demand is greatest during late spring and summer when

grass is growing rapidly and sufficient K is most critical to sustain high levels of grass growth in summer. Typically, intensively managed grasslands only receive 6–8 fertiliser applications throughout the growing season, which lasts for up to 10 months. Therefore, there is heavy reliance on soils to store, recycle and supply the appropriate N-P-K-S + trace element mix when required for grass production. This supply of nutrients can be more challenging if soils are compacted or if soil nutrient reserves have been depleted over time.

Fertiliser planning — right product, right rate, right time, right place

Knowing the pH and nutrient levels in the soil is important to develop an appropriate fertiliser strategy. The next information required is the nutrient off take from the different fields in order to replenish these nutrients with fertilisers or organic manures. A field-by-field fertiliser plan is the best way to utilise this information and develop a fertiliser and manure application strategy. The fertiliser planning system "NMP Online" develops tailored and easy to follow fertiliser plans with colour coded maps to guide lime, manure and fertiliser applications throughout the growing season.

Getting the balance right

Perennial ryegrasses, and especially clovers, are sensitive to soil acidity and regular monitoring of soil pH levels and applications of lime are essential. A balanced fertiliser programme is required to supply in-season plant available nutrients and maintain an adequate level of soil fertility by replacing all nutrient off-takes. For example, a 5 t DM/ha silage crop will remove ~20 kg P/ha (16 units/ac) and 125 kg K/ha (100 units/ac).

Return on Investment

Improving soil fertility is a worthwhile investment. Research shows that every $\in 1$ invested, in either lime, P or K, results in payback of $\in 4$ in extra production on low fertility soils (pH <6.5 and P or K index <2). For example, grass has been shown to yield at least 2.0 t DM/ha more, which is worth $\in 275$, at soil P Index 3 compared to P Index 1, regardless of fertiliser inputs. Supplying balanced fertiliser inputs and maintaining or building soil fertility has other benefits such as increasing the persistence of swards and helping to drive early season growth to extend the grazing season.



PastureBase Ireland — getting Ireland utilising more grass Mícheál O'Leary and Michael O'Donovan

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

Summary

- Dairy farms recording farm cover regularly on PastureBase Ireland (PBI) have grown between 11.1 and 14.4 t DM/ha/year over the past six years.
- Measurement is the first step to managing grass swards better and increasing grass utilisation.
- Farmers should use the PBI offline app when recording grass covers.

Introduction

PastureBase Ireland (PBI) is an internet-based grassland management programme for all grassland farmers. In operation since 2013, it has gained momentum in recent years due to the development work and offers farmers 'grassland decision support'. It also stores a vast quantity of grassland data from dairy, beef and sheep farmers in a central national database. PastureBase Ireland has an array of tools available in the programme including the grass wedge, spring and autumn rotation planners, feed budget, fertiliser/ slurry applications and reseed records. PastureBase Ireland recently launched an offline app which is available for both android and iPhone smart devices. Over the last 12 months the inclusion of the projected wedge, weekly grazing planner, offline app, invitations/group section and connecting with eight milk processors along with improving performance issues have all been completed.

Why are farmers using PBI?

The advantages for farmers in using PBI are:

- Short term: after completing a farm cover the programme displays a grass wedge and calculates the average farm cover, cover per livestock unit, growth rate etc. This helps farmers in making day-to-day decisions.
- **Medium term:** when a farmer records 25–30 farm covers during the year, PBI calculates the total quantity of grass grown in each paddock (paddock summary report). This gives the farmer the opportunity to investigate underperforming paddocks and helps initiate appropriate corrective action.
- **Long term:** after a few years using PBI, the farmer will be able to determine how much grass their farm grows in an 'average' year and set the stocking rate accordingly.

PastureBase Ireland App

The PBI offline app is available for all smart devices and can be downloaded from the App store and Google play store. The app is free to download, just search for 'PBI Grass'. The objective of the offline app is to record grass covers, graze dates, fertiliser application, livestock number/intakes as well as milk data quickly while undertaking the task in the paddock whether mobile coverage is poor or not available. The app is very user friendly and quick. Data will synchronise with the website when coverage/Wi-Fi is available.

What does the future hold for PBI?

There have been a lot of new additions during 2018 and more to be introduced in 2019. We have established a PBI steering group consisting of five farmers and three advisors to help us determine the future developments in PBI and we have also received feedback from a number of discussion groups. Our aim is to react fast to new ideas and implement them, if appropriate. In 2019 we hope to generate more reports, for example grass and milk reports while a new annual tonnage report will be developed. In response to the fodder shortage last year a 'fodder budget' tool will be developed. This will help farmers calculate how much winter feed is available on the farm and how much is required over the winter period. Another exciting development is the 'Grass Growth Model' which is being validated on 40 commercial farms where PBI is being used. It is hoped after this validation to make the grass growth model available to all farmers through PBI. The model will predict the grass growth for the following week for the farm, taking into account the grass covers on the farm, the paddocks in the grazing rotation, up to date fertiliser data and predicted local weather forecast. This will be a huge asset to grassland farmers and will help make the management of grass easier.

Why should you use PBI?

The unique selling point of Irish products abroad is Ireland's grassland image and its sustainable food production chain. Food Wise 2025 targets an increase in grass utilisation on all Irish farms of 2 t DM/ha to increase farm sustainability. PastureBase Ireland offers the medium to improve grazing management through grassland measurement and better decision making. Irish dairy farmers have incredible potential to increase annual DM production with a better focus on grazing management, but can only do this through measurement. Using PBI will help farmers to achieve this objective. PastureBase Ireland is available to all grassland farmers. If you wish to sign up or require more information please call out dedicated help centre on 046-9200965 or email support@pbi.ie.



Grass10 campaign

John Maher, Fergus Bogue and John Douglas

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

Summary

- Future growth in pasture based milk production in Ireland will depend on an effective grass-based system.
- The Grass10 campaign promotes sustainable grassland excellence.
- The objective of the campaign is to achieve 10 grazings/paddock per year utilising 10 t grass DM/ha.
- The number of grass measurements recorded on PastureBase Ireland by dairy farmers has increased significantly in 2019.

Introduction

Our competitive advantage in milk production can be explained by the low cost of grass relative to silage and concentrate feeds. Therefore, increased focus on grass production and efficient utilisation should be the main driver for improving efficiency and profitability of milk production. An analysis of farms completing both grassland measurement in PastureBase Ireland and a Profit Monitor demonstrated increased profit of €173/ha for every 1 t DM/ha increase in grass utilised. It should be noted that environmental sustainability (carbon footprint, nutrient use efficiency, etc.) is also improved by increased grass utilisation. Future growth in grass based milk production in Ireland will depend on an effective grass-based system. However, Irish farmers are not using grass to its potential and there is thus a need to (1) increase grass production and (2) ensure efficient utilisation of that grass on farms.

Current grazing performance on dairy farms

Currently, it is estimated that about 8 t grass DM/ha is utilised nationally on dairy farms. There are major improvements required in areas of pasture production and utilisation. Data from the best commercial grassland farms and research farms indicate that the current level of grass utilisation on dairy farms can be significantly increased (to greater than 10 t DM/ha utilised — i.e. 14 t DM/ha grown and 75% utilisation rate).

It is important to recognise that improvements in the level of soil fertility, grazing infrastructure and level of reseeding are crucial to achieve higher levels of grass production and utilisation. To achieve greater change in the level of grass utilised, farmers will need to improve their grazing management practices. This means regular measurement of grass supply, using specialised grassland focused software to analyse grass production, and implementing grazing management decisions. These are key drivers to increase grass production onfarm. New technologies are available which make grass cover assessment and the decision making process easier.

Grass10 campaign

Grass10 is a four-year campaign spearheaded by Teagasc to promote sustainable grassland excellence. The Grass10 campaign is playing an important part in increasing grass growth and utilisation on Irish grassland farms, thereby improving profitability at producer level and helping to ensure the long term sustainability of dairy production.

Objective

The objective of the campaign is to achieve 10 grazings/paddock per year utilising 10 t grass DM/ha. In order to achieve this objective, we need to achieve significant changes in on-farm practices, specifically:

- Improved grassland management skills.
- Improved soil fertility.
- Improved grazing infrastructure.
- Improved sward composition.
- Increased grass measurement and usage of PastureBase Ireland.

Grass10 grazing management training courses

To help improve knowledge of grazing and improve grazing skills, Teagasc, with the support of the Grass10 team, are providing 35 training courses to dairy farmers across the country to help farmers who want to learn more about grazing and enhance their grazing management skills and use of PastureBase Ireland, etc. Each course has a grazing coach who acts as a platform farm/farmer to help mentor course attendees. Across the country, there has been a significant increase in farmers measuring grass this year compared to 2018.

Grassland farmer of the year competition

Teagasc research indicates that grass utilisation can be increased significantly onfarm, and research shows a proven link between increased grass utilisation and increased profitability. In 2017, designated the Year of Sustainable Grassland, the Department of Agriculture, Food and the Marine, in collaboration with numerous industry stakeholders including Teagasc, launched a competition as part of the Grass10 initiative to find the Grassland Farmer of the Year. The objective of the Grassland Farmer of the Year Competition is to promote grassland excellence for all Irish livestock farmers. The winners of the Grassland Farmer of the Year incorporate all of the practices necessary to increase grass production and utilisation, including soil fertility management, sward renewal, grassland measurement and improving grazing infrastructure. They are true ambassadors for our grass based system.



Predicting grass growth: The MoSt GG model Elodie Ruelle¹, Luc Delaby² and Deirdre Hennessy¹

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Summary

- The MoSt Grass Growth model was developed to predict grass growth, grass N content and N leaching at paddock and farm level.
- The MoSt GG model has been evaluated across several farms and years and shows good accuracy in grass growth prediction.
- A pilot program is being run across 40 farms with weekly grass growth prediction being sent to farmers each Tuesday.
- The MoSt GG model will soon be incorporated into PastureBase Ireland (PBI) giving each PBI user access to growth prediction specific to their farm.

Introduction

PastureBase Ireland (PBI) is a grassland management tool for farmers which incorporates grassland management tools such as the spring and autumn planner, and the grass wedge. Currently within PBI, farmers can only make decisions based on historical information. Grass growth is highly seasonal and is dependent on climate conditions and soil type. The incorporation of a predictive grass growth model such as the MoSt GG Model into PBI would improve the decision making of the farmer by providing the farmer with a prediction of future growth at paddock and farm level.

Model description and evaluation

The MoSt grass growth (GG) model was developed at Moorepark for Irish grazing systems and Irish 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 in the model are nitrogen (N) fertiliser application as well as pre and post grazing sward height, or pre and post cutting height.

The MoSt GG model was evaluated using experimental data for 2013–2018 from three Teagasc experimental farms - Ballyhaise, Clonakilty and Curtins. Corresponding weather data from a nearby weather station and information about N fertiliser application, grazing and cutting events, as well as biomass and growth (for each herbage mass estimation entered by the farm manager) were imported from PBI. The results of the evaluation of the model are presented at the farm level (Table 1). Overall the model showed a similar accuracy across farms. The model is acceptably accurate at the farm level but somewhat less accurate at the individual paddock level.

Table 1. Comparison of gras	ss growth (kg DM/ha per day) simulated by the MoSt G	G
Model and that recorded in	PBI for three Teagasc farms at the paddock level	

Farm	Ballyhaise			Curtins			C	Clonakilt	у
	PBI	MoSt	RMSE	PBI	MoSt	RMSE	PBI	MoSt	RMSE
2013	50.7	49.0	12.7	46.6	46.9	16.8	45.5	45.3	15.4
2014	60.0	52.9	17.2	57.0	56.6	15.3	47.4	45.2	14.8
2015	46.6	48.6	11.5	53.5	51.9	13.6	53.6	51.2	13.2
2016	47.9	48.2	15.3	52.1	48.6	15.7	49.6	48.5	17.9
2017	49.7	47.7	14.2	NA	NA	NA	49.6	51.7	14.3
2018	44.1	45.0	17.2	37.3	36.1	16.3	NA	NA	NA
All years	49.7	48.4	6.9	45.8	44.6	9.4	49.1	48.4	7.6

Pilot program

In 2018, the model was live tested on three farms, two Teagasc farms (Curtins, Co. Cork and Ballyhaise, Co. Cavan) and one commercial farm in Mitchelstown (Co. Cork). The weather forecast for each location was provided by Met Éireann. The other inputs (N fertiliser application, grazing and cutting events) were extracted weekly from PBI for each farm. The model adapted to the different growth patterns on the farms, as well to the extreme conditions of 2018 with a very wet and cold spring and a very dry summer. The feedback from the farm managers was very positive, and the farmers considered the predictions to be very useful aids to decision making in challenging times.

Since January 2019, the model is being used to predict grass growth on 40 farms across Ireland. The farms are representative of a large range in soil type and geographic locations. Historical and forecast weather data are provided for each individual farm by Met Éireann. Information about N fertiliser and grazing and cutting events are imported from PBI weekly. The weekly grass growth prediction is communicated to farmers involved in the study in the form of a map.

Conclusions

The initial on-farm testing (2018) of the MoSt GG model indicates that the model is capable of adapting to differences on farms and in weather conditions. The on-going pilot study will provide a true indication of the MoSt GG model's ability to provide useful grass growth prediction across soil types, regions and management conditions. If the pilot study is successful, and the accuracy of the model is sufficient across the different farms, the model will be incorporated into PBI.

IRISH DAIRYING | GROWING SUSTAINABLY

GrassQ — precision grass measurement for the future Darren Murphy and Bernadette O'Brien

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

Summary

- Optimising the measurement of grass quantity and quality is integral to increasing the efficiency of pasture utilisation.
- A precision grass measurement protocol has been prototyped for the rising plate meter (RPM) that involves sampling fields in a random stratified manner at a rate of 25–50 samples/ha.
- New sensor technologies are being developed along with an online decision support system to aid the onset of real-time precision grass measurement.

Introduction

GrassQ is a holistic grassland decision support system (DSS) that encapsulates a range of measurement technologies to provide yield and quality data to a cloud based platform, which can provide users with real time management information in the field. Novel systems of measuring grass yield and quality are currently under development at Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork. These systems include both ground based and aerial techniques, referred to as remote sensing. The prototype GrassQ DSS is designed to process data uploaded from all proposed measurement systems. An infographic outlining the GrassQ concept can be seen in Figure 1 below.



Figure 1. Infographic of the GrassQ cloud based decision support system

Moorepark trial work

Over the 2017 and 2018 grazing seasons, ground based measurements were recorded using a smart RPM and lab based near infrared spectroscopy (NIRS) on Moorepark trial plots and paddocks. Remote sensing was carried out using an unmanned aerial vehicle (UAV), and

data from the European Union's Sentinel-2 satellite (S2) was also collected. Measurement parameters included compressed sward height (CSH; mm), herbage mass (HM; kgDM/ha), dry matter (DM; g/kg) and crude protein (CP; g/kg). Reference measurements were carried out at Moorepark's Grassland Laboratory and all sample locations were geo-tagged to enable spatial mapping of all parameters.

Optimising the accuracy of the rising plate meter

The efficiency and accuracy of the RPM was evaluated as part of this study, with the aim of creating a precision sampling protocol to optimise how farmers measure their grass. Paddocks were blanket sampled at a rate of 320 plonks/ha in a random stratified manner to determine 'true mean' CSH. A simulation algorithm was developed to investigate the relationship between sampling rate and average height prediction error to determine optimum sampling rates for the RPM, which would minimise both sampling error and effort. Optimum sampling rates were found to be in the region of 25–50 plonks/ha, which results in a prediction error of less than 5%. Based on these findings, a precision sampling labour utilisation tool, that will prompt farmers on how best to measure grass using real-time GPS data, is being developed to be built into GrassQ.

Remote sensing and NIRS

Preliminary findings for NIRS indicate that fresh grass quality can be predicted with acceptable accuracy ($R^2 = 0.93$, $R^2 = 0.89$ for DM and CP) within a time frame of three to five minutes. Initial results for remote sensing are promising with HM prediction models for UAV ($R^2 > 0.8$) and Satellite ($R^2 > 0.7$) based sensors achieving reasonable levels of accuracy, although data from S2 was disrupted by cloud cover on numerous sampling dates. All sensing data along with ground based measurements will be uploaded onto GrassQ for processing and storage.

Conclusions

The prototype GrassQ DSS is complete and can be accessed at www.grassq.com. The DSS allows users to download and view interactive maps that illustrate the spatial variation of grass quantity and quality throughout their grazing platform. Furthermore, a prototype smartphone app has been developed so that GrassQ can be accessed by users in the field. The final stages of this project which is due for completion in 2019, will focus on the comparison and validation of all measurement systems. GrassQ will be a concept model for future updates to PastureBase Ireland.



Effects of autumn grazing management on over-winter growth, sward quality and sward structure

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Summary

- Each one day delay in closing date after September 25th resulted in a reduction of 16 kg DM/ha in spring herbage supply.
- Earlier closed paddocks had reduced sward quality.
- In earlier closed paddocks up to three leaves per tiller can die over winter and there is higher mortality.
- Higher covers of autumn produced tillers should be grazed to a residual of 3.5 cm as early as possible in spring to remove dead material, maintain sward quality and allow for daughter tiller survival.

Introduction

Perennial ryegrass (PRG) growth is highly seasonal with little growth from November to February. With increasing herd demands in spring, Irish dairy farmers must make careful decisions on autumn closing date to ensure sufficient over-winter growth, while at the same time ensuring sward structure is not compromised. Tissue turnover is the appearance and senescence of green leaf material in the sward. A PRG plant continuously produces new leaves, with three live leaves on a plant and one actively growing at a time. As a new leaf appears the oldest leaf starts to senesce. The closed period directly contributes to the number of leaves that appear and senesce over winter, which can result in increased senesced material and reduced sward quality. Spring and autumn are the key periods for tiller production in a PRG plant. Survival of daughter tillers produced is of key importance as tillers only live for approximately a year and daughter tillers maintain continued persistence of the sward.

Autumn grazing management research in Moorepark

An experiment was established at Teagasc Moorepark evaluating over-winter growth, sward quality and sward structure in autumn 2016. Briefly three autumn closing managements Early (25th Sept-9th Nov), Normal (10th Oct-24th Nov) and Late (25th Oct-9th Dec) were evaluated. Over-winter growth rates and tissue turnover (leaf appearance and senescence and daughter tiller survival over winter) were measured every three weeks over the closed period and sward quality was measured prior to grazing in spring.

On average over the three years from autumn closing to spring opening (February 6th), every one day delay in closing from September 25th resulted in a reduction of 16 kg DM/ ha/day in spring grass availability (Figure 1). At the point of spring grazing, on average, 11 kg of the 16 kg DM/ha was classified as green material in early closed swards, due to the higher level of senesced material. Senescent material was significantly higher in earlier closed paddocks compared to the late closed paddocks (71% vs. 76%). The higher level of senescent material on the early closed paddocks was as a result of increased leaf appearance and senescence. The early closed treatments on average produced three times more leaves than the late closed paddocks, which accounted for the increased herbage mass in spring, however it also had a greater level of leaf death, with 50% of new leaves dying. Early closed paddocks also had reduced sward quality at spring grazing compared

PUTTING GRAZING MANAGEMENT INTO PRACTICE

to later closed paddocks (OMD of 831 and 847 g/kg DM respectively). Daughter tillers produced in autumn in early closed swards showed high mortality rate swards (Table 1). It has previously been reported that earliest closed sward should be grazed by mid-March the following spring to reduce the negative impact on sward quality. However this is also the case for tillering, as tillering increases again in spring; and to ensure a higher rate of survival in spring daughter tillers, swards with high levels of herbage mass should be grazed early to allow light in to the base.

Table 1. The effect of autumn closing date	e (Early, Normal and Late) on green leaf
mass, leaf appearance and senescence ar	nd daughter tiller mortality over winter

Autumn Closing	% Green Leaf	No. of leaves grown	No. of leaves senesced	Daughter tiller mortality
Early	71%	6	3	35%
Normal	72%	4	1	14%
Late	76%	2	0	9%



Figure 1. The effect of autumn closing date on spring grass availability (kg DM/ha)

Conclusions

Earlier closing of swards resulted in an increased level of herbage mass availability for grazing in spring. To ensure there are no negative effects on the sward and the best quality grass is fed to freshly calved cows, paddocks closed earlier in autumn should be prioritised for grazing earlier in spring to remove senescent material from the sward base and aid daughter tiller survival and persistence.

Effects of autumn grazing management on spring grass availability

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Summary

- Closing date in autumn does not have an effect on late lactation milk production.
- Closing date has a significant impact on grass availability in the subsequent spring.
- Spring grass availability is a driver of animal performance in early lactation.

Introduction

Autumn closing date is one of the most important factors affecting spring grass supply. With little grass growth over the winter months, there is a necessity for careful planning in autumn to ensure adequate grass will be available to meet the herd demand in spring. The current recommendation for Irish dairy farmers in autumn is to close off 60% of the grazing area between early October and November 7th. The remaining 40% of available area should be grazed by late November and animals housed until turnout in early February.

To ensure adequate quantities of grass are available at the start of calving on highly stocked (> 2.9 LU/ha) farms, farmers must ensure that an average farm cover (AFC) is above 750 kg DM/ha at closing cover on December 1st. However, PastureBase Ireland data suggests that most farms are not achieving sufficient levels of grass on farm at closing and therefore will require increased levels of supplementation to support the demand of the herd in early lactation.

Autumn grazing management research in Moorepark

In September 2016, a grazing experiment was established at Teagasc Moorepark examining autumn and spring grazing management practices. The objectives of the experiment were to evaluate the potential of alternative grazing management practices in autumn to increase grass supply in the subsequent spring. To determine this; the current recommendations outlined above were evaluated across a 10.2 ha farm-let in comparison to an early closing farmlet (15 days earlier) and a late closing farm-let (15 days later; Table 1). All three treatments were stocked at 2.9 cows/ha, and all swards received the same Nitrogen fertiliser application. The animals are turned out post-calving from February 6th and allocated an equal grazing area/day in line with the spring rotation planner guidelines.

Table 1. Three autumn closing managements: early (Sept 25 th –Nov 9 th), normal (10 th Oct–24 th Nov) and late closing (25 th Oct–9 th 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

There was no effect of closing date on milk production over a 13-week period from peak AFC (mid-Sept) to the housing of the late closed treatment (13.7 kg milk/cow and 1.26 kg MS/cow). However, the late closed treatment had higher milk protein (+ 0.13%/day) compared to the early closed treatment. As the early treatment was housed first, they consumed a higher level of silage than the normal and lates (450, 310 and 140 kg DM/cow, respectively). As a result of the earlier closing of swards, additional herbage was available in spring compared to the normal and late treatment, respectively (Table 2).

Table 2. Opening farm cover (kg DM/ha) on February 1st on the three farmlets in 2017, 2018 and 2019, daily winter growth (kg DM/ha) and soil temperature from November to March

	Opening farm cover (kg DM/ha)			Growth (kg DM/ha)	Soil temp.
	Early	Normal	Late		
Year 1 (2017)	1,010	815	650	6.8	6.5°C
Year 2 (2018)	1,060	675	440	4.1	5.7°C
Year 3 (2019)	1,400	1,080	800	7.4	7.6°C

The greater opening farm cover (OFC) in spring resulted in a greater herbage allowance (kg DM/cow) (+4.1 kg DM/cow). Each 1 kg increase in herbage allowance increased milk production by 0.35 kg milk/cow/day. Similarly, with the lower OFC, there was a greater requirement for silage supplementation on the normal and late treatment (+40 & +75 kg DM/cow/day, respectively) to offset the reduction in grass availability up until the end of April.

Conclusions

To consistently meet the requirements of a highly stocked dairy farm (> 2.9 LU/ha), an earlier closing date is required to achieve sufficient grass supply on farm at turnout. Housing cows earlier in autumn did require a greater level of supplementation; however, the benefit of a greater OFC in spring outweighed the necessity for additional supplementation in autumn.


The impact of autumn grazing management on animal and pasture productivity

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Summary

- Increasing pasture supply via increased pre-grazing herbage yields resulted in increased pasture removal and similar animal performance during autumn.
- The combination of reduced post-grazing residuals and increased concentrate supplementation of higher SR grazing systems can increase both pasture utilisation and individual animal performance during autumn.

Introduction

Increasing stocking rates (SR) on Irish dairy farms place added pressure on available feed resources and can result in increased feed supplementation and a shortening of the grazing season. Grazing practices must be adapted to allow higher SR farms to continue to harness the benefits of a predominantly pasture-based diet.

The Pasture Supply Study

The objective of this study was to evaluate the impact of three autumn pasture supply (PS) strategies and two farm system intensities on the performance of spring calving dairy cows during autumn. In 2017, 144 spring-calving dairy cows were randomly allocated to one of the three PS treatments which included a Low Pasture Supply (LPS; 400 kg DM/ ha available at winter housing), a Medium Pasture Supply (MPS; 600 kg DM/ha available at winter housing) and a High Pasture Supply (HPS; 800 kg DM/ha available at winter housing) treatment. The three PS treatments were established by extending rotation length from late summer to achieve peak autumn average farm pasture covers of 900, 1,150 and 1,400 kg DM/ha for LPS, MPS and HPS, respectively. The two whole farm system (FS) intensities were a Medium Intensity (MI; 2.75 cows/ha plus 90% pasture diet) and a High Intensity (HI; 3.25 cows/ha and 80% pasture diet)). The HI groups also received an additional 2 kg of concentrate/cow daily to compensate for the increased stocking rate and reduced availability of pasture.

Results

Before grazing, mean paddock pre-grazing herbage yield and sward density were significantly higher with increased PS (Table 1). Mean paddock residency time significantly increased with increased PS averaging 2.3, 2.5 and 3.1 days for LPS, MPS and HPS, respectively. There was no difference in daily herbage allowance between the 3 PS treatments (15.1 kg DM/ cow per day). After grazing, mean post-grazing height and herbage removed increased with increasing PS. Grazing efficiency was higher for LPS compared to both MPS and HPS while higher PS treatments achieved increased herbage removal per hectare. The HI FS had a lower herbage allowance and post-grazing height and increased grazing efficiency and herbage removal compared with MI FS.

Table 1. The effect of pasture supply and farm system on pasture characteristics during autumn

	Pasture supply			Farm system		
	LPS	MPS	HPS	MI	HI	
Pre-grazing						
Herbage yield (kg DM/ha)	1,616	1,793	2,338	1,862	1,970	
Sward density (kg DM/cm)	237	254	271	250	258	
Herbage offered (kg DM/cow/d)	14.3	15.1	15.8	15.8	14.3	
Post-grazing						
Residual height (cm)	3.5	3.7	3.9	3.8	3.6	
Grazing efficiency (%)	102	98	96	97	100	
Herbage removed (kg DM/ha)	1,613	1,743	2,216	1,776	1,938	

Despite the significant effect of PS treatment on pre-grazing herbage yield, no significant effect on milk production variables was evident. There was also no significant effect of FS on daily milk yield, fat, protein and lactose composition during autumn although the HI FS achieved a higher daily MS yield.

Table 2. The effect of pasture supply and farm system on animal performance during autumn

	Pasture supply			Farm system	
	LPS	MPS	HPS	MI	HI
Milk yield (kg/cow/d)	15.6	15.1	15.2	15.1	15.5
Fat content (%)	5.59	5.75	5.60	5.63	5.66
Protein content (%)	4.00	4.10	4.06	4.06	4.05
Lactose content (%)	4.69	4.66	4.68	4.68	4.67
Fat + protein yield (kg/cow/d)	1.46	1.45	1.43	1.42	1.47

These results highlight the potential for intensive grazing systems to maintain an extended grazing season with MI and HI FS by increasing PS during autumn without detriment to individual animal performance.

Conclusions

Increasing pasture supply via increased pre-grazing herbage yields resulted in increased pasture removal and similar animal performance during autumn. Equally the combination of reduced post-grazing residuals and increased concentrate supplementation of higher SR grazing systems can increase both pasture utilisation and individual animal performance during autumn.

Benefits of white clover in grass-based milk production systems

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Summary

- Grass-white clover swards can fix 100–250 kg nitrogen/ha/year.
- Incorporating white clover in fertilised grass swards can increase herbage and milk production.
- Reducing N fertiliser application to grass-white clover swards can increase N use efficiency of the farm system.

Introduction

White clover is the most commonly sown legume species in temperate grassland. White clover grows well in association with grass. It is tolerant of grazing and can grow over a fairly wide range of climatic conditions. There are several benefits associated with the use of white clover in grass-based milk production systems.

Nitrogen fixation

White clover can fix nitrogen (N) from the atmosphere and make it available for plant growth. Rhizobia bacteria live in nodules on the roots of the white clover plant and exist in a symbiotic relationship with the clover whereby they fix N making it available for plant growth using energy provided by the clover plant through photosynthesis. Many experiments have been undertaken examining the quantity of N fixed in grass-white clover swards. In frequently grazed swards (8–10 times/year) up to 250 kg N/ha per year can be fixed. The rate of N fixation is influenced by the N fertiliser supply to the sward and the sward clover content. Generally, an average annual sward clover content of at least 20% is required for N fixation. In fertilised swards, as N fertiliser application rate increases, N fixation generally declines (Figure 1).



Figure 1. Nitrogen fixation (kg N/ha) on grass clover swards receiving 0, 60, 120, 196 and 240 kg N fertiliser/ha over three years

Herbage production

Incorporating white clover into grazed grassland can increase herbage production, particularly at lower N application rates. Research from Clonakilty Agricultural College found that incorporating white clover into intensively managed swards increased annual herbage production by 1.2 t DM/ha, on average, relative to grass only swards (where both

sward types received 250 kg N/ha) over a four year period and where sward clover content was 23%. Research at Moorepark shows that grass-white clover swards receiving 150 kg N/ha grew the same quantity of herbage as grass-only swards receiving 250 kg N/ha (13.5 t DM/ha).

Milk production

Grass-white clover swards tend to be higher quality in mid-season compared to grass-only swards as sward clover content increases from May onwards. Clonakilty and Moorepark research both show increases in milk and milk solids production from grass-white clover swards compared to grass-only swards (Table 1).

Table 1. Effect of white clover inclusion on milk and milk solids yield in the Moorepark and Clonakilty grazing experiments							
Moorepark Experiment	Grass-only 250 kg N/ha	Grass- 250 kg	clover N/ha	Grass-clover 150 kg N/ha			
Milk yield (kg/cow)	6,108	6,4	98	6,466			
Milk solid yield (kg/cow)	460	49	96 493				
Clonakilty experiment	Grass-onl 250 kg N/ł	y 1a	Grass-clover 250 kg N/ha				
Milk yield (kg/cow)	5,222		5,818				
Milk solid yield (kg/cow)	437			485			

Nitrogen use efficiency

Nitrogen use efficiency is hugely important in grazing systems as N is a key nutrient lost from our systems. It is influenced by many factors including N fertiliser application rate, quantity and crude protein content of concentrate fed and N removed from the system in milk and meat. The N use efficiency of a farm systems experiment undertaken at Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork from 2013 to 2016 was examined using a farm gate N balance model. 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. The N inputs were purchased concentrate, fertiliser and replacement animals, and the N outputs were milk and livestock. The N fixed by the clover was not included. The N use efficiency of the systems increased from 40% on the Grass250 to 59% on the Clover150 due to the reduction in N fertiliser application and the increase in milk production (and therefore increased N in milk) on that treatment.

Conclusions

Incorporating white clover in grass-based systems can increase herbage production and animal performance at grazing and can contribute to reduce N fertiliser application thereby improving N use efficiency of farms.

Moorepark clover study update Deirdre Hennessy, MaryAnne Hurley and Ellen Fitzpatrick

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Summary

- Grass-clover swards receiving either 100 or 150 kg N/ha/year had similar pasture production to grass-only swards receiving 250 kg N/ha.
- Grass-clover swards receiving either 100 or 150 kg N/ha/year had greater milk solids production compared with grass-only swards receiving 250 kg N/ha at a stocking rate of 2.74 cows/ha.

Introduction

Incorporating white clover into grass based systems can increase herbage quality in midseason and potentially supply nitrogen (N) for grass growth through N fixation. Farms with high stocking rates (> 2.5 LU/ha), and therefore a high feed demand, generally rely on fertiliser to supply adequate N for sward growth. Previous Moorepark research has shown that including white clover in intensive grass based systems can allow a reduction in N application rate from 250 to 150 kg N/ha, without impacting on herbage production, while also increasing milk solids production compared to a grass-only sward receiving 250 kg N/ha. Clover growth compliments perennial ryegrass with peak growth during August compared to the peak in grass growth during May/June. Clover growth is slower than grass over winter and in early spring because clover requires soil temperatures of approximately 8°C for growth while grass grows at soil temperatures of 5–6°C. Applying N fertiliser to grass-clover swards can compensate for low clover growth rates in spring. Incorporating clover into 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 is being undertaken at Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork. The experiment commenced in 2017. The experiment is comparing herbage and milk production from a grass-only sward receiving 250 kg N/ha per year (Grass250) and grass-clover swards receiving 150 or 100 kg N/ha per year (Clover150 and Clover100, respectively). Each treatment is stocked at 2.74 cows/ha. All swards received N fertiliser throughout the year, though the rate varies depending on treatment. Target rotation length, pre-grazing herbage mass (1,300 to 1,500 kg DM/ha in mid-season) and post-grazing sward height (4 cm) are the same for all treatments. Concentrate feeding was the same for each treatment. Results from 2017 are presented.

Results

Pasture production was 14.0 t DM/ha on Grass250, 14.6 t DM/ha on Clover150 and 13.4 t DM/ha on Clover100. Sward clover content was 18% in both Clover150 and Clover100. Milk and milk solids production was greatest on Clover150, least on Grass250, with Clover100 intermediate (Table 1 and Figure 1). Based on the results of this experiment there is potential to reduce N fertiliser application to grass clover swards in milk production systems with stocking rates up to 2.74 cows/ha. This offers considerable potential saving to the farmer in terms of reduced N fertiliser application.

Table 1. Average daily milk and milk solids yield and annual milk solids yield on grass-only swards receiving 250 kg N/ha (Grass250) and grass-clover swards receiving 150 or 100 kg N/ha (Clover150 and Clover100, respectively)

		<u> </u>	
	Grass250	Clover150	Clover100
Milk yield (kg/cow/d)	20.7	22.4	21.9
Milk solids (kg/cow/d)	1.7	1.9	1.8
Cumulative milk yield (kg/cow/yr)	5,141	5,607	5,469
Cumulative milk solids (kg/cow/yr)	420	468	442
Cumulative milk solids (kg/ha/yr)	1,151	1,282	1,211



Figure 1. Average daily milk solids production (kg MS/cow) from a grass-only sward receiving 250 kg N/ha (Grass250) and grass-clover swards receiving 150 or 100 kg N/ha (Clover150 and Clover100, respectively)

Conclusions

Milk solids production was greater on the grass-clover treatments compared to Grass250. Sward clover content was similar on the two clover treatments.

Acknowledgements

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Clonakilty Update: The effect of perennial ryegrass ploidy and white clover inclusion on animal, sward and farm economic performance Brian McCarthy¹, Bríd McClearn¹, Laurence Shalloo¹, Áine Murray¹ and Fergal Coughlan^{1,2}

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Summary

- The inclusion of white clover in perennial ryegrass swards increased milk and milk solids yield and grass dry matter (DM) production compared perennial ryegrass to grass-only swards.
- As sward white clover content decreased over time, the beneficial effects of white clover on milk and grass DM production were reduced.
- Perennial ryegrass ploidy did not affect milk or grass DM production.
- Including white clover in a sward increased net profit/ha by €305.

Introduction

Perennial ryegrass (Lolium perenne L.) ploidy and white clover (Trifolium repens L.) can affect both grass DM production and milk production in grazing systems. There has been renewed interest in the use of white clover in grazing systems due to its ability to biologically fix nitrogen (N), increase herbage nutritive value and improve animal performance.

Clonakilty experiment 2014–2017

The experiment was established in Clonakilty Agricultural College in 2012 and 2013 and ran from 2014 to 2017. 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 grazing treatment. In the clover paddocks, a 50:50 mix of chieftain and crusader white clover were sown at a rate of 5 kg/ha. There were 30 cows in each treatment group and treatments were stocked at 2.75 cows/ha, received 250 kg of nitrogen (N) fertiliser/ha and target concentrate supplementation was 300 kg/cow for each treatment.

Results 2014-2017

On average over the four years, perennial ryegrass ploidy did not affect grass DM production or milk production per cow, therefore the results will focus on the differences observed between grass-only (TO and DO) and grass-clover (TC and DC) treatments. Sward white clover content was similar for TC and DC (23.1%; Table 1) and white clover content varied both within year and over time. In 2014, sward white clover content was high (37%) however, white clover content declined each year (2015 = 25%, 2016 = 18% and 2017 = 15%). On average, grass DM production was 15.6 t DM/ha on grass-only swards and 16.8 t DM/ha on grass-clover swards over the four years. However, as sward white clover content declined over time the difference in DM production also declined and ranged from 2.5 t DM/ha in 2014 to 0.4 t DM/ha in 2017. Average concentrate supplementation

across all treatments was 344 kg DM/cow per year during the experiment. Average silage supplementation during lactation to the grass-clover cows was significantly greater (450 kg DM/cow per year) compared with the grass-only cows (350 kg DM/cow per year).

White clover inclusion increased milk and milk solids yield per cow. Cows grazing grassclover swards produced 597 kg more milk and 48 kg more milk solids per year than cows grazing grass-only swards. However, the difference in milk production per cow between grass-only and grass-clover declined as sward white clover content declined. The economic performance of grass-only vs. grass-clover swards was modelled, based on a 40 ha farm, using the biological performance from this experiment with the Moorepark Dairy Systems Model. Net profit/ha was €305 higher for grass-clover swards compared to grass-only swards.

Table 1. The effect of grazing treatmen	¹ on grass and	d milk production a	and economic
performance over four years (2014-201	7)		

	ТО	DO	TC	DC		
Grass growth (t DM/ha)	15.6	15.5	16.8	16.8		
Sward white clover content (%)	-	-	22.6	23.6		
Milk yield (kg/cow)	5,235	5,208	5,854	5,782		
Milk solids yield (kg/cow)	439	434	487	482		
	Grass-only		Grass-	-clover		
Net Profit (€/40 ha farm)	94,774		106,964			
Net Profit per ha (€)	2,3	369	2,6	574		

 $^{1}TO =$ tetraploid only; DO = diploid only; TC = tetraploid + clover; DC = diploid + clover.

Clonakilty experiment 2019-2021

The new grazing experiment in Clonakilty will investigate the effect of sward type (grassonly vs. grass-clover) and N fertiliser level (150 vs. 250 kg N/ha) on the productivity of spring milk production systems and will examine how reducing N fertiliser levels on grassonly and grass-clover swards will affect grass and milk production. In this experiment a concerted effort will be made to increase and maintain sward white clover content at optimum levels (approx. 20%–25%) through a systematic programme of over-sowing and reseeding.

Conclusions

Perennial ryegrass ploidy did not affect milk or pasture DM production. White clover inclusion in perennial ryegrass swards significantly increased both milk and grass DM production. The increased net profit/ha observed highlights the potential of white clover to increase the profitability of pasture-based systems.

Sustainable use of concentrates on dairy farms — best practice for supplementation Brian Garry

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Summary

- Concentrate prices are volatile and increasing faster than milk prices.
- Feed low protein ingredients to avoid excess nitrogen excretion.
- Feeding surplus protein will not increase milk production.

Introduction

It is important to recognise the role of concentrate supplementation within such systems. Nationally, in 2017, the average amount of concentrate fed per cow was 1,011 kg, which is 18% of the total annual feed budget for a typical dairy cow. With purchased concentrate being a major farm cost it is important that it is used effectively. In addition, with increased pressures on the environmental sustainability of dairy farms it is prudent to look at ways to minimise the environmental impact of purchased concentrate.

Sustainable concentrate use

Over the past 10 years, we have experienced increased volatility in both milk and feed prices. While milk prices have risen sharply during certain periods, they have inevitably coincided with an increase in concentrate price (Figure 1). As a result the ratio of milk price to concentrate cost has had, on average, a downward trend over the past 20 years. Systems depending on a large proportion of purchased concentrate will come under increasing pressure as this ratio reduces. Additionally, increasing farm performance on purchased concentrates will add to the on the carbon emissions from dairy cows.



Figure 1. Average trends in milk and concentrate feed price and the ratio of milk to meal price from 2000–2018

The crude protein (CP) content of grass is between 18 and 27%. This is surplus to dairy cow dietary requirements of 15–17%. The imbalance of protein in grass is better described by the PDI system, high quality grazed grass has a PDIN of 130 g/kg DM and a PDIE of 105 g/kg DM. A diet imbalanced in PDI supply can result in poorer N use efficiency (NUE) because an insufficient supply of fermentable energy can limit N capture by microbial protein in the rumen (PDIE < PDIN). This results in excessive urinary N output and, consequently,

increased NH₃ emissions from manure. Previous studies indicate that only 25–35% of dietary protein is captured and secreted in milk, with most of the remaining N lost in urine and faeces. Nitrogen is excreted either as organic N (40–50% of total N, mostly in faeces) or urea (50–60% of total N, mostly in urine). Urea is readily converted to ammonia, which can be volatilised during spreading of manure. Ireland exceeded its ammonia emissions targets in 2017, with 92% of emissions from the agriculture sector. Moorepark research has shown no difference in the performance from cows offered 4 kg of a 27% CP, 19% CP or 10% CP concentrate when on a grass only diet in early lactation. There was no difference in performance from cows across the differing CP supplement types. Table 1 shows PDI available and required for a spring calving dairy cow. Once PDI supplied by the diet meets requirements, there is no production benefit to additional protein.

Table 1. PDIN and PDIE values for a typical spring calving dairy cow						
	16 kg DM grass	2 kg 12% CP ration	Total PDI (g)			
PDIN (g)	2,065	160	2,225			
PDIE (g)	1,860					
PDI requirement 600 kg dairy cow - 27 kg milk at 3.6% protein 1,858						

While commercially available concentrates will be formulated using available ingredients, the environmental impact should be considered when deciding on specifications and ingredients. Table 2 below shows the recommended protein specification to use when feeding dairy cows at a moderate rate. As forage quality decreases the amount of concentrate required will increase to promote energy intake. Always aim to choose a high UFL (0.94+ kg fed) feed, to ensure adequate energy supply to utilise N in grass effectively.

Table 2. Protein specifications for feeding dairy cows							
	Stage of lactation						
	Early Mid Late						
Milk solids yield, kg/day	2.0–2.2	1.8–2.0	1.5–1.7				
Diet type	Ration CP%						
High quality grass	12–14	12	12				
Grass + silage/poor quality grass	16	14–16	14				
Silage/hay	18–20 16–18 16						

Conclusions

As concentrate makes up 18% of a dairy cow's annual diet, savings can be made by reducing the reliance upon purchased concentrate. Future agricultural policy will aim to reduce the environmental impact of dairying. By choosing to lower concentrate usage and protein content farmers can increase nitrogen use efficiency and reduce N losses.

Effects of concentrate type on dry matter intake and milk solids production of mid-lactation dairy cows grazing perennial ryegrass with elevated neutral detergent fibre, indigestible NDF and reduced crude protein

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Summary

- Grazed pasture is a high quality forage, however due to seasonal and climatic factors, the chemical composition is variable.
- Providing a source of metabolisable protein when pasture offered was elevated in neutral detergent fibre, indigestible NDF and reduced crude protein enhanced animal performance.
- Increased performance from pasture can be achieved if a greater understanding of the specific nutrient first limiting milk solids production is identified.

Introduction

Pasture-based systems have the ability to utilise large quantities of human inedible forages and convert them to edible human food of high biological value contributing positively to net food production. These systems also support environmental sustainability and an animal welfare friendly image. It is important to investigate if the efficiency of milk production from pasture-based systems can be enhanced in a sustainable manner. The objective of this experiment was to evaluate factors limiting dry matter intake (DMI) and milk solids production in dairy cattle grazing mid-season swards.

Experimental design

An experiment was conducted at Teagasc Clonakilty Agricultural College from June to August 2018. Eighty dairy cows were randomly assigned to one of four treatments: 1. perennial ryegrass (PRG), 2. PRG plus 4.8 kg DM citrus pulp and 0.075 kg DM urea (Citrus); 3. PRG plus 0.8 kg DM heat treated soybean meal (TSBM); and 4. PRG plus 3.1 kg DM of a mix of citrus and heat treated soybean meal (Mix). Briefly, the increased sugar and reduced fibre content of citrus was postulated to allow greater DMI compared to PRG only by reducing physical fill limitations and providing more feed for digestion in the rumen. By heat treating soybean meal, the degradability of the protein in the soybean is reduced, thereby allowing more of the protein to escape digestion in the rumen and pass into the small intestine to supplement the amino acids needed for enhanced milk solids production.

Results

Grass growth during week one to seven of the experiment was severely restricted due to increased soil moisture deficit. This resulted in increased neutral detergent fibre (NDF), indigestible NDF (uNDF) and reduced crude protein in the pasture offered compared to typical mid-season pasture composition (Figure 1). During week eight, drought conditions

were alleviated. Total DMI of cows on the Citrus treatment was greatest, as they had 2 kg/day greater DMI compared to PRG only (Table 1) cows. Although greater DMI was achieved on the Citrus treatment, milk solids production was greater for the treatments that included heat treated soybean meal compared to PRG suggesting that, under the conditions experienced during this experiment, i.e. severe drought, metabolisable protein might have limited milk solids production rather than metabolisable energy. A greater response to supplement was achieved for the TSBM than the Citrus treatment (2.25 and 0.44 kg milk/kg concentrate, respectively) as the citrus was offered at a higher rate.



Figure 1. Weekly indigestible neutral detergent fibre (uNDF) and crude protein content of midseason perennial ryegrass offered over 10-weeks

Table 1. Effects of concentrate type on dry matter intake and milk production of mid- lactation dairy cows grazing PRG					
Item	PRG ¹	Citrus	TSBM	Mix	
Pasture intake (kg DM/day)	15.6	12.8	15.3	13.8	
Supplement intake (kg DM/day)	0	4.8	0.8	3.1	
Total intake (kg DM/day)	15.6	17.6	16.1	16.9	
Milk production (kg day)	18.5	20.6	20.3	21.3	
Crude protein (g/kg)	33.9	33.0	34.7	33.7	
Milk solids production (kg/day)	1.41	1.49	1.55	1.59	

¹PRG = perennial ryegrass, Citrus = perennial ryegrass + citrus pulp + urea, TSBM = perennial ryegrass + heat treated soybean meal, Mix = perennial ryegrass + citrus pulp + heat treated soybean meal

Conclusions

The severe soil moisture deficit in 2018 significantly altered the chemical composition of the pasture offered. Encouragingly, in weeks eight to ten, when sward chemical composition returned to typical values, heated treated soybean still outperformed PRG. The data generated is a future resource for when the industry is faced with similar drought conditions. These findings indicate that it is critical to understand the chemical composition of the pasture available in order to supplement effectively and meet animal requirements.

Effects of feeding barley grain on dry matter intake and apparent total tract digestibility of mid-lactation dairy cattle fed pasture-based diets

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Summary

- Energy intake, due to the low amount of starch, is typically cited as the first limiting factor to milk solids production in pasture-based diets.
- In this experiment, barley grain supplementation caused a large substitution effect and reduced apparent total tract digestibility of dry matter and neutral detergent fibre.
- The lack of milk response and a high substitution of perennial ryegrass for barley grain suggests that under these experimental conditions, energy supply might not have been the limiting factor of the pasture only diet.

Introduction

The population of the world is projected to surpass 9.6 billion by 2050. With this growth trajectory, humankind will have to produce the same amount of food in the next 50 years as has been produced to date. In temperate regions, pasture-based diets are an important source of nutrients for the production of animal products and an appropriate and beneficial use of the resource. Whilst well-managed pasture is highly digestible, energy intake is typically reported as first limiting milk solids production. There is a large amount of research investigating the effect of providing energy dense supplements to grazing dairy cows however, wide variation in milk response and substitution effects exist with little explanation of how or why different responses to these supplements occur. Therefore, more data on ruminal digestion kinetics and nutrient flows are required to understand these variable outcomes. This will help determine how to complement and further capitalise on highly digestible, nutrient dense grass swards.

Experimental design

A study was conducted to evaluate the effects of barley grain supplementation on milk production, rumen metabolism, and omasal flow of nutrients in lactating dairy cattle fed mechanically cut fresh perennial ryegrass indoors. The techniques implemented in this experiment, such as rumen evacuations and omasal sampling, provide the ability to quantify the digestion and metabolism of feed by the microbial population in the cow's rumen. This paper will focus on the intake and apparent total tract digestibility (TTD) outcomes of dry matter (DM) and Neutral Detergent Fibre (aNDFom). Ten ruminally cannulated Holstein cows averaging 70 DIM and 513 kg BW were assigned to one of two treatments in a switchback design. Treatments were (on a DM basis) 100% perennial ryegrass (PRG) or 80% PRG and 20% rolled barley (PRG+B). Swards of PRG were cut twice and offered across six meals daily with barley grain being fed at milking as two equal meals. The trial consisted of three 29 day periods where each period consisted of 21 days of diet adaptation and eight days of data and sample collection. Faecal samples were collected during three eight-hour intervals on day 24, 26 and 27 to encompass every two hours of a 24 hour cycle. Apparent total-tract digestibility of DM and aNDFom was determined using

the faecal composite with indigestible NDF (uNDF) as an internal marker. Daily dry matter intake (DMI) was determined by weighing the feed offered and refused with samples being analysed daily for DM content.

Results

Supplementation with barley grain reduced PRG intake (Table 1) resulting in a substitution of PRG for barley (0.88 kg/kg), however, treatment did not affect total DMI. Apparent TTD of DM and aNDFom were reduced when cows were supplemented with barley grain (Table 1). The reductions in TTD are in agreement with previous experiments. However, this reduction is typically offset by an increase in total DMI, which was not achieved in this experiment. It has been suggested that when fermentable carbohydrates are fed to cows on pasture-based diets, rumen pH and the ability of the microbial population in the rumen to digest fibre can be reduced. In this experiment, barley starch digestibility was high (98% starch TTD). The concentration of uNDF was higher in the barley grain compared with PRG (6.3% v 3.5% uNDF (% DM) respectively) as the grain contained hull material, which might have also contributed to the reduction in TTD. Energy corrected milk was not effected by treatment (24.5 vs. 24. kg/cow per day for PRG and PRG+B, respectively).

Table 1. Effects of barley grain on intake and apparent total tract digestibility (TTD)in lactating dairy cattle fed pasture-based dietsItemPRGPRG + B

Item	PKG	PRG + B
Pasture intake (kg DM/day)	15.94	13.02
Barley intake (kg DM/day)	-	3.32
Total intake (kg DM/day)	15.94	16.34
Apparent TTDMD ¹ (g/g)	0.83	0.80
Apparent TTaNDFomD² (g/g)	0.83	0.75

¹TTDMD = total tract dry matter digestibility ²TTaNDFomD = total tract aNDFom digestibility

Conclusions

Despite providing energy dense barley grain to cows fed a pasture-based diet, the lack of milk response and a high substitution effect suggests that energy supply might not have been the limiting factor for milk production. Reductions in TTD of DM and aNDFom might have been caused due to an altered rumen environment, low rumen nitrogen content for microbial growth, changes in the animal's microbial population or due to a greater contribution of uNDF in the barley grain supplement. Sample analysis is on-going to provide a more complete understanding of the biological mechanisms involved in these experimental outcomes.

Making enough quality grass silage for dairy systems

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Summary

- Target grass silage dry matter digestibility (DMD) of at least 68–70% for spring calving dry cows, and 72–74% for milking cows and young stock. Winter milk herds should aim for >75% DMD silage for fresh calved cows.
- Growth stage at cutting and sward condition at closing are the main determinants of silage DMD.
- Ensure good soil fertility status and adequate spring nitrogen application to maximise silage yields at target quality.
- Manage silage ground for high total annual dry matter yield per hectare rather than yield from an individual cut.

Making quality silage

Grass silage makes up around a quarter of the annual feed budget on the average dairy farm. Where land type is heavy and/or dairy grazing stocking rates are high (>3.6 cows/ ha milking platform), this could be closer to one third of annual feed intake. It is essential then, to have a plan in place to meet silage yield and quality targets. A good management plan will deliver on the three main objectives for quality silage:

- Good dry matter (DM) yield for the first and subsequent silage cuts with high annual grass tonnage per hectare.
- A clean, well-preserved silage with good palatability and minimal waste.
- The appropriate quality (DMD) for the type of stock to be fed.

Achieving high annual DM yield/ha and good crop preservation are consistent aims across all farming systems. Optimum DMD will vary depending on the type of animals to be fed, e.g. dry cows vs. milking cows. Table 1 outlines typical quality targets and corresponding expected DM yields for first cut silage crops. Differences in yield due to cutting date will generally be offset by heavier second cut crops on swards cut earlier for first cut. In some circumstances (e.g. silage-only land blocks), earlier cutting will also facilitate a third cut in late August, further boosting total annual silage production.

Table 1. Guideline grass silage DMD for different classes of dairy stock						
	Dry cows	Spring cows in milk	Growing heifers	Winter cows in milk		
DMD %	68–70	72	72	75		
Typical 1 st cut date	Early June (or 2 nd Cut)	Late May	Late May	Mid May		
1 st cut yield (t DM/ha)	5.5 to 6.0	5.0 to 5.5	5.0 to 5.5	5.0*		

*Assuming grazed in late autumn not in spring

Recent Teagasc surveys of silage quality have shown that national average DMD on dairy farms stands at 66% (DMD range 58% to 78%). This is comparable to silage quality survey results from the mid-1980's and shows that the average silage DMD remains sub-optimal for any class of dairy stock. It is often argued that spring-calving pasture-focussed systems feed silage mostly to dry cows, and therefore do not require significant stocks of quality feed. However, in a typical spring calving system stocked at 2.5 to 2.8 cows/ha, up to 50% of total silage will be consumed by milking cows. This will increase for farms at higher stocking rates, or farms operating on heavy land. Furthermore, all youngstock silage and 100% of recommended silage weather reserve (>500 kg DM/cow) should be of good quality. This highlights a requirement to put renewed focus on silage quality as well as quantity. In any case, the management practices that maximise annual forage DM yield/ha will also deliver better DMD so these objectives can be considered as complementary.

Key silage management practices are:

- Identify how much high DMD silage is needed for the system. Calculate the minimum area (1st and subsequent cuts) needed to produce this silage. Set a target cutting date. Use all remaining silage area to produce standard quality material.
- Soil test silage area every two years. Soil fertility limits silage DMD on many farms by slowing growth rates and delaying harvest date beyond heading date. Ensure adequate soil pH, P and K status.
- Apply adequate P and K to ensure grass is ready for cutting by late May. A 5 t DM/ha first cut crop requires approximately 100 kg K/ha and 20 kg P/ha to meet off-takes alone. Index 1 and 2 soils will require more for nutrient build-up later in the season. Apply sufficient N (125 kg/ha) to drive first cut yield, plus sulphur (12–15 kg/ha) where required.
- Remove dead material from the sward by grazing tight in early spring or in late autumn (for external land blocks).
- Understand that DMD drops quite rapidly once grass reaches heading date (1 to 1.5 units every three days). The crop must be harvested within 4–5 days of seed head emergence to achieve 70% DMD silage.
- A rule-of-thumb is that grass uses up two units of N (2.5 kg) per day. Fertilizer N should be applied approximately 50 days before planned cutting date. However, the crop may be harvested sooner depending on nitrate and sugar levels. Test the crop rather than delaying cutting based solely on the '2-unit rule'.
- Wilt grass to >28% DM to aid preservation if nitrate readings are high. Tedding out grass for 24 hours in dry conditions is recommended.
- Fill and seal pits rapidly and completely. Monitor pit covers and bale plastic regularly through the summer.
- Up to 10% losses are possible at feed-out. Maintain a tidy, cleanly cut pit face. Narrow pits work best to manage losses.
- Reseed silage swards using high performance perennial ryegrass varieties.

Assessing and managing fodder stocks on dairy farms

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Summary

- Design a winter feed plan to assess how much silage you require.
- Continuously assess fodder stocks over the winter period.
- Good management practices prevent costly ensilage losses.

Calculating silage requirement

Preventing a fodder shortage requires forward planning and calculation of how much fodder is needed for the winter period. When constructing a winter feed plan there are a number of items to consider. Firstly, we must determine the amount and quality of silage required on the farm. Typically animals with the greatest level of performance require the highest quality feed (72–74 DMD for young stock and milking cows). Silage required can be estimated from stock numbers, the expected duration of the winter and the dry matter (DM) intake per animal, as shown in Table 1. Secondly, our aim is to calculate how much herbage needs to be harvested to produce the required yield, as shown in Figure 1. Mark out this area on a farm map and have a planned cutting date. Any remaining silage production can be managed to produce dry cow silage (68 DMD). If the silage cannot be produced from a single cut, there is a need to calculate an area required for further harvesting i.e. a second cut.

Measuring fodder stocks

Measuring fodder stocks in situ on farm is important to allow for correct assessment and management of supply. Typically silage is measured in tonnes fresh weight before being converted to DM. To calculate the tonnage of a silage pit, multiply the length by breadth by height to get volume in m³. The volume is then divided by 1.35 to give the tonnes equivalent at 22% DM. Obviously, with modern ensiling practices, DM targets are greater than 22% so adjustments can be made for density in drier silages, i.e. for 28% DM silage divide by 1.5 instead of 1.35 to give the tonnes of silage available. Silage bale weights have increased over the past decade. Recent appraisal of bale weights would indicate that silage bales are 800–900 kg fwt or 200 to 260 kg DM. A 220 kg DM bale is equivalent to one tonne of pit silage at 22% DM. For example a single bale will feed 20 dry cows for a day.

Preserving silage and minimising losses

Silage quality and quantity losses occur during ensiling. For every 1,000 kg grass DM in a silage sward, between 150 and 300 kg of losses can occur. Furthermore, the DMD of ingested silage can be 0–7% units below the cut sward. These losses occur in the field (leaf shatter, incomplete pick-up, etc.), at the silo (respiration losses, effluent, etc.) and in the feed trough (respiration, spillage, etc.). Some losses are unavoidable but others can be reduced or prevented. For example, a sward yielding 6,000 kg DM/ha produces 5,040, 4,620 and 4,200 kg edible silage DM/ha where losses of 16% (excellent management), 23% (good management) and 30% (poor management) occur, with quality decline of 0, 1.5 and 4% units DMD, respectively. The yield loss difference between 16 and 30% DM loss results in over 80 fewer animal feed days/ha. The DMD loss difference of 0 vs. 4% units DMD requires over 1 kg concentrate/animal daily to compensate. Thus, DM losses of 16, 23 and 30% (+ DMD loss) result in costs of \in 207, \in 230 and \in 263, respectively, to provide cows with the

same feed energy as silage. This shows the importance of reducing silage losses. Efficient mowing and pick-up, effective wilting, fast filling and perfect sealing of the silo, ensuring good fermentation and relatively little effluent, fast and tidy feed-out, and sensible feed provision and waste removal at the feed trough can all help minimise losses.

Table 1. Establishing winter feed requirements for dairy females						
Stock	Winter feed required per month (tonnes)	No. of animals	No. of months	Feed required (tonnes)		
Cows	1.6					
0–1 year old	0.7					
1–2 year old	1.3					
Total (normal winter)						
Additional feed						
New total required						

Winter	feed plan
Stock	108 spring calving dairy cows, 26 weanling heifers and two bulls
Land	44 ha dairy grazing, 12 ha out-farm
1.	Good quality silage 72–74 DMD > milking cows + weanling heifers
2.	108 cows @ 400 kg DM = 43.5 t DM 26 heifers for 150 days @ 5.5 kg DM = 21.5 t DM Total = 65 t DM of 74 DMD silage
3.	Require 14 ha @ 4.5 t DM for high quality silage Close outside block (12 ha) plus 12 ha milking block for silage Bale 7 ha of closed milking block area on May 20 th (35 t quality silage) Target 130 bales from grass surpluses Jun-Aug (30 t quality silage)
4.	Standard silage - 68 DMD for dry cows in good condition, stock bulls
5.	110 (dry cows plus bulls) * 125 days* 11 kg DM = 151 t DM
6.	17 ha (12 ha outside block plus 5 ha) cut in early June at 7.5 t DM = 127 t DM Close 7 ha of outside block for 2 nd cut silage in late July = 35 t DM

Figure 1. A proposed example of a winter feed plan

Conclusions

Unforeseen circumstances can often arise which increase the predicted length of the winter feeding period. Therefore, plan early in the grazing season by calculating your expected animal numbers and their requirements for the winter ahead, while ensuring good management practices are followed during preservation.

Securing a reserve of quality forage on dairy farms

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Summary

- Optimally stocked dairy farms match feed demand to annual pasture growth, allowing at least 5.5 t DM grass growth per cow equivalent on the whole farm. Overstocked farms are most at risk of forage shortages, not heavily stocked farms *per se*.
- Adverse weather effects on dairy farms can be mitigated by securing a forage reserve of 500–800 kg DM/cow, depending on the potential extent of weather impact. Good storage facilities are required.
- Forage reserves typically cost €150–210/t DM depending on yield and other factors. Though expensive to build, feed reserves improve system security and add to farm stock inventory value.

Introduction

Adverse weather has always been understood as more an inevitability than a risk in farming. Nonetheless each recurrence of prolonged poor weather brings acute challenges to workload, grazing management, feed supplies and costs. As the structure of dairy farming in Ireland moves to increased herd scale, there is a growing need for better contingency for such weather events. Having good grazing infrastructure and appropriate facilities are clear strategies to improve resilience. Equally important but less readily defined perhaps, are the questions of optimal stocking rate and adequate feed reserves. These have come under renewed focus in recent seasons due to various weather-related forage supply issues.

Defining optimum stocking rate

Calculating stocking rate (SR) as simply livestock units (LU) per ha has obvious limitations as a management metric, because it takes no account of variation in feed supply (annual pasture growth per ha) or demand (feed intake per cow). The situation is further complicated where dairy herd expansion on a limited milking platform results in a progressive displacement of silage production and greater dependence on external land blocks to balance silage budgets. This is illustrated in Table 1. As herds expand in these circumstances, there may be greater disparity between milking platform SR and wholefarm SR.

Table 1. Effect of grazing stocking rate on feed budget per cow							
Food por cour		Milking platform ¹ stocking rate (cows/ha)					
	2.2	2.5	2.8	3.1	3.4	3.8	4.2
Silage made kg DM	2,000	1,490	1,100	790	540	179	140
Silage balance kg DM 598 82 -306 -658 -1,023 -1,414 -1,538							-1,538
Concentrate kg	670	720	810	950	1,041	1,159	1,320

¹Assuming 15.5 t DM grown per ha; budgets change depending on annual growth

Nonetheless, a useful guideline is that a typical dairy cow fed 0.5 t concentrate annually requires at least 5.5 tonnes DM grass grown to meet total forage (grass plus silage) demand.

Mean (2014–17) annual tonnage recorded by dairy farms on PastureBase Ireland was 13.9 t DM/ha, capable of supporting 2.52 LU per farm ha. The bottom 10% of farms recorded 10.2 t DM/ha growth, or a potential farm SR of 1.82 LU/ha. Stocking the farm in excess of 5-year average growth capacity creates reliance on bought-in feed, even before allowance is made for weather shocks.

Building forage reserves-costs and options

Optimising SR creates a long-term balance between forage utilisation and controlling feed cost. A separate provision is needed to insulate against poor growth conditions within year however. The cumulative effect of weather events in 2018 was a grass growth reduction of almost 3.0 t DM/ha in the worst affected regions. This is an estimated 1 t DM deficit/cow, which is instructive as to potential scale of reserves required for future events. A practical guideline would be to carry at least 50–80% of this figure (500–800 kg DM/cow) as feed surplus above the normal stocks needed to balance the system. This would be built up over time and vary with degree of risk per farm. Some key considerations are:

- Increasing forage grown per ha currently farmed is usually the cheapest means of building forage reserves. This is a priority.
- Typical market cost of purchased forage options is €150–210/ t DM for grass silage, wholecrop and maize silage.
- Yield variation has a huge effect on unit feed cost. (Table 2). Buy single-cut crops on a DM yield rather than per ha basis.
- Forage reserves by definition will be fed to fill pasture deficits 100% of stocks should be of high feed quality.
- Feed quality (energy, protein, and digestibility) varies greatly within crop types set minimum criteria before purchase.
- Seek to establish feed reserves in good growth years. This has the dual benefit of better quality crops and reduced market cost.

Table 2. Wholecrop silage yield and cost per ha versus feed cost per t DM								
Field cost per ha Feed cost per								
€1,970 (€800/acre)	10 5	€158						
€2,470 (€1,000/acre)	12.5	€198						
€1,970 (€800/acre)	0.5	€207						
€2,470 (€1,000/acre)	9.5	€260						

• Good facilities are essential for longer term forage storage.

Establishing feed reserves does not come cheap. At recommended volumes and moderate costs of $\in 160-180$ /t DM, herds would need to invest $\in 80-120$ /cow for no increase in milk revenue. However unlike purchased feed utilised within-year, the reserve is retained as inventory and so is largely profit-neutral. Finally, the cost of building a feed reserve highlights a need to closely examine the economics of increasing herd scale based on conserved forage and concentrates.

The effect of supplementation type on animal performance in mid lactation during periods of reduced pasture growth

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Summary

- Supplementation feed choice has an effect on animal performance during drought periods.
- Soya hulls had similar production responses compared to concentrate alone.
- Palm kernel and beet pulp did not maintain milk production.
- Feed cost and animal responses must be consider when selecting feed supplementation choice.

Introduction

Due to the seasonal growth pattern of perennial ryegrass, there is little grass growth during late autumn and early spring resulting in increased levels of supplementation to grazing animals. In summer (mid-April to September), when grass growth exceeds feed demand, grazed grass makes up the majority of the animals diet, however, concentrate supplementation may be required during periods of reduced grass growth. Typically, concentrates offered to dairy cows are in the form of cereal grains and residues of oilseed crops. By-products, secondary products obtained during harvest or processing of a principal commodity can also be used as a substitute to expensive cereal based concentrates to meet animal requirements and reduce supplementation costs. The use of by-products for ruminant feeding has increased substantially in recent years in Ireland. Soya hulls imports have increased three-fold and palm kernel expeller (PKE) doubled since 2008 with beet pulp increasing by 60% since 2012.

Drought feeding research in Moorepark 2018

In July 2018, a grazing experiment was established at Teagasc Moorepark examining feed type fed to lactating dairy cows in mid-lactation in a sustained period of reduced grass growth. The objective of the study was to evaluate the effect of supplementation choice on animal performance to spring calving dairy cows during a prolonged herbage deficit in mid-late lactation. Four feeding systems were compared over the eight week period; palm kernel (PKE), soya hulls (SOYA), beet pulp (BEET) and parlour concentrate (CONC) (Table 1). Cows were fed the additional supplement (+4 kg DM/day) after morning milking in individual feeders in addition to 2 kg DM/day of concentrate at milking. Grass silage and grass allocations were similar on all treatments.

Feed type had an effect on animal performance, the CONC and SOYA treatments had the greatest milk yield (22.0 and 21.5 kg/day) and milk solids (1.77 and 1.74 kg/day) production followed by the BEET (20.6 and 1.62 kg/day) and PKE the lowest (19.1 and 1.59 kg/day) treatments. Feeding PKE did however increase fat content but it had a negative effect on milk protein content (Table 2). The large differences in animal performance can be somewhat explained by feeding value, as PKE had the lowest OMD and greatest ADF and NDF content.

Table 1. Concentrate feed allocation and forage allowance (grazed grass an	d grass
silage) offered daily	

Group	Concentrate allowance (kg/cow/day)	Additional supplement allowance (kg/cow/day)	Grass silage allowance (kg/cow/day)	Grazed grass allowance (kg/cow/day)
Palm kernel	2	4	5	6
Soya hulls	2	4	5	6
Beet pulp	2	4	5	6
Concentrate	6	0	5	6

Table 2. The effect of concentrate supplementation [molassed beet pulp, soya hulls and palm kernel expeller] on milk production and milk composition

	Beet pulp	Soya hulls	Palm kernel	Parlour concentrate
Milk yield (kg/cow/day)	20.6	21.5	19.1	22.04
Fat %	4.47	4.70	4.77	4.58
Protein %	3.57	3.56	3.45	3.65
Milk solids yield (kg/ cow/day)	1.62	1.74	1.59	1.77
Body weight (kg)	512	505	517	515
Body condition score	2.90	2.95	2.85	2.98

Conclusions

Feeding palm kernel and beet pulp as a supplementation feed choice during a drought were not sufficient to maintain milk production when compared to parlour concentrate and soya hulls. At the time of the experiment, feed cost was similar for palm kernel, beet pulp and soya hulls (*circa* ϵ 220–250/t), however parlour concentrate was more expensive (ϵ 310/t). Careful consideration must be given when selecting supplements based on feed cost, feeding method and animal production responses.



Grassland and carbon sequestration

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Summary

- Grasslands in Europe act as a carbon sink and grazing systems are important for carbon storage.
- Carbon sequestration in grassland is influenced by many management factors.
- Sequestration can have benefits for both the atmosphere and farmer.

Introduction

Ireland has the largest proportion of land under grassland in Europe at 56.3%. This compares with an EU average grassland cover of 20.7%. The potential of grasslands as a carbon (C) sink is large. The livestock sector is responsible for approximately 14.5% of all anthropogenic greenhouses gas emissions worldwide. However grassland soils have the ability to sequester C and thereby partly offset C emissions.

What is carbon sequestration?

Carbon sequestration is a natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form. Grasslands can absorb carbon dioxide (CO_2) during growth of grass plants and store it in different tissues. Above ground biomass is eaten by grazing animals and the C will eventually return to the soil as manure or to the atmosphere via enteric fermentation. The remaining grass and roots will eventually decompose and the C will then be stored in the soil.

Why is carbon sequestration important for farmers?

Soil carbon storage (SOC) is of interest to all due to the role it can play in removing CO₂ from the atmosphere. However grazing practices that favour SOC have benefits for farmers apart from carbon sequestration. These benefits include increasing the quality of the soil (soils with high C generally have better soil structure, water holding capacity and provide more nutrients), reduction in on-farm costs and added value of the final product.

What techniques impact on grassland carbon sequestration?

Studies have suggested that grassland soils can potentially act as significant C sinks. Land management practices can enable sequestration. Some examples of these possible management techniques to increase C sequestration include:

- Grazed pastures may sequester more C than grasslands used for silage or hay production, due to the recycling of organic matter and nutrients from faeces and plant residues.
- Improve fertiliser management. Combine liming treatments with nutrient fertilisation.
- Increase the time between re-seeding to at least five years, as this will contribute to organic matter build up Cultivating the sward can result in soil disturbance resulting in C release.
- Ensure good grazing infrastructure this will lead to less grassland damage and less frequent reseeding.
- Marinating permanent grassland and increasing the area of long term grassland by minimising short leys, maize and arable cropping can increase C sequestration.

• Managing grasslands for high plant diversity can enhance soil organic C. Increasing species in some grass swards can improve sequestration and reduce inorganic N inputs.

It is important to note that the effect of these management practices can depend on many factors including soil type, current soil C content, climate etc.

Conclusions

Different land management practices are potentially a tool to enable sequestration of atmospheric carbon into soils. The potential of grasslands as a sink for carbon in Europe is large.

Acknowledgement

NEFERTITI is an EU horizon 2020 project aiming to networking European farms to enhance cross fertilisation and innovation uptake through demonstration. 10 themes are addressed with one being Grassland and Carbon Sequestration. Register on https://nefertiti-h2020. eu/ keep up-to-date with the project and demonstration events that will be ran in your region!



Appendix 1. 2019 Grass Recommended List Varieties									
			Pastui	e Profit	Index	Values	€/ha/ye	ar	
	Total	Sub-Indices							
Variety Name	Ploidy	Heading Date	Idd	Spring	Summer	Autumn	Quality	Silage	Persist.
Abergain	Т	4-Jun	214	37	40	43	56	37	0
Aberclyde	Т	25-May	205	54	43	34	44	30	0
Abermagic	D	29-May	197	44	46	70	19	17	0
Nifty	D	27-May	193	80	50	57	-23	29	0
Fintona	Т	22-May	191	73	23	43	12	40	0
Aberchoice	D	9-Jun	189	32	45	51	47	15	0
Moira	D	24-May	187	118	21	49	-30	29	0
Abergreen	D	31-May	182	58	52	62	4	6	0
Aberplentiful	Т	8-Jun	182	57	44	42	17	22	0
Elysium	Т	25-May	171	73	30	26	19	22	0
Dunluce	Т	29-May	170	31	39	45	25	31	0
Aberwolf	D	29-May	169	65	33	34	14	23	0
Meiduno	Т	3-Jun	167	55	39	41	16	22	-5
Astonconqueror	D	25-May	165	79	29	34	-4	27	0
Gusto	D	30-May	161	67	31	55	15	-7	0
Briant	Т	3-Jun	157	37	39	39	19	24	0
Rosetta	D	23-May	156	85	25	40	-16	22	0
Seagoe	Т	26-May	155	45	35	36	-1	40	0
Aberbite	Т	1-Jun	154	10	38	44	39	34	-11
Ballintoy	Т	2-Jun	150	31	35	35	22	28	0
Triwarwic	Т	2-Jun	139	42	34	23	13	27	0
Kintyre	Т	6-Jun	134	25	33	50	5	22	0
Astonenergy	Т	2-Jun	132	9	30	36	48	10	0
Solas	Т	10-Jun	131	16	31	50	10	24	0
Xenon	Т	8-Jun	128	18	31	30	29	20	0
Aspect	Т	6-Jun	124	20	32	24	32	16	0
Oakpark	D	2-Jun	118	34	30	33	-8	28	0
Drumbo	D	7-Jun	117	29	27	34	24	3	0
Astonking	D	5-Jun	116	64	28	22	-15	17	0
Alfonso	Т	1-Jun	113	7	30	34	34	8	0
Smile	D	5-Jun	101	24	25	43	-6	14	0
Kerry	D	2-Jun	98	42	31	35	-23	13	0
Glenroyal	D	4-Jun	96	25	32	40	-11	12	0
Clanrye	D	6-Jun	68	27	31	15	-30	25	0
Majestic	D	1-Jun	66	35	26	36	-38	7	0

SUSTAINABLE MILK PRODUCTION SYSTEMS



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Optimising stocking rate and calving date in grass-based production systems

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Summary

- Stocking rate is the main driver of productivity in grass-based systems and should be matched to the grass growth capability of the farm.
- Calving date will affect the length of lactation and the requirement for supplementation and mean calving date for most Irish dairy farms should be in the range of 15th February to the 2nd March depending on farm characteristics.
- Highly stocked compact calving herds may benefit from delaying calving to reduce supplementation requirements.

Introduction

Within grass-based dairy production systems, achieving high levels of milk production from grazed grass with minimal supplementation occurs when the appropriate mean calving date and distribution of calving is achieved in conjunction with the optimum stocking rate ((cows/ha); SR) to align feed supply to herd demand. Careful consideration needs to be given to the appropriate SR and calving date (CD) for individual farms as changes to one or both will have implications on the productivity and profitability of the farm.

Stocking rate

Stocking rate is acknowledged as the main driver of productivity in grazing systems. The ideal SR should balance the available feed supply (grass grown plus supplements used) and overall herd demand (number of cows needed to eat the grass grown). Therefore, the overall SR of a farm should be closely aligned to the individual farms grass growth capability. Stocking rate will vary from farm to farm depending on soil type, grass growth, milking platform area, if there are other animals grazing on the milking platform, outside blocks of land available for silage making and the amount of supplement fed/bought in. In Table 1, the optimum SR for farms that produce different amounts of grass and feed different amounts of supplement are defined. For example, if a farm can grow 10 t DM/ ha of grass on average and the system involves feeding 0.5 t supplement DM/cow, the SR should be 1.8 cows/ha. In comparison, a farm capable of growing 16 t DM/ha and feeding 0.5 t concentrate DM/cow should be stocked at 3.0 cows/ha.

Calving date

Calving date is an important factor in grass-based milk production systems and influences both milk production and the requirement for supplementation at grazing. In general, the herd should be calved as early as possible, provided that it can be fed adequately from a predominantly grazed grass diet during lactation. Research in Moorepark has shown (across three SR) that delaying calving by 15 days in spring (i.e. the 15th February vs. the 2nd of March) results in less concentrate and silage being fed during lactation to the late calving treatments compared to the early calving treatments (Table 2). Lactation length was reduced but there was no difference in total milk yield (or milk solids yield), as daily milk yield was higher for the late calving treatments. Delaying calving led to reduced grass utilisation as insufficient numbers of animals were available to meet spring grazing targets (particularly achieving 30% area grazed in February).

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

Table 2. Effect of calving date on milk production variables ¹							
Early calving Late calving							
Mean calving date	15 th February	2 nd March					
Concentrate fed (kg DM/cow)	425	376					
Silage fed (kg DM/cow)	200	137					
Milk yield (kg/cow/day)	18.7	19.9					
Milk yield (kg/cow)	5,452	5,514					
Milk solids (kg/cow)	430	431					
Lactation length	291	277					

¹Each calving date was assessed at 2.5, 2.9 and 3.3 cows/ha

Stocking rate and calving date interaction

In the research presented above there was no interaction between CD and SR for any of the milk production variables examined. However, in recent years, some farmers have chosen to delay calving because of higher SR and more compact calving patterns. This may suit highly stocked farms with very compact calving patterns as it will shorten the interval to magic day and reduce the requirement for supplementation in spring but will also shorten lactation length.

Conclusions

While there is no ideal SR or mean calving date that will be appropriate to every farm (due to differences in soil type, grass growth rates etc.), a SR that matches the grass growth capability of the farm and a mean calving date of 15th February to 2nd March appears to be generally appropriate for most Irish dairy farms. Therefore, the start of calving should be approximately 50–60 days before magic day to ensure that cows are fed a predominantly grass-based diet with minimal levels of supplementation.

Stocking rate — how important is it? Kevin Macdonald

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Summary

- Stocking rate is important for efficient pasture utilisation, but how the system is managed is just as important.
- There needs to be an appropriate set of farm management decision rules to optimise profit.
- Use of decision support tools can be used to determine the appropriate stocking rate for any farm.
- Be aware of present and future environmental issues that may place limitations on your system.

Introduction

The efficiency of milk production from pasture is a function of annual pasture production, pasture utilisation, and the efficiency of milk solids (MS) production per cow. Annual pasture production (or feed on farm) determines the total amount of feed energy available for animal maintenance, growth and milk production. If attempting to determine an appropriate stocking rate (SR) for any farm, pasture growth patterns and feed demand need to be determined.

Important factors to consider for your farm

Pasture eaten per hais obviously an important component of successful farm management, but it is often forgotten in an attempt to maximise per cow intake. The amount of pasture eaten is also dependent on the weather due to variations in seasonal pasture growth and the amount that can be utilised by the cow. The amount and distribution of pasture production is driven by several factors such as climate, soil type, soil fertility and management. Within Ireland, there is a large variation in daily pasture growth between and within years. To manage seasonal variation requires planning, the appropriate infrastructure on the farm and a set of decision rules that govern pasture management to achieve the critical factors for a sustainable system which are, average pasture cover (APC) and cow body condition score (BCS) at turnout and BCS at mating. Importantly, the effects of shortfalls in these are greater as SR increases.

The decision rules need to achieve target levels of APC for different seasons of the year. As rotation length is a key driver of APC and post-grazing residuals, there needs to be rules on rotation length, especially for high stocked farms. On a low-stocked farm, a fast rotation may be used to reduce pasture growth to match feed supply while, on a high-stocked farm, a slower rotation length should be used to maximise growth rates, e.g. rotation length never faster than 21 days. The risks for any farm system need to be identified and minimised by applying the appropriate decision rules. When to make silage out of surplus pasture is also critical to the success of any farm operation. Knowing what pasture growth is, will allow timely and efficient silage harvesting and confidence in removing areas for conservation. Along with decision rules, the use of decision support programs such as PastureBase Ireland can be invaluable. For a farming system to be sustainable, there needs to be a set of management rules to ensure that negative effects from one season are not carried through to the next. These rules ensure that production between years is stable and that there are no carry-over effects from one year to the next. Attaining a BCS of 3.25

at calving is an important component of this. Having compact calving is dependent on successful mating which will only occur with appropriate management at mating time.

Planning

Planning is an important aspect of wet weather management. Wet weather and poor drainage of soils means that plans must be in place to limit soil damage. To ensure there is sufficient pasture on the farm in the spring, poaching of the soil must be minimised. At turnout, there needs to be a wedge of feed ahead of the herd and not a large bank which is unmanageable because all the pasture is ready for grazing at once. Therefore, some paddocks will have been closed for too long and the quality of the subsequent feed available is compromised. Also, when pasture is closed for too long a period, regrowth is slowed (canopy closure) and the farm can go very quickly from a feed surplus to a deficit. This is particularly so if the calving spread is not compact.

Increasing attention, both locally and internationally, is being focussed on the sustainability of modern agricultural production systems, including Ireland's dairy industry. To ensure Ireland retains its present 'clean green' image, it is essential that you are aware of present and future environmental issues that may place limitations on your system and have plans to overcome or mitigate these. Do not sit back and wait to be forced into doing something. 'Failing to plan is planning to fail.'

Stocking rate has been identified as one of the main drivers in farm profitability in both Ireland and New Zealand. In reporting on early stocking rate trials in New Zealand, McMeekan stated in his book "Grass to Milk," "No more powerful force exists for good or evil than the control of SR in grassland farming. Properly understood and used, it can influence productive efficiency for good more than can any other single controllable factor. Misunderstood and misapplied, it can lead to abuses which may have permanent harmful effects on land use." I believe that the abuses that McMeekan referred to can be eliminated by good planning and appropriate decision rules.

Conclusions

How the dairy farm is operated is just as important as choosing the appropriate SR. This requires a clear set of decision rules, applied with discipline, to ensure pasture is efficiently utilised and cows are well managed.



The effect of grazing platform stocking rate on farm profit

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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 stocking rate from 3.1–4.5 cows/ha and importing additional supplementary feeds reduces farm profitability at low and medium milk prices with only marginal economic benefits at higher milk price.
- The results reinforce the necessity for pasture-based dairy farmers to improve pasture productivity to provide additional home grown feed 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 well become a major stumbling block for many dairy 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 can be achieved. The objective of a 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 within grazing systems.

Treatments and Results

Physical performance data 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 ha, reproductive performance and requirement for externally sourced feed supplements. Two grazing platform stocking rate (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).

Output per ha was increased considerably by increasing GPSR from 3.1–4.5 cows/ha. However this increase in productivity was driven solely by imported silage and concentrate feed. Grass growth and grass utilisation were the same for both systems. The economic implications of the various treatments were also evaluated (Table 2).

Table 1. Effect of grazing platform feed system¹ 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				
Purchased feeds, kg DM ha 1 year 1						
Silage	1,917	5,796				
Concentrate	1,708	3,924				
Milk production performance						
Fat plus protein yield, kg	377	390				
Fat plus protein, kg/ha	1,153	1,786				

¹HCFS = High closed feed system; HOFS = High open feed system

Table 2. The effect of base milk price and pasture productivity on farm system profitability for alternative grazing platform feed systems ¹								
Feed System HOFS 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								

¹HCFS = High closed feed system; HOFS = High open feed system

The results show that increasing SR from 3.1–4.5 cows/ha and importing additional supplementary feeds reduces farm profitability at low and medium milk prices with only marginal economic benefits at higher milk price. 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 ensure that increases in stocking rate are matched by improvements in pasture productivity and utilisation.

Once-a-day milking: Short and long term options to reduce labour

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Summary

- Cows can be milked once-a-day (OAD) for up to eight weeks from the start of lactation without reducing annual milk solids yield.
- OAD milking did not increase somatic cell count.
- Labour was reduced with OAD milking.

Introduction

Recent CSO figures show the number of dairy cows in Ireland has increased to 1.4 million, ICBF have also released six week calving rates for 2018 showing a 6% increase since 2016 (64% in 2018 compared to 58% in 2016). A greater number of cows calving more compactly results in increased workload, particularly during the early spring period. While twice-a-day (TAD) milking is accepted as the standard milking frequency more dairy farmers are challenging this theory. A number of farmers are now investigating the option of once-a-day (OAD) milking throughout the year but also just for a number of weeks at the start of lactation, during the busy calving period. A recent Teagasc Moorepark calf welfare survey conducted on 47 farms in the Munster area during spring 2017 showed that almost 10% of the herds enrolled on the study were milking OAD until the start of March.

Study

In spring 2018, a new programme of work investigating OAD milking commenced at Teagasc Moorepark. The study investigated the effect of short-term OAD milking at the start of lactation on dairy cow production, labour input and animal welfare both during the OAD milking period and also across the entire lactation. The four treatments were i) cows milked OAD for the first four weeks of lactation; ii) cows milked OAD for the first six weeks of lactation; iii) cows milked OAD for the first eight weeks of lactation; and iv) cows milked TAD for the entire lactation. Once cows were finished their respective OAD milking phase they returned to TAD milking for the remainder of lactation.

Results

The results (Table 1) showed that when cows were milked OAD, daily milk solids (MS) production was reduced by 25% (0.47 kg MS/day) for the first 4-weeks. Where cows continued on OAD milking for weeks 5 and 6 of lactation, MS yield was 50% less than the TAD cows that were producing 1.95 kg MS/cow/day during those 2-weeks of lactation. Continuing milking OAD for a further 2-weeks i.e. weeks 7 and 8 of lactation, reduced daily MS yield to 70% of the TAD cows (0.76 vs. 2.46 kg MS/cow per day, respectively). When OAD cows returned to TAD milking, production recovered and MS yield was similar for all treatments across the 35-week lactation period (401 kg/cow).

Table 1. Effect of short-term OAD milking on cumulative milk solids (MS) production							
Cumulative MS yield (kg/cow)	TAD	OAD 4 wks	OAD 6 wks	OAD 8 wks			
1 st 4 weeks	55	44	46	42			
1 st 6 weeks	87	74	73	68			
1 st 8 weeks	117	101	100	90			
1 st 10 weeks	142	124	125	114			
35 weeks	415	405	398	387			

Less labour was required for the OAD herd, in terms of both droving and actual time spent milking. Total daily milking time for the TAD cows was 3.9 mins/cow greater than the OAD cows; it took on average 9.4 mins/cow to milk a cow assigned to an OAD treatment.

Cows enrolled on this study varied greatly in terms of their somatic cell count (SCC); there were cows at both the low and high end of the SCC spectrum. Milking cows OAD did not result in higher SCC, in fact there was no difference between treatments nor was there a difference in the incidence of mastitis, which incidentally was low.

As only 60 cows were assigned to this study it is necessary to repeat it over a number of years to identify differences in SCC, fertility and body condition score. This year, a new experiment was undertaken, however this year the short-term OAD milking treatments were for two, four or six weeks in early lactation; a OAD milking treatment for the entire lactation is also included. This herd (same cows) will be maintained for the next number of years and further investigation will be undertaken.

Conclusions

Once-a-day milking offers farmers a real option to reduce labour requirement during the spring period. Although MS yield was reduced during the OAD milking period, there was no difference in total MS yield at the end of lactation. Somatic cell count was also not different between the treatments. This study will be continued over the coming years to fully monitor the effects of OAD milking on dairy cow production and welfare.



IRISH DAIRYING | GROWING SUSTAINABLY

Financial performance of dairy farms in 2018 George Ramsbottom, Michael O'Donovan and Tom O'Dwyer

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Summary

- Spring milk producers generated a net profit, excluding premia, of €1,559/ha in 2018 according to the Teagasc eProfit monitor results.
- The corresponding figure for winter milk producers was €1,707/ha.
- The combined effects of higher production costs and a lower milk price in 2018 resulted in a reduction in net profit in 2018.

Introduction

A summary of the average physical and financial performance from an analysis of approximately 1,500 dairy farms that completed a Profit Monitor (PM) by the end of April 2019 for the 2018 financial year is presented in Table 1.

Table 1. Physical and fin completed a Profit Monit	ancial perf or for 2018	ormance c 3	of spring a	nd winter	milk produ	icers who		
	Spring milk (N = 1,390)		Winter milk (N = 163)					
Physical								
Herd size (no. cows)	124		143					
Dairy ha	55.1		63.6					
St. rate (LU/ha)1	2.25			2.28				
Pasture used	8.6		8.3					
(t DM/ha)								
	/ha	/cow		/ha	/cow			
Milk yield (litres)	12,843	5,708		14,517	6,367			
Fat (%)		4.25			4.10			
Protein (%)		3.55			3.44			
Milk solids (kg)	1,031	458		1,124	493			
Financial								
	€/ha	€/cow	c/litre	€/ha	€/cow	c/litre		
Gross output	4,711	2,094	36.68	5,351	2,347	36.86		
Co-op price			36.27			36.52		
Variable costs	1,921	854	14.96	2,173	953	14.97		
Gross margin	2,789	1,240	21.72	3,178	1,394	21.89		
Fixed costs	1,230	547	9.58	1,469	644	10.12		
Net profit excl. premia	1 5 5 9	693	12 14	1 707	749	11 76		

Trends in financial performance between 2017 and 2018

Data from a matched sample of 693 spring calving farms that completed Profit Monitor in both 2017 and 2018 is presented in Table 2.

Table 2. Herd size, milk price, production, feed and total costs and net profit for a matched sample of 693 spring calving farms in 2017 and 2018

	2018		2017		Difference (2018–2017)	
Herd size (cows)	137		130		+ 7	
Dairy ha	59		57		+ 2	
St. rate (LU/ha)	2.31		2.29		+ 0.02	
Pasture used (t DM/ha)	8.6		10.9		- 2.3	
	/ha	/cow	/ha	/cow	/ha	/cow
Milk yield (litres)	13,296	5,755	12,754	5,569	+ 542	+ 186
Fat (%)		4.30		4.25		+0.05
Protein (%)		3.57		3.57		0.00
Milk solids (kg)	1,077	466	1,027	448	+ 51	+ 18
	€/ha	€/cow	€/ha	€/cow	€/ha	€/cow
Gross output	4,898	2,120	4,933	2,154	- 34	- 125
Total costs	3,262	1,412	2,650	1,157	613	255
Including feed costs	952	412	529	231	423	181
Net profit	1,636	708	2,283	997	- 648	- 289

While cow numbers increased by 5% (seven cows), this group of farmers reported a 10% increase in total milk solids production (achieved through a combination of increased cow numbers and increased production per cow). Gross output declined because of the decline in milk price between 2017 and 2018. The large increase in feed costs of $+ \in 181/$ cow is reflective of the reduced pasture growth of 2018. The increase in cost of production was greater than the change in gross output. So while feed usage and milk production increased, the net profit declined by 28%.

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. 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.
Characteristics of high profit spring calving dairy farms

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Summary

- High profit spring calving dairy farms are the most technically efficient and also tend to be the most specialised.
- They are consistently the most profitable, irrespective of weather or milk price.
- They exhibit a greater capacity to recover profit following a low milk price or a climatically challenging year (i.e., low pasture growth and utilisation).

Introduction

The profitability of dairying is highly variable between years because of variability in milk price and weather conditions; the latter is particularly pertinent in pasture-based systems. Recent research has focused on the concept of system, 'resilience' or the ability to withstand or mitigate the effects of change.

Farm database used in the study

In the present study, farm physical and financial performance data were extracted for 315 spring calving dairy farmers who were continuous users of the Profit Monitor programme during each of the years 2008–2015, inclusive. The 8-year average whole farm net profit per hectare for each of the farms was generated. Farms were then categorised into highest, second highest, second lowest and lowest net profit per hectare (ha). Summary physical and financial results are presented in Table 1.

Table 1. Eight year average physical and financial results for spring calving dairy farms categorised by eight-year (2008–2015) average whole farm net profit (highest to lowest)

10 10 10 10 10				
	Highest profit	Second highest profit	Second lowest profit	Lowest profit
Number of farms	79	79	79	78
Number of cows	100	103	95	88
Specialisation (dairy LU as a% of total LU)	72	70	66	66
Stocking rate (LU/ha)	2.42	2.28	2.13	1.96
Milk yield (kg MS/cow)	433	412	397	383
Pasture used (t DM/ha)	9.9	9.0	8.3	7.4
Gross output (€/ha)	3,831	3,376	2,978	2,553
Variable costs (€/ha)	1,345	1,279	1,185	1,101
Fixed costs (€/ha)	876	910	858	824
Total costs (€/ha)	2,221	2,189	2,043	1,925
Total Costs/kg MS (€)	2.12	2.33	2.42	2.56
Net profit (€/ha)	1,611	1,189	937	630

The highest profit farms were more specialised, had a greater stocking rate, produced more milk/cow, and had greater pasture utilisation/ha than the other profit categories. They also had the greatest variable costs/ha, but the lowest total cost/kg MS. Importantly, long term averages can hide year to year fluctuation. The annual farm net profit per ha for the four categories of farm in each of the study years is presented in Figure 1.



Figure 1. Annual farm net profit (\in /hectare (ha)) for spring calving dairy farms categorised by 8-year average (2008–2015) whole farm net profit

The year 2009 was one in which milk price was low and rainfall was above average. Farms in all profit categories declined in farm net profit/ha that year; however, those in the highest profit category still had the greatest farm net profit per ha. Their average farm net profit/ha was ϵ 763/ha that year and the following year they had the largest increase in farm net profit/ha (ϵ 743/ha). This recovery was underpinned by a substantial increase in farm gross output/ha between the two years, which varied from ϵ 990/ha to ϵ 545/ha for the highest and lowest profit categories respectively.

Conclusions

The results indicate that low milk prices result in a comparably greater reduction in profitability within the highest profit category of dairy farms because of their greater specialisation in dairying. However, farms in this category remained most profitable when milk price was low and climatic conditions limited pasture growth and utilisation and a greater capacity to recover profitability when conditions changed.

Grass-fed Irish milk

Donal O'Brien, Brian Moran and Laurence Shalloo

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Summary

- Grass fed milk is a high value product that some purchasers are willing to pay extra for, provided certain conditions are met e.g. a minimum proportion of grass in a cow's diet.
- A methodology was developed to determine the amount of grass Irish dairy cows consume and deployed at the national scale using the Teagasc national farm survey.
- On average, the approach showed grass (grazed grass and grass silage) represented over 95% of the Irish dairy cow's annual diet as fed over the period 2013–2017.

Introduction

Grass fed milk or "Grassmilk" is rising in popularity in some European and US markets and is reported to fetch a premium price. There is a plethora of grass fed milk claims from different companies, but most provide little detail on the proportion of a cow's diet represented by grass, and therefore, may not actually be advantageous from nutritional, animal welfare and ecological viewpoints. Consumers are beginning to question the current measures of grass fed milk and are increasingly requesting information on the typical quantities of grass that a dairy cow consumes. The objective of this study was to develop a methodology that can quantify the annual amounts of grass in the diet of dairy cows at a regional or national level on an as fed basis.

Quantifying grass fed milk

Diets of Irish dairy cows were estimated with the Teagasc national farm survey (NFS) for the years 2013-2017. The survey was carried out on 275-341 specialist dairy farms and weighted to represent the national land area under milk production. The survey was expanded to collect technical data such as turnout and housing dates, monthly concentrate feeding rates, forage(s) conserved, milk production and composition. Data necessary to compute the diet of animals that could not be collected via surveys were obtained from the literature and via industry consultation. Dairy farms surveyed were operating grazing systems. The methodology applied the Irish net energy (NE) demand system to quantify total NE requirements for cow maintenance, activity, milk production, pregnancy and growth. The NE from concentrate was subtracted from cows' total NE requirement to estimate the NE provided by forage per month. The proportion of NE that came from pasture monthly was estimated by relating turnout and housing dates to the total NE provided by forage monthly. Net energy provided by conserved forage was estimated as the difference between NE provided from forage and grazed grass. Forage intakes were computed by dividing the NE provided by a forage by its NE value/kg dry matter (DM) or as fed. Grass intake was computed by summing grazed grass and grass silage intakes. The level of grass in the diet was determined on an as fed basis and was expressed dairy cow annual grass intake as a proportion of their total diet. The proportion of grass in the diet on a DM basis was also quantified.

Irish milking cows typical diet

Grass was the main feed Irish dairy cows consumed (Table 1). At the national scale, the Irish grass fed milk number was on average 95%. In terms of DM, the national results showed that across most years, grass comprised 81%-83% of the average cow's annual diet. Grazed pasture was the main component of dairy cow's diet contributing on average

73%-77% of the annual cow's diet as fed (57%-63% as DM). Grass silage was the next largest component of the average annual cow diet as fed followed by concentrate. The former was also the second largest consumed by cows on a DM basis, except in 2013.

Table 1. Typical (mean) annual Irish dairy cow diets on an as fed and dry matter (DM) basis from the Teagasc national farm surveys specialist dairy farms						
Parameter	2013	2014	2015	2016	2017	
Number of farms	275	318	314	341	327	
Total intake as fed, tonnes/cow	22.7	23.7	24.8	25.1	25.0	
Grass fed milk, % diet as fed	93.4	94.9	95.3	95.2	95.4	
Grazed grass, % diet as fed	74.2	76.8	76.9	72.8	73.4	
Grass silage, % diet as fed	19.2	18.0	18.4	22.4	22.1	
Grass, % DM diet	76.6	81.0	82.3	83.7	82.2	
Grazed grass, % DM diet	56.8	61.6	62.2	59.3	60.5	
Grass silage, % DM diet	19.8	19.5	20.1	24.4	21.7	

¹Grass included grazed grass and grass silage.

Our results were validated using Teagasc dairy research farms and showed that diets were similar for the top 5% of farms in the NFS, but the average dairy farmer fed 500–600 kg more concentrate DM/cow. Nevertheless, the average milk producer was still very reliant on grass. The findings imply that the overall proportion of grass in the average Irish cow's diet may be possible to increase.

Conclusions

A robust modelling method to estimate the typical Irish cow's diet on a countrywide scale was developed. The approach can be applied to support Irish dairy systems grass fed milk claims and provide interested consumers with better information on the contribution of grass to a dairy cow's diet.

Acknowledgements

We thank the farmers and recorders for their valuable contributions.

Reducing carbon footprint of milk production systems

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Summary

- Ireland will struggle to simultaneously increase milk production and meet its annual emission reduction targets for the EU effort sharing directive.
- The Teagasc national farm survey shows Ireland's milk carbon footprint is amongst the lowest in the world.
- Most dairy farms can enhance profits and reduce carbon footprint of milk by increasing efficiency e.g., improving soil fertility.
- Low emission technologies and practices that build soil carbon have substantial potential to further reduce farms carbon footprint, but have cost implications.

Introduction

Nationally, we have agreed to reduce carbon emissions by 30% compared to 2005 levels by 2030 for the EU effort sharing directive. The milk sectors emissions are regulated by this directive and account for about 17% of Ireland's non-traded emissions in 2017. The sector's carbon emissions have increased by one million tonnes since the abolition of the milk quota system. They are projected to rise further as the industry expands to meet the dairy requirements of a growing world population. A diverse set of measures have been recommended to reduce milk producers carbon footprints e.g., improving genetic merit, increasing grass utilisation and maintaining hedgerows. This work aimed to quantify the potential of a number of measures to reduce Irish milk production system's carbon footprint.

Carbon reduction strategies

The strategies modelled to reduce carbon emissions were 1) Improve efficiency 2) Adopt low emission technology 3) Build soil carbon. The first strategy's mitigation options were from the carbon navigator and included improve soil fertility, increase economic breeding index (EBI), improve animal health, increase grass yield and utilisation, and increase white clover content. For the second strategy, low emission slurry spreaders and protected fertiliser were tested. The third strategy's mitigation options were plant hedgerows or trees, minimise ploughing and maintain the area of permanent pasture. The effect of the three reduction strategies on the carbon footprint of Irish milk systems were quantified using a life cycle approach. The method was applied using the Teagasc national farm survey 2017 dataset and a Teagasc dairy model certified to comply with the British specification for carbon footprint (PAS 2050). On-farm carbon emissions and off-farm emissions associated with the production of purchased inputs (e.g. concentrate feed) were quantified by the life cycle model. Post-farm emissions were not considered. The model related the annual CO₂ equivalent emission from the farm to milk and meat to determine the carbon footprint of product(s). The share of emissions allocated to milk and meat was based on the proportion of income each product generates over a 3-year period.

Potential carbon footprint

Improving farm efficiency has the largest potential to directly reduce the average Irish milk producer's carbon footprint (Table 1). Applying the measures of this strategy simultaneously, reduces potential carbon and nitrogen emissions by 1) increasing grass

yield and utilisation per hectare, 2) minimising the quantity of concentrate feed and nitrogen fertiliser required, 3) improving lifetime milk solids output and cow fertility. For top performing farms, the efficiency strategy has less mitigation potential, but further footprint improvements are possible by using protected urea fertiliser and low emission slurry spreaders (e.g. trailing shoe).

Table 1. Reduction strategies potential effect on Teagasc 2017 national farm survey average and top milk producer's carbon footprints (kg CO_2e^1 /kg fat and protein corrected milk)

Reduction strategy	Measures	Average farms² milk carbon footprint	Top 1/3 milk carbon footprint
None	None	1.14	1.04
Improve efficiency	Improve animal health and EBI + Enhance soil fertility + White clover + Increase grass yield and utilisation	-20%	-13%
Low emission technology	Protected urea + Low emission slurry spreader	-5%	-6%
Build soil carbon	Maintain/Increase permanent pasture + Plant hedgerows and/or trees	-5%	-4%
Combined	All	-30%	-23%

¹Equivalent emission ²Average net margin €1,730/ha and top third net margin €2,596/ha

Dairy farmers can also reduce their footprint by maintaining permanent pasture and by planting trees and hedgerows. These practices reduce emissions by removing carbon from the atmosphere and improve farm's nature value (biodiversity). However, their long-term capacity to accumulate carbon is limited. Fortunately, new low emission technologies are emerging for cattle methane (e.g., 3-NOP and Mootral) and may be available if tests in grass-based systems confirm they maintain production and reduce emissions.

Conclusions

The milk sector can continue to reduce its emissions by adopting a suite of strategies to reduce carbon footprint. The main strategy recommended can be implemented at little or no cost.

Teagasc Sustainability Report 2017 Cathal Buckley, Trevor Donnellan, Emma Dillon, Kevin Hanrahan, Brian Moran and Mary Ryan

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Summary

- Economic return and profitability per hectare was 2–4 times higher on dairy farms versus non-dairy farms.
- Emission per hectare of greenhouse gas (GHG), ammonia (NH₃) and N balances were between two and five times higher on dairy farms.
- Emissions intensity of milk production declined between 2012 and 2017

Introduction

The recently published Teagasc 2017 sustainability report considers Irish farm production systems in terms of their economic, environmental and social sustainability. The report tracks the sustainability performance of dairy, drystock and tillage farms through data collected by the Teagasc National Farm Survey.

Results

Economic Indicators

Dairy farms show the strongest economic performance, significantly higher (2–4 times) than all other systems in terms of economic return and profitability on a per hectare basis. The farm systems are most similar in terms of market orientation, with dairy and tillage having the greatest share of output derived from the market. Dairy farms were the most economically viable followed by tillage systems as seen in Figure 1.



Figure 1. Economic Sustainability: Farm Comparison 2017 (farm system average)

Environmental Indicators

Dairy farms had the largest GHG emissions (CO_2 equivalent) on a per hectare basis, 2–4 times higher greater than the other systems. The trend was reversed for kg of CO_2 equivalent emitted per Euro of output generated. Ammonia (NH_3) emissions per hectare were significantly higher (2–5 times) on dairy farms compared to other systems. In terms of NH_3 emissions per Euro of output generated, cattle farms emitted the highest level of NH_3 (due to the generally lower levels of output) followed jointly by dairy and sheep farms. Nitrogen balances (kg N surplus per hectare) on dairy farms were 3–4 times higher than the other farm systems. Higher dairy emissions are a function of greater stocking rates, more energy intensive diets and more use of chemical fertilisers than the other livestock systems.



Figure 2. Environmental Sustainability: Farm Comparison 2017 (farm system average)

Social Indicators

Social sustainability indicators show a similar overall trend to the economic performance, with dairy and tillage farms distinct from cattle and sheep systems. The greater labour intensity of dairying is illustrated by the longer hours worked on-farm, although other farm systems are more likely to incur hours on off-farm employment. Household vulnerability (non-viable with no off-farm employment within the household) and isolation risk was lowest across dairy farms. Dairy and tillage farmers were more likely to have attained agricultural education or training versus cattle or sheep farmers, on average (as seen in Figure 3).



Figure 3. Social Sustainability: Farm system Comparison 2017 (farm system average)

Emissions Intensity

Figure 4 illustrates that kg of CO_2 equivalent and NH_3 per kg of Fat and Protein Corrected Milk (FPCM) (standardized to 4% fat and 3.3% true protein per kg of milk) followed a declining trend between 2012 and 2017 on a three year rolling average basis. Additional milk output post milk quota has been produced at a lower emissions intensity.



Figure 4. Kg of CO₂ equivalent and NH₃ per kg FPCM (Dairy Farms)

Conclusions

Dairy farms in general tended to have higher economic and social sustainability but also higher levels of absolute environmental emissions due to the greater production intensity on these farms. While emissions intensity of milk production has improved, absolute emissions on dairy farms have increased over the study period.

Nitrogen, water quality and the weather Edward Burgess and Per-Erik Mellander

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Summary

- Weather and soil type have a significant influence on the nitrate concentration found in water.
- The proportion of nitrogen (N) inputs recovered in production (N use efficiency) on Irish dairy farms is typically 25% to 33%.
- Fertiliser N readily converts to a soluble form (nitrate) that does not bind to soil and is easily leached to ground water.
- Areas in the country that have more intensive dairying have been found to correspond with the rivers and estuaries showing higher nitrate concentrations.

Introduction

The increase in dairy cow numbers from one million in 2012 to 1.5 million this year is unlikely to slow down given the relative financial returns from dairying in comparison with other enterprises. Ireland exports a large amount of dairy products produced based on our green image and sustainable grass-based production systems. However, this increase in dairy cow numbers is often questioned as being incompatible with improving ecological and environmental standards. For example, an EPA report shows clear distinctions between regions of the country where N concentrations are high and low. While phosphorous (P) is the main concern for rivers and lakes (fresh water), N is the nutrient that impacts on coastal/salty water. Estuaries on the east and south coast have high nitrate concentrations in comparison to the rest of the country. These areas correspond to (i) areas with the greatest increase in cow numbers and (ii) areas with free draining soils.

The recent changes in the dairy industry have taken place against the back drop of environmental regulations, namely the "Nitrates Directive" and the "Water Framework Directive" (WFD). The nitrates regulations restrict farm stocking rates to two cows per hectare unless a derogation has been sought and approved. Ireland must get permission to implement the derogation process from the EU every four years and it should not be taken for granted. For the WFD assessment, the EPA classifies the quality on over 5,000 "water bodies" nationally and they include ground water, rivers, lakes, estuaries and coastal water. The five categories are high, good, moderate, poor and bad. The WFD objectives are that all monitored water bodies meet good or high status and that existing high status water bodies should not deteriorate. Worryingly, a recent water quality report from the EPA showed a downward trend in river water quality. While agriculture is only one of a number of sectors that influence water quality, should this downward trend continue, it may affect Ireland's implementation of the Nitrates derogation in the future.

Agricultural Catchments Programme (ACP)

The ACP has been monitoring the effectiveness of the Nitrates regulations in six small (ca. 1,000 ha.) catchment areas for the last 10 years. In addition to measuring farm production (land use, stocking rate, fertiliser application etc.), each catchment has a monitoring station recording the volume (discharge) and nutrient (N and P) concentration of the water leaving the catchment every 10 minutes. While farm practice is important, the ACP has found that soil type has a very significant influence on N concentrations. Free draining soils are more risky in terms of N losses. The Ballycanew catchment has a heavy soil and its average N concentration (2.5 mg/l) is two to three times less than Timoleague (5.7 mg/l) and Castledockrell (7.0 mg/l). This is because soil does not hold onto nitrate, which

dissolves easily in water. Water percolating through the soil in free draining catchments carries dissolved nitrate that eventually ends up in the estuary via spring fed watercourses.

Weather is also a significant factor impacting on the nutrient concentration of water. The dry summer of 2018 shows this (Figure 1). During the drought, soil bacteria continued to break down organic matter, releasing mineral N. However, as grass was not growing due to drought stress, there was little or no uptake of either this naturally occurring N or any other applied fertiliser N. When the rain did eventually come in the autumn, much of this unused N was washed through the dried out soil and into ground water. The water tables then rose and the streams started to flow with concentrations of N that were higher than that found in previous, drought free years.



Figure 1. Nitrate in Ballycanew in 2015 and 2018

Conclusions

When you compare the farm N inputs (N in fertiliser, meal etc.) with off-takes (milk and livestock sales etc.) typically only 25% of the N is recovered, the remainder being lost to the atmosphere, water or bound up in soil organic matter. More efficient N use of up to 33% can be achieved and this has a dual benefit of reduced input costs as well as reduced environmental losses. If we are to achieve maximum N use efficiency, it is critical to manage fertiliser applications to suit the soil type, weather and growing conditions. Correct timing of N will significantly reduce losses and give greater growth response per kg N applied. The ACP has recently launched a website (www.acpmet.ie) displaying hourly weather updates from each of their six catchments, including soil temperature. This information will assist farmers near to the catchments to maximise N use efficiency on their land.



Improving farm efficiency using low Ammonia-N emission technologies

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Summary

- Low emissions slurry spreaders retain an extra three units of nitrogen per 1,000 gallons
 of slurry compared to splash-plate spreaders.
- Low emissions slurry spreaders reduce grass contamination, widening spreading windows to target low soil test P and K paddocks.
- Protected urea grows the same amount of grass as CAN while being very cost competitive and reducing emissions.

Introduction

The production and utilisation of grass is a key driver of farm profitability. Irish grasslands respond strongly to nitrogen (N) so it is important to make the most of available N on farms. Two important N resources on farms are purchased N fertiliser and slurry N. Nitrogen fertiliser type and slurry application technique affects N efficiency. Nationally, it is estimated that 15.5% of the N applied as urea is lost as Ammonia-N gas, Teagasc research shows that protected urea reduces this loss to low levels. Measurements at Johnstown Castle found that slurry broadcast by splash-plate tankers can lose up to 83% of the readily available N, which could have grown grass. Holding on to this Ammonia-N to grow grass and to reduce mineral fertiliser expense makes sense.

Benefits of low emissions slurry spreaders (LESS)

LESS machines e.g. trailing shoe and dribble bar retain more N on farm to grow grass, reducing fertiliser N expense. A LESS spreader will retain an extra three units of N per 1,000 gallons (gals) of slurry vs. splash-plate, which is a 30–50% improvement in the slurry N values due to lower ammonia-N emissions. Low emissions slurry spreaders allow slurry to be spread on higher covers increasing the window to target slurry nutrients to fields with low soil test P and/or K.

Teagasc have shown that cows prefer to graze LESS spread pastures due to lower grass contamination (Figure 1). Another benefit is allowing the interval between slurry spreading and grazing to be reduced. Low emissions slurry spreaders are a capital expense cost for farms. Depending on herd size and available labour, the use of a contractor with one of these machines may be a way to access these machines and free up labour for other farm tasks. Where a trailing shoe or dribble bar with an umbilical system is practical and available, lower compaction is an additional benefit.



Figure 1. Post-grazing covers as affected by application method. Cover of 1,100 kg DM/ha at spreading, grazing occurred three weeks after slurry spreading

Benefits of using Protected Urea

Nationally, it is estimated that 15.5% of urea-N applied is lost to the air as Ammonia-N. Protected urea (urea + NBPT, urea + 2-NPT or urea + NBPT + NPPT) cut this loss to low levels. Teagasc research has shown that protected urea grows the same amount of grass as CAN. It is also cheaper than CAN per unit of N at current fertiliser prices (Figure 2). Protected urea reduces greenhouse gas and ammonia emissions substantially compared to CAN and Urea, respectively. This presents an opportunity for agriculture to meet current and future emissions commitments without affecting production.

Fertiliser N type	N content	Cost €/kg N	Annual grass yield	GHG emissions	Ammonia emissions	Nitrate leaching Spring
Urea	46%	0.85	\checkmark	\checkmark	X	\checkmark
Protected urea	46%	0.95	\checkmark	\checkmark	\checkmark	\checkmark
CAN	27%	1.05	\checkmark	X	\checkmark	X

Figure 2. Comparison of Urea, Protected urea and CAN fertiliser N in terms of cost, grass growing ability and environmental efficiency

Conclusions

Using low emission slurry spreaders on farm makes sense as they improve the N value of slurry, add flexibility around spreading slurry into higher grass covers and shorten the interval between slurry spreading and grazing. They increase the window for targeting slurry to low soil test P and/or K paddocks. Protected urea ensures ammonia-N is retained to grow top yields of grass while reducing greenhouse gas losses cost effectively.

Agricultural Sustainability Support and Advisory Programme (ASSAP)

Pat Murphy¹ and Noel Meehan²

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Summary

- Ireland has been set a target by the E.U. Water Framework Directive of achieving 'Good Status' for all waters.
- The River Basin Management Plan for Ireland 2018–2021 sets out Ireland's plan to achieve good status.
- The Agricultural Sustainability Support and Advisory Programme (ASSAP) service is available to farmers in 190 Priority Areas for Action (PAA's) and is a key part of helping achieve good status.
- The Agricultural Sustainability Support and Advisory Programme (ASSAP) is a free and confidential advisory service available to all farmers.

Introduction

In Ireland, all water policy and management is led by the Water Framework Directive. Under this directive, Ireland has been set a target of achieving 'good status' for all waters. However, despite a lot of good work over the last 20–30 years, we are falling short in achieving this target and water quality has declined in recent years.

Ireland's response to challenges around water quality is set out under the national river basin management plan. As part of this plan, 190 priority areas for action (PAA) have been identified across the country where water quality improvements need to be made. There are multiple pressures across each of these PAA's including industry, waste water treatment plants and septic tanks, forestry, agriculture and urban pressures.

Implementation of the Agricultural Sustainability Support and Advisory Programme (ASSAP)

The local authorities have deployed a catchment assessment team of 60 scientists across the country to assess the PAA's in detail and identify the significant pressures in each PAA. This group communicates the detailed information about the PAA to all of the stakeholders across the local community including agricultural and non-agricultural land owners and businesses.

Where an agricultural pressure is identified the farmers in the area will receive the offer of a free farm visit from an advisor under the ASSAP programme.

The ASSAP programme is made up of a group of 30 advisors (20 working under Teagasc jointly funded by DHPLG and DAFM and 10 from the dairy industry). These advisors are available to provide farmers with a free and confidential advisory service that farmers in a PAA can avail of on a voluntary basis.

The advisors will meet the farmer to assess the farm for any potential issues that are having an effect on the water quality in the local stream. In general an advisor will assess the farmyard, nutrient management practices and general farm land management practices including the use of pesticides etc.

At the end of a visit the advisor and farmer will agree on where the farmer should focus improvements or actions, if any are required, on his/her farm. The practical advice will be designed to 'break the pathway' and prevent nutrients from entering water. A written summary of the advice and actions will be provided and a timeframe for completion agreed between them.



Figure 1. Heavy rainfall leads to overland flow of water, Phosphorus able and soil particles



Figure 2. Nitrogen that is not used up by the grass/plant growth is available to be leached to groundwater/streams during heavy rainfall.

Conclusions

The ASSAP programme is collaborative and the funding and support received from DAFM, DHPLG and the dairy industry has been critical to allow a new approach to enabling local landowners to engage positively in seeking solutions to local problems with the support of a confidential advisory service. Support from the farming organisations for the programme has been very strong and this is vital in communicating and informing farmers about the ASSAP programme and its key messages.

IRISH DAIRYING | GROWING SUSTAINABLY

Increasing biodiversity on intensive farms Daire Ó hUallacháin and John Finn

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Summary

- Wildlife measures designed and targeted for intensive dairy systems can play an important role in halting the decline of biodiversity and achieving the goals of sustainable agriculture.
- The quality of existing farmland habitats should be maintained or enhanced before new biodiversity measures are established.
- New biodiversity measures could be targeted to less-productive areas of the farm but should not replace existing wildlife habitats.

Introduction

Many farmland plants and animals are dependent on agricultural practices, and changes in these practices affect farmland ecology. Whilst there is a need to increase production to cope with increasing food demands, the environment and associated ecosystem services need not be compromised. Emerging research and policy agendas are now based on sustainable management of agricultural land.

Objectives of the FoodWise 2025 report and proposals under the new Common Agricultural Policy include the need for effective methods for biodiversity conservation, as part of the development of sustainable production systems. Incorporation of such measures could provide a very important contribution to the reversal of biodiversity decline; in addition, this can offer a branding and marketing opportunity to Irish farmers and retailers in terms of capitalising on Ireland's reputation for sustainable production systems.

Measures to enhance biodiversity on dairy farms

Grass-based farming systems in Ireland are well positioned in terms of the wildlife they support. It is estimated that natural and semi-natural habitats constitute over 7% of intensive dairy farm area. Appropriately-designed wildlife measures, targeted for intensive dairy systems, could play an important role in halting the decline of biodiversity, along with improving water quality, reducing greenhouse gas emissions and achieving the goals of sustainable expansion.

Maintain and manage existing habitats

It is important to optimise the biodiversity value of existing farmland habitats before new biodiversity measures are established. It is typically more effective to retain existing habitats rather than establishing new ones. Existing habitats, including woodland plots, ponds and wetlands should be protected from more intensive agricultural management. These areas should be appropriately managed and avoided when sites are being selected for 'new' biodiversity or carbon initiatives. Many of these semi-natural habitats benefit from farm management that prevent the area from scrubbing over (e.g. light grazing of woodland plots in spring and autumn can help improve the quality of the area).

Hedgerow management

Hedgerows are the dominant habitat feature on Irish farms with the average dairy farm (56 ha) having over 6 km of hedges. However, the quality of many of the hedgerows is low. High quality hedgerows provide multiple benefits, including providing shelter for stock and improving biosecurity; improving water quality; sequestering carbon; and acting as a refuge for biodiversity. Optimal management include:

- The sides of hedges should be trimmed, with the top allowed to grow taller. This provides greater shelter and stock-proofing for animals, and improves the diversity and quality for wildlife.
- Replant escaped or 'gappy' hedgerows with native species (e.g. hawthorn). Native species support a greater abundance and diversity than non-native species.
- Leave occasional trees or bushes to mature, thus providing greater feeding and nesting habitats for a variety of species.

Ensure that appropriate management is undertaken outside the closed period from March $1^{\rm st}$ to August $31^{\rm st}.$

Watercourses and buffer strips

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

- Avoid fertiliser, slurry or herbicide application in the buffer strip.
- Allow vegetation in the strip to develop, but avoid the strips becoming dominated by scrub.
- Exclude livestock fully from watercourses (if feasible).
- If cleaning the channel-bed, the spoil should be deposited away from the buffer strip.

Consult with Inland Fisheries Ireland prior to undertaking any in-stream management.

Establishing new habitats

New biodiversity measures play an important ecological role where there is a lack of existing habitats. New measures could be targeted to less productive areas of the farm, but should not replace existing wildlife habitats. Replacing existing habitats with newly created habitats is poor practice and typically results in a reduction in farmland wildlife.

- Wider field margins (including those sown with grass and wildflower mixes) provide a habitat for plants and animals, can prevent undesirable plant species from encroaching into the field, and more easily facilitate management of hedgerows.
- Awkward field corners could be left uncut following silage removal. This temporary measure provides food and cover for a variety of species such as farmland birds and small mammals. Corners could be grazed-off when animals are re-introduced to the field.



The Biodiversity Regeneration In a Dairying Environment (BRIDE) Project Donal Sheehan, Sinéad Hickey and Tony Nagle

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Summary:

- The BRIDE project is a results-based demonstration project that will aim to increase the quantity and quality of habitats on intensively managed farmland.
- The project will be located in the River Bride valley of north County Cork, which constitutes part of the River Blackwater Special Area of Conservation and will run for a five year period with up to fifty farmers involved.
- The project will explore an innovative implementation of a results-based approach for wildlife habitats on intensively managed farmland.

Introduction

Farmland wildlife has undergone significant declines throughout Ireland and Europe in recent decades. Changes in farming practices (e.g. intensification, specialisation, abandonment) have led to a decrease in habitats and species dependent on agricultural practices. Conservation of natural resources (e.g. water quality, carbon storage, biodiversity) are key environmental objectives of the European Union.

Objectives

The Project aims to design and implement a results-based approach to conserve, enhance and restore habitats in lowland intensive farmland

The BRIDE project hopes to demonstrate to farmers, the food industry, policy makers, other decision-makers and the general public that it is possible to have thriving systems of modern agricultural production alongside a natural environment that is managed to support farmland wildlife. Irish landscapes that produce high quality dairy, beef and cereals can be managed sustainably to simultaneously protect and enhance farmland habitats and species.

Approach

The BRIDE approach is a results-based scheme, whereby measures to sustain and enhance farmland wildlife will be specifically designed and targeted to each participating farm. Potential participant farmers will have their farms mapped to determine the percentage of Biodiversity Managed Area (BMA %). Based on the results of the BMA mapping, they will then be presented with a Biodiversity Management Plan for their farm, recommending a number of measures that they can undertake to increase the quantity and quality of their BMA. Monitoring will be conducted to assess the environmental effectiveness and impact of the BRIDE measures.

Farmers will be reimbursed the capital cost payments incurred during the initial instigation of the measures where applicable (e.g. purchase and planting of trees and hedgerows, purchase and installation of nest and bat-boxes, purchase of seed for field margins (Figure 1 and 2)). The results-based approach is a relatively novel approach and will be used to incentivise the improvement of the ecological quality of existing, restored, or created habitats. The greater the quality of individual habitats, the higher the payment. Results Based Payments will thus vary depending both on farmer effort and habitat condition - the BRIDE project does not offer a flat rate area-based payment.

The project is co-funded by the European Union and the Department of Agriculture, Food and the Marine through the European Innovation Partnership (EIP) funding initiative and is expected to run for up to five years.



Figure 1. Pollinator field margin



Figure 2. Mature Hedgerows

Conclusions

An important aim will be to use the BRIDE project to showcase and communicate lessons learned to the agri-food industry. The project will place emphasis on dissemination to a wide variety of stakeholders via multiple methods. We expect that the BRIDE project will become a nationally recognised case study of how a concerted action in intensively managed farmland can achieve farmland wildlife benefits without significantly affecting farm profitability or production. IRISH DAIRYING | GROWING SUSTAINABLY

Forestry — an important ally for farm sustainability Tom Houlihan and Richard Walsh

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Summary

- Forestry is a sustainable option for marginal and fragmented land offering economic, environmental and societal benefits.
- Forest design, scale and good management are critical to maximise crop quality, timber value and environmental contribution.
- Forest establishment grants cover the cost of planting. Following planting income can be generated from the annual premiums for the first 15 years while future incomes can be generated from timber revenues and non-timber products or services.

Introduction

Over the past 25 years 22,000 landowners have converted some land into forestry, creating a complementary and sustainable farm resource. There is an increasing recognition of the economic, social and environmental contributions from forestry including its crucial role in greenhouse gas mitigation, particularly for future scenarios post-2030. As well as providing a range of ecosystem services, forestry has a significant role to play in enhancing farm viability, optimising use of marginal land, optimising work time, facilitating tax efficiency and assisting retirement planning.



Figure 1. Forestry complementing Dairy



Figure 2. Productive and Sustainable forestry

Complementing Dairying in Cork

Donal McCarthy from Ballydehob, Co. Cork (Figure 1) is a progressive dairy farmer who identified opportunities to diversify his farming activity and create a complementary on-farm enterprise. Donal planted 11 hectares of marginal land located on an out-farm in 2010. This mainly conifer forest also includes broadleaf tree species, areas retained for biodiversity and areas for landscape enhancement. Donal went on to plant a further 27 hectares of marginal land in 2015 (Figure 2). He is one of the 30% of forest owners nationally who, over the last 10 years, have gone on to plant at least a second time. Donal says "I have no regrets whatsoever. Forestry can help optimise my returns on out-farms and marginal land. I now have a growing, sustainable and secure pension plan which I will be in control of myself". Teagasc analysis show the annual equivalised value of productive forestry can exceed €550 per hectare, delivering sustainable and economic objectives.

Forestry - Multiple Benefits

Historically the primary role of forests has been to develop a supply of Irish grown timber for construction, furniture and wood energy relying less on wood imports. The current vision and objectives of forests have been transformed with a strong emphasis on the multiple benefits that they can provide. The strategic goal stated in Ireland's forest policy review is "To develop an internationally competitive and sustainable forest sector that provides a full range of economic, environmental and social benefits to society". In this regard, well-planned forestry can also deliver a wide range of non-wood products and ecosystem services on-farm. These services include carbon sequestration, protection of water quality and biodiversity enhancement.

Carbon Sequestration

Forests are effective at mitigating climate change through sequestration of carbon by tree growth and carbon storage in soils, tree stems, roots and ground litter. The extent of mitigation depends on planting levels, the type of forests, site types and



Figure 3. Indicative carbon sequestration by forest type

forest management systems (Figure 3). Carbon Sequestration by forestry can act as a future ally for dairy and other farm enterprises while contributing to our future national abatement effort. Ireland's contribution to the Paris Agreement on climate change is via the Nationally Determined Contributions proposed by the EU on behalf of its Member States. The Commission Effort Sharing Proposal included the allocation of 26.8 million tonnes (CO₂ equivalents) of land-use, land-use change from forestry (LULUCF) credits to Ireland over the 10 year period 2021–2030. Member States with a larger share of emissions from agriculture were allocated a higher share of LULUCF credits. This equates to 2.68 Mt CO_2 equivalents per year. Teagasc 'Gaseous Emissions Working Group' project that, with the bulk of the sequestration by increasing forestry, the full allocation could be met.

Protecting Water Quality

Landowners play an essential role as custodians of the natural landscape and resources. The recent DAFM 'Woodlands for Water' publication explores the appropriate afforestation measures to create a resource that can help to protect and enhance water quality. The establishment of new native woodlands combined with undisturbed water setbacks can deliver services that protect and enhance water quality and aquatic ecosystems. Even a limited area of woodland near watercourses (riparian woodland) can become a protective, enhancing and visually attractive resource on the farm, without reducing enterprise productivity.

Enhancing Biodiversity

Forests are among the world's most complex and diverse ecosystems. All forests contribute significantly to biodiversity, both within their boundaries as corridors for wildlife and as refuges in the wider landscape. Areas for Biodiversity Enhancement are incorporated into all new forests. They conserve existing habitats and biodiversity features while promoting further diversity. A minimum of 15% broadleaf component is required on all new planting sites. Forest management planning affords the opportunity to enhance future biodiversity in our forests, provides benefits to society and additional income to farmers or land owners.

Evaluating food-feed competition in Ireland's dairy sector

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Summary

- Currently, Irish dairy farming is a net positive contributor to the global protein supply.
- The average Irish dairy cow produces significantly more protein from the same land than if it was used for crop production.
- For every 1 kg of human edible protein consumed by a dairy animal it produces 4.92 kg of human edible protein.

Introduction

There is a significant debate on the role that livestock will take in future food systems. Feed-food competition is said to occur when crop and land-area is used for livestock feed rather than more efficient food crop production. This can lead to the argument that land used for livestock feed instead of crops for human consumption may cause a net loss to the global supply of protein. This argument considers land-use efficiency, examining whether the potential protein from crop production that is foregone for livestock-feed, is greater than the protein provided by the livestock animal. While there is evidence supporting this argument in all livestock systems, much depends on the type of feed used to produce the protein. Therefore examining whether Ireland's current dairy system is an efficient use of land is important when assessing its future role in global protein production. This is done by assessing the feed footprint of an average dairy cow, calculating the area of land its feed was harvested from and calculating the potential yield of crop-based protein from that area.

The National dairy cow

Using production data from the 2015 National Farm Survey, an average dairy cow to represent the entire national herd was compiled, this includes the feed consumed as a heifer divided across all lactations, with an average lactation yield of 436 kg of milk solids.

The current edible protein efficiency of this cow was calculated as producing 4.92 kg of human edible protein for every 1 kg of human edible protein consumed. The cow's intake includes 3,840 kg DM in the form of grass and silage and 873 kg DM of ration, a blend of barley, soya, molasses and by-products. By-products are not included as they are not considered drivers of land-use.

Calculating the protein production from crop production

The land-use efficiency is calculated by using the Land-Use Ratio. This is done by dividing the potential crop protein yield from the land-area foregone against the protein produced by the dairy cow. Quantifying the plant protein foregone is done using FAOSTAT for national average yields to calculate the area of land used both nationally and internationally to feed the dairy cow. This included the land-area that is currently under pasture that is suitable for crops. This land-area is then replaced with crops, using the six most globally common annual crops with the highest protein yield chosen. The protein yields only consider human edible protein of the plant and animal protein.

Results

Figure 1 below illustrates a comparison animal protein against plant protein foregone for the National Farm Survey average dairy cow.



Figure 1. Land use ratio of the average Irish dairy cow

Currently the average Irish dairy cow is a more efficient use of land for protein than crop production. When taking into account actual human digestibility, plant protein could only replace 64% of the typical dairy animal protein from the same land area.

Conclusions

The average Irish dairy cow is a net contributor to the global protein supply. This is primarily due to the use of highly productive grasslands to feed the Irish cow, demonstrating that food feed competition does not occur in the Irish dairy sector. When considering the global environmental impact that agriculture has, efficient land-use and environmental efficiency may not be in direct plant production but instead from efficient animal production.



New focus at Shinagh Dairy Farm John McNamara¹, Padraig French² and Kevin Ahern³

¹Teagasc, Cork West Advisory Unit; ²Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork^{: 3} Farm Manager, Shinagh Dairy Farm

Summary

- Shinagh dairy farm began milk production in 2011 and has demonstrated that a wellmanaged grass based dairy farm can adequately remunerate all of the resources employed including land, labour and capital.
- While the farm has focused in the past on managing the economic risks and challenges associated with dairy farm conversion, start-up, expansion and volatility, the farm will also focus on the challenges that the industry faces on environmental and social sustainability in the future.
- The technical focuses of Shinagh dairy farm have been to maximise the amount of grass grown and utilised per hectare and to optimise the proportion of the cow's diet coming from grazed grass, the future technical focuses will include reducing carbon, nitrogen and ammonia losses from the farm and improving labour efficiency while optimising animal welfare.

Introduction

Shinagh dairy farm near Bandon in West Cork is a Teagasc-led project demonstrating efficient spring milk production from grass on a farm that was converted from a beef farm in 2010, with the first cows being milked in January 2011. The 78 ha farm is owned by the four west Cork co-ops and was leased at \notin 450/ha for 15 years by Shinagh Dairy Farm Ltd. The total conversion costs for the farm was \notin 820,000, with \notin 260,000 of that provided by the West Cork Co-Ops as equity and the remainder borrowed with a 15 year loan costing approximately \notin 46.5k per year to service. The labour on the farm is provided by one full time farm manager (Kevin Aherne) along with part time labour in spring and for relief throughout the year with total labour costs of approximately \notin 70k/year.

Farm performance

Over the last nine years, the focus of the farm has been to maximise grass production and utilisation and to breed a high EBI crossbred herd that could calve compactly at the start of the grass growing season and efficiently convert grass into milk solids (Table 1). The farm has successfully exceeded all of the performance targets that were established at the outset of the project and this has led to very significant cash surpluses and accumulated profits (Figure 1). While there has been inter-year variation in cash surpluses and profit, due primarily to milk price volatility, the farm is now very resilient due to a very low breakeven milk price of less than 23 c/l.

Future focus

The original objectives of Shinagh dairy farm were to identify and manage the economic risks and challenges associated with a dairy farm conversion with significant volatility in milk price and these will continue to be significant considerations in the future with continued monitoring and reporting of all of the KPI's that drive dairy farm profitability. However the farm will also focus on some of the other challenges that the industry faces on environmental and social sustainability in the future. These will include strategies to reduce the carbon footprint of the milk produced, reduce the total ammonia emissions from the farm and increase the nitrogen efficiency and the biodiversity value of the farm.

Table 1. Physical performance of Shinagh dairy farm from 2011 to 2018							
	2011	2012 to 2016 average	2017	2018			
Cows milked	195	217	232	238			
Stocking rate (LU/ha)	3.12	2.86	3.19	3.36			
Grass grown (t DM/Ha)	12.25	13.55	16.35	11.55			
Grass utilised (t DM/Ha)	10	11.1	13.6	9.6			
Six week calving rate (%)	58	82	93	93			
Empty rate (%)	13	7.6	6.7	8.3			
Mean calving date	28-Feb	18-Feb	21-Feb	20-Feb			
Milk solids (kg /ha)	817	1,082	1,256	1,431			



Figure 1. Cumulative cash flow and profitability from Shinagh dairy farm from 2011 to 2018

Because the farm has been operated to a very high level of efficiency with high genetic merit cows grazing over a long grazing season, the farm environmental emissions have been significantly below the industry average.

However, the farm will aim to further reduce emissions by adopting the key technologies within the Teagasc marginal abatement curve to demonstrate that an environmentally efficient farm can operate at a very high level of production efficiency and profitability. In 2019, this has included a switch to using protected urea instead of CAN to reduce ammonia emissions and all slurry is now being applied with low emission slurry spreading equipment. The crude protein content of any concentrate being fed to grazing cows will also be reduced. The farm is also replacing the milking machine vacuum pump with a variable speed motor. All of these technologies should increase the efficiency of the farm operation while reducing the environmental footprint.

Conclusions

Shinagh dairy farm will continue to provide leadership to Irish dairy farmers by demonstrating the operation and management of an environmentally and economically efficient farm.

Update on the Greenfield dairy farm, Kilkenny Abigail Ryan¹, David Fogarty² and Niall Duffy²

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

Summary

- Milk Production has increased each year to 144 and 123 tonnes milk solids sold in 2017 and 2018, respectively. Herd Fertility is at 10% infertile using 100% artificial insemination and a six week calving rate of 80%. The herd is now predominantly Jersey crossbred with an EBI of €156 (top 15%).
- Herd Health/Animal Welfare is good. Cow mortality is low at <2% annually and calf mortality at less than 7% annually. The average culling rate since the start is 24%.
- Grass Production and soil fertility is fundamental to the farm. Soil fertility is monitored yearly. The farm Phosphorus (P) and Potassium (K) levels are at an average of 10.33 ppm and 164 ppm in 2019, respectively. The farm has grown 13.1 t DM/ha on average since 2011. Clover has played an important role in helping improve grass production on the farm.
- Environmental efficiency. The average annual Nitrogen (N), Phosphorus (P), Potassium and Sulphur spread was 250, 12, 75 and 36 kg/ha, respectively. Nitrogen and P use efficiency were high at 0.32 and 0.93, respectively, and indicative of good environmental management.
- The cash reserve built during the cash surplus years was used up in 2018 due to the poor spring and the prolonged dry period in the summer resulting in extra feed being bought in. The farm has also funded extra on farm development (€300,000 since 2012). The farm debt is now at €420,000, down from €850,000.
- **People Management** is one of the key factors for a successful project. Rostering and training has always being important for the farm staff. In 2018, the farm invested in a new farm canteen, office, living quarters and large meeting room for the farm staff. **Lean management** was also introduced.

Introduction

The farm is 9.5 years through a 15 year lease. The success of the project so far is attributed to the excellent farm staff since start up. Some key figures can be seen in Table 1. David Fogarty is the current farm manager and Niall Duffy is the assistant farm manager along with Joe Murphy who is a professional farm manager student with help from third level students from February to July.

Grassland and cow herd

Grassland management on Greenfield has been challenging. In two of the eight summers, there were very prolonged dry periods with no rain that impeded grass growth. Grass production was only 12 t DM/ha in 2018 due to a poor spring (snow, storms and wet weather) followed by drought. After analysing the yearly Pasturebase data, along with low annual rainfall (800 mm) and the challenge to have enough winter feed on the farm, the decision was made to reduce the stocking rate by culling based on low EBI and Cow's Own Worth. The P index has increased but it has been a challenge to keep it at optimum levels as there is not sufficient P applied as the farm has kept within the derogation guidelines. Potassium levels have increased to optimum levels by applying over 70 kg K/ha annually.

Conclusion to successful sustainable expansion (small/large)

- Allow plenty of time to plan the business.
- Phase development.
- Source good genetics and invest heavily in grassland infrastructure from the start.
- Set realisable modest cow and grass production targets initially.
- Measure, benchmark and react to measurement.
- Review stocking rate compared to grass growth regularly.
- Over dependence on bought in feed is high risk and high cost and isn't sustainable.
- Plan to put cash reserves aside for the poor performance years.
- Never underestimate the value of excellent people.

Table 1. Physical and financial figures from the Greenfield dairy farm								
	2011	2012	2013	2014	2015	2016	2017	2018
Peak cows (No.)	295	294	324	307	328	331	350	330
Not in calf rate (%)	13	11	10	10	5	8.5	12.7	8
Culling rate (%)		25	32	26	19	18	24	24
Milk solids sold (tonnes)	110	113	125	125	131	137	144	123
Milk solids sold (kg/cow)	368	372	386	396	400	415	408	398
Fat (%)	4.41	4.61	4.44	4.60	4.64	4.84	4.82	4.82
Protein (%)	3.52	3.57	3.62	3.74	3.87	3.81	3.82	3.90
Grass grown (t DM/ha)	11.8	11.8	10.0	13.5	13.9	14.7	15.2	12.0
Meal fed (kg/cow)	300	307	620	270	180	240	220	1,000
Environmental								
Phosphorus (% index 3/4)		87	71	55	58	60	27	37
Potassium (% index 3/4)		51	61	56	70	77	50	70
N-use efficiency	0.32	0.30	0.32	0.33	0.33	0.33	0.31	0.32
P-use efficiency	1.02	1.01	1.00	1.00	1.00	1.00	1.00	0.99
Carbon footprint (kg/kg)		1.14	1.33	1.20	1.13	1.12	1.14	1.41
Habitat cover (%)	0.7	0.7	0.7	0.7	1.0	1.5	2.0	2.0
Financials								
Total costs(c/l)	40.5	40.0	41.4	42.0	37.1	37.2	37.0	56.5
Total output (c/l)	42.7	43.6	49.4	48.8	40.3	36.6	45.0	43.0
Milk price (c/l)	38.0	35.9	41.8	42.6	34.3	31.6	42.0	41.0
Return on Investment (%)	9	6	10	11	8	1	12	<0

Conclusions

The long term success of the Greenfield project is attributed to high levels of pasture production and utilisation by a high EBI crossbred herd, a clear focus on soil fertility and pastures, excellent herd fertility and health and the committed work of a highly skilled farm team.

The effect of increasing grazing season length and stocking rate on milk productivity and feed requirements on grazing systems in the Border Midlands Western region

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Summary

- Highly productive extended grazing systems are achievable in the BMW region.
- Extending the grazing season by 60 days increased both grazed grass utilisation and milk and milk solids production and reduced annual supplementary feed requirements.
- Increasing stocking rate resulted in increased milk and milk solids production per hectare but also in increased supplementary feed requirements.

Introduction

Extending the grazing season has been shown to be an effective way to reduce milk production costs in temperate regions of the world where grass can be grown cheaply. In recent decades, Irish dairy systems research has focused on strategies to improve grass utilisation and increase the proportion of the milking cow's diet coming from grazed pasture. Despite advances in grazing systems at research level, uptake at farm level has been slow, particularly in the border, midlands and western (BMW) regions. National farm survey data shows that, although the national average grazing season length is currently 235 days, the duration of the grazing season in the BMW region is considerably shorter (213 days) resulting in significantly reduced grass utilisation. Although previous studies within the region have shown lower spring and autumn grass growth when compared to Moorepark, extended grazing systems have been practiced at the Ballyhaise site over the past 10 years, with grazing routinely commencing in mid-February and continuing until mid-November (260–270 days). A multi-year whole farm grazing systems trial was established in Ballyhaise in 2017 to look at the impact of increasing grazing season length and stocking rate (SR), on animal performance, pasture productivity and imported feed requirements within a grass based milk production system in the BMW region.

Treatments and Results

This study was carried out at Ballyhaise Agricultural College during 2017 and 2018. The study aims to quantify the impacts of alternative SR and grazing season lengths on animal and grass productivity in the BMW region. In January 2017, 120 spring calving dairy cows were randomly assigned to one of four grazing systems comprised of two grazing season (GS) lengths: average (AGS; 205 days; 15 March to 20 October) and extended (EGS; 270 days, 15 February to 20 November) and 2 SR treatments: medium (MSR; 2.5 cows/ha) and high (HSR; 2.9 cows/ha); these treatments are further explained in Table 1.

Table 1. The four grazing systems at Ballyhaise Research Farm						
Stocking rate (LU/ha)	2.5	2.9				
Grazing season length (days)						
Average grazing season (205 days)	AGS X MSR	AGS X HSR				
Extended grazing season (270 days)	EGS X MSR	EGS X HSR				

The effect of GS and SR on animal performance is displayed in Table 2. Grazing season length varied from 209 days for both AGS treatments to 262 and 259 days for the MSR EGS and HSR EGS treatments, respectively. Extending the grazing season in spring and autumn resulted in increased grazed grass utilisation, increased milk and milk solids production per cow and per hectare and a significant reduction in the requirement for supplementary feeds. Stocking rate had no significant effect on individual animal performance. Higher SR resulted in significantly increased milk and milk fat plus protein production per hectare but also in significantly increased supplementary feed requirements. As both AGS treatments were indoors for an additional 60 days, significantly more concentrate and silage was required during lactation compared with the EGS treatments.

Table 2. Effect of stocking rate (SR) and grazing season length (GS) on animal performance and feed requirements during 2017 and 2018						
Grazing season length	Ave	rage	Extended			
Stocking rate	Medium	High	Medium	High		
Milk yield (kg/cow)	5,040	5,211	5,178	5,243		
Milk yield (kg/ha)	12,619	15,131	13,993	15,166		
Fat plus protein yield (kg/cow)	423	448	454	458		
Fat plus protein yield (kg/ha)	1,059	1,299	1,134	1,327		
Grazing rotations (No.)	5.3	5.8	6.3	6.9		
Grazed grass utilisation (t DM/ha)	9.4	10.0	10.3	11.6		
Total grass utilisation (t DM/ha)	14.5	14.0	13.9	14.7		
Concentrate fed (t DM/cow)	0.68	0.70	0.64	0.64		
Concentrate fed (t DM/ha)	1.71	2.03	1.62	1.87		
Silage fed (t DM/cow)	1.66	1.78	1.27	1.19		
Silage fed (t DM/ha)	4.15	5.15	3.17	3.46		

Conclusions

The results of this study show the potential of both extended grazing and higher SR to support increased milk productivity while reducing supplementary feed requirements. Increasing SR resulted in similar milk production per cow and significantly increased milk output per hectare.

Comparing calving patterns for winter milk systems

Joe Patton¹ and Aidan Lawless²

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Summary

- The Johnstown Castle winter milk project compared performance of block spring calving, block autumn calving, and 50:50 split autumn-spring calving systems.
- Increasing the proportion of autumn calving increased milk output per cow; however the value of additional milk was largely nullified by additional purchased feed cost.
- Compared to spring calving, daily milk volume at summer peak was reduced by 9% and 14.7% by split and block autumn calving respectively. Block autumn calving delivered 43% of annual supply in the Oct-Feb period compared to 26% for split calving and 10% for spring calving.
- High EBI cows delivered high milk performance and good fertility across all calving pattern systems.

Introduction

Calving cows in autumn to generate a planned winter milk supply is practiced on approximately 2,700 dairy farms nationally. For the vast majority of these herds, a 'split calving' model is employed, whereby a proportion of cows (typically 20%-50%) calve in autumn and the remainder calve in spring. This approach works best where winter milk payment contracts specify a fixed volume of winter supply. Optimum pattern can be defined as having the minimum percentage of autumn calving required to meet contract volumes in winter. As the Irish dairy industry expands and evolves, a number of key issues emerge regarding the future role of winter milk. The fresh milk market is an essential component of the sector and requires specialist production, but it is of modest and relatively fixed scale (approximately 580 million litres) within the overall industry. Numerous liquid milk producers have thus expanded the spring-calving component of the herd but now face the question of whether retaining a small proportion of autumn calving within the herd is viable. On the other hand, many producers view winter milk as an opportunity to increase output and winter cash flow from a given land base. However, effects on annual costs and labour must also be accounted for. From a processing perspective, the potential for altering milk supply profile to improve efficiencies and handle extra volumes requires clarification.

The study

With these questions in mind, a study comparing the performance of three calving patterns was undertaken at Teagasc Johnstown Castle. Systems compared were SPR-100% compact spring calving; AUT- 100% compact autumn calving and SPLIT- 50% spring and 50% autumn calving. Herds were managed at a grazing stocking rate of 2.90 cows per ha. The SPLIT and AUT herds incorporated maize silage as 33% of winter forage for milking cows. Herd EBI was €156 (€53 milk, €63 fertility). Grazing commenced in early February with the first rotation completed by early April. Mid-season pasture was managed to target 1,400 kg DM/ha pre-grazing cover. The final rotation was completed by early November for the AUT herd and 10–12 days later for SPR and SPLIT herds.

Results

Across a 3-year period, the AUT and SPLIT herds had greater milk output per cow relative to SPR. This arose through a combination of increased annual concentrate input and flatter lactation curves for autumn-calving cows. However, when additional feed costs were accounted for, gross margins per cow (before winter bonus payments) were similar across the systems.

Table 1. Milk and feed profiles for calving pattern systems 2015–2018						
	SPR	SPLIT	AUT			
Milk solids per cow	489	517	561			
Concentrate fed kg DM	536	1,050	1,380			
Mean milk kg/cow Apr-Jun	27.1	24.6	23.1			
% total milk in winter Nov- Feb	10.1	29.4	43.2			
Margin over feed at €0.34/litre base	-	+€11/cow	+€29/cow			
Margin over feed at €0.30/litre base						
price	-	-€3/cow	+€9/cow			
Milk bonus value						
Liquid milk €0.075/litre 50% contract	-	+€129/cow	+€135/cow			
Flat Payment €0.075/litre Nov-Feb		+€150/cow	+€230/cow			

Comparing system overheads and labour in this study is difficult. Using data from commercial farms, it has been estimated that split-calving systems require 3–4 hours extra labour input per cow annually compared to spring calving. Machinery costs are also increased. Labour data on block autumn systems is limited, but it would be expected that hours per cow may be intermediate between spring and split systems. The study highlights that any financial advantage to systems with autumn calving, requires a price incentive to at least offset additional overhead costs. Depending on pricing structure, the AUT system has greatest capacity to generate milk premium values per farm due to the proportion of milk supplied in winter.

When annual supply profiles were compared, the SPLIT and AUT systems reduced peak (Apr-Jun) daily volumes by 9% and 14% respectively. Further modelling work showed that shifting a smaller percentage of cows to autumn from spring had a negligible effect on peak volumes. Therefore, winter supply and peak volume management should be considered as separate but related issues at processing level.

Conclusions

The autumn-calving systems tested did not improve margins over feed but may increase farm overhead costs. Winter milk pricing incentives should combine the dual objectives of securing defined winter milk volumes while maximising production efficiencies across the entire milk pool. Rationalising winter supply schemes toward more specialised herds with a higher proportion of autumn calving may be a suitable strategy.

Optimum stocking rate on the grazing platform of fragmented dairy farms

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Summary

- The stocking rate on the grazing platform of a fragmented farm can be as high as 3.5 cows/ha and remain competitive with non-fragmented farms.
- High quality silage should be made to supplement cows during times of pasture deficit on the grazing platform. This home-grown feed is a cheaper alternative than concentrates.
- There needs to be a clear plan for making and feeding out silage. It is easy to underestimate the amount of high quality silage needed for supplementing cows during lactation.

Introduction

The majority of dairy farms are fragmented and a typical farm of 50 ha has 28 ha in the grazing platform and 22 ha in outside parcels. Before the phasing out of the milk quota, many such farms carried 60–70 dairy cows on the grazing platform (2.2–2.5 cows/ha) with an overall farm stocking rate of 1.8–2.0 LU/ha including replacements and beef cattle on outside parcels. Since the phasing out of milk quotas, many farmers have increased dairy cow numbers. The objective of the current research is to investigate the optimum stocking rate of dairy cows on the grazing platform of a fragmented dairy farm.

It is clear that Ireland's competitive advantage lies in our capacity to turn low-cost grazed grass into milk. Higher-cost alternative feeds expose the farm business to downturns in milk price and upturns in concentrate costs. The challenge for fragmented farms in Ireland is to get the most out of grazed grass on the grazing platform and to get the most out of outside parcels in terms of high quality silage for supplementing lactating cows and dry-cow winter feed.

Systems comparison

Four dairy systems are compared. Each of these systems is stocked at 2.5 cows per ha but fragmented to different degrees as shown in Table 1. Outside parcels are used solely for silage production that is used to fill feed deficits in the feed budget of each herd. On the outside parcels, silage is harvested three times per year (mid-May, Mid-July and end of August) and residual grass is zero-grazed in October or grazed with dry cows in December. So far, this project has been conducted over two relatively difficult years, with a wet spring and a wet autumn in 2017 and a very wet spring and summer drought in 2018. The length of the grazing season decreased with higher stocking rate on the grazing platform (Table 1). Grass growth averaged 16.6 t DM/ha in 2017 and 13.9 t DM/ha in 2018. The amount of grazed grass per cow declined with higher grazing platform stocking rate (GPSR), whereas the quantity of silage harvested increased. Nevertheless, differences in feed costs per cow were relatively small. Concentrate costs were the same because the same amount was fed in each system each year and although the silage costs increased with higher GPSR, some of this was offset by lower consumption of grazed grass. Grazed grass was estimated to cost €80 per t DM, which included the cost of fertiliser, slurry spreading, land rental, lime applied every five years and reseeding at 10 year intervals. Silage making costs were additional to the cost of grass. Degree of fragmentation did not influence silage making costs because contractors charge the same for making silage on outside parcels within

reasonable distances. Housing costs (slurry application etc.) increased with higher GPSR.

In an overall assessment of the four GPSR systems, the additional costs associated with GPSR 3.0 cows/ha and 3.5 cows/ha were offset by the value of additional milk produced on these systems. This surprising result is attributed to supplementing cows on pasture with very low dry matter content (12%) during the spring and autumn with high dry matter silage (35 to 40%) with 72% DMD. We have recorded this in both years and more work is needed before we can draw firm conclusions about it. There was a very clear lesson in the need to make high quality silage for supplementing lactating cows particularly at the higher GPSR. Averaged over two relatively difficult years, the proportion of all silage made, that was fed to the cows during lactation, ranged between 48% and 62%. Clearly it is not good management practice to disregard silage as a 'dry cow feed' even at the lower GPSR.

systems	i budgets a	ind net ma	irgins for t	ne iour
GPSR system	S1	S2	S3	S4
Overall farm stocking rate (cows/ha)	2.5	2.5	2.5	2.5
Proportion of the farm in grazing platform	100%	83%	71%	63%
Grazing platform stocking rate (cows/ha)	2.5	3.0	3.5	4.0
Milk yield (L/cow)	5,455	5,571	5,766	5,425
Milk solids (kg/cow)	456	468	478	457
Fat yield (kg/cow)	255	262	266	255
Protein yield (kg/cow)	201	206	212	201
Grazing days per cow	235	223	211	199
Grazed grass (t DM/ha)	10.8	9.6	9.0	8.6
Grass harvested for silage (t DM/ha)	4.5	5.6	6.3	6.7
Silage fed (t DM per cow)*	1.60	1.77	2.04	2.16
Feed costs (€ per cow)	703	720	743	746
Net margin (€ per 50 ha farm)	117,490	119,604	119,137	105,993
Proportion of silage fed during lactation	48	53	58	62

*Multiply by five to get a rough estimate of silage fresh-weight fed per cow

Conclusions

The stocking rate on the grazing platform of a fragmented farm can be as high as 3.5 cows/ ha and remain competitive with non-fragmented farms. Making high quality silage is a priority on fragmented farms.



HEALTHY COW - HIGH QUALITY MILK



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Chlorine-free cleaning protocols for milking equipment

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Summary

- It is increasingly difficult to achieve dairy product specifications with regard to Trichloromethane (TCM) and Chlorate residues, when chlorine-based cleaning products are used in milking equipment cleaning routines.
- Chlorine-free cleaning protocols require increased usage of hot water, acid detergents and higher working solutions of caustic.

Introduction

There are increased food safety concerns regarding the use of chlorine for cleaning milking equipment, due to residues of TCM and Chlorate. The removal of chlorine from cleaning routines would significantly reduce the risk of these residues in milk and consequently, in final products, such as lactic butter and milk powder. The adoption of chlorine-free cleaning of milking equipment is currently an on-going process. Some milk processors have already requested their milk suppliers not to use cleaning products that contain chlorine. Others are focussing initially on removal of chlorine products from just bulk-tank cleaning routines.

Necessary steps associated with changing to chlorine-free cleaning

Re-calibration of the automatic detergent dosing systems for both milking machine and bulk milk tank:

This will ensure correct uptake rates of the different detergent products; uptake rates may be lower for some chlorine-free products that have slightly higher caustic content than products previously used. Higher working solutions of caustic (0.7–1%) are now applied when cold water is being used.

Hot water for daily cleaning

When chlorine-free liquid based cleaning protocols (as opposed to powder products) are used, regular hot washes (70/80°C) are necessary, with temperatures remaining \geq 40°C on completion of the wash cycle. A suggested routine may involve hot and cold circulation cleaning to be operated after AM and PM milking, respectively.

Peracetic acid: a replacement for chlorine

Peracetic acid has similar antimicrobial properties to sodium hypochlorite and is effective against a broad spectrum of bacteria, spores, yeasts, moulds and viruses. Post milking wash routines can include an additional rinse involving peracetic acid. But caustic detergent solution used for the main circulation must be rinsed thoroughly from the plant before the additional rinse containing peracetic acid. This is important both for safety concerns and effectiveness; otherwise, the caustic could neutralize the acid, making the peracetic acid ineffective.

Chlorine-free cleaning protocols

Using powder products:

A number of potential options can be considered in addition to the use of the caustic powder product:

- Include up to three hot acid washes (phosphoric acid) per week.
- Include peracetic acid in an additional rinse twice daily.
- Add hydrogen peroxide to the diluted powder solution on one occasion per week.

Using caustic liquid and acid:

Combinations of caustic and acid based products can be selected for use in weekly milking machine wash protocols:

- A caustic liquid product (21/29%) used with hot water (70/75°C) four times weekly after AM milking and used with cold water seven times weekly after PM milking. Acid (phosphoric) is then used with hot water on the remaining three times weekly after AM milking.
- Alternatively, a caustic liquid product (21/29%) used with hot water seven times weekly after AM milking and used with cold water seven times weekly after PM milking may be put in place. An additional rinse containing peracetic acid should be carried out after the completed detergent rinse cycles at both AM and PM milking.

Using acid as the main cleaning agent

'One for all' acid based cleaning products (chlorine-free) have been developed. This simplifies the cleaning protocol as one product is multi-functional; this removes organic materials and also sterilizes the stainless steel surfaces.

Chlorine-free cleaning of the bulk milk tank

Various options can be used for fully automatic wash systems:

- Dosing unit can be programmed to use caustic detergent (21/29%) after two collections and an acid detergent (phosphoric/nitric) after the third collection, using hot water (60/75°C) at each collection.
- Alternatively, the caustic detergent could be used daily with hot water and a second pump could be used to add peracetic acid to an additional final rinse after each collection.
- If an acid-based 'one for all' product is used, then no other product is required.

Conclusions

Visit the Teagasc milk quality webpage to get more information on chlorine–free cleaning of milking equipment:

https://www.teagasc.ie/animals/dairy/milk-quality/
Chemical residues in milk and dairy products: proactive management to achieve 'within specification' levels

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Summary

- When detergents containing chlorine are used for cleaning milking equipment and food processing plants, they can result in residues such as Trichloromethane (TCM) and Chlorates in milk and dairy products.
- These residues must be reduced and controlled to product specifications that are acceptable at market level.
- Current and new strategies for control are being deployed.
- If using alternative chlorine-free detergent products, it must be ensured that cleaning is effective and alternative residues do not arise.

Introduction

Dairy foods are nutritious and are an essential part of sustainable diets. However, milk on its journey from cow to human consumer is exposed to various sources of residues linked to modern production practices and processing procedures. Some of those residues are potentially harmful if present at significant levels in product, others impact product quality as perceived by consumers and regulators.

Sources and significance of residues

Chlorine and chlorine-based detergents are the most common chemicals used to assist in cleaning milking equipment and food processing plants, as well as for water disinfection. However, there is increasing concern with regard to the development of TCM in butter and Chlorates in milk powder, i.e. residues derived from chlorine-based disinfectants. The target level for TCM in butter is <0.03 mg/kg, which is equivalent to <0.0015 mg/kg in milk. With regard to Chlorates, the EU Commission has proposed imposing a Maximum Residue Limit (MRL) of 0.01 mg/kg of food. It is already established that many foods, including dairy products may exceed this proposed MRL. There is particular concern in the Irish dairy industry regarding achieving this MRL as a significant portion of the milk and dairy ingredients produced here go towards whole- and skim-milk powders and a new category referred to as Specialised Nutritional Powders (SNP). SNP include infant milk formula and sports nutrition foods with a combined export value of >€1.1b to the Irish economy. The markets for these products are particularly aware of and sensitive to chemical contaminants including Chlorates, as they may be destined for particularly vulnerable consumers. In fact, ~50% of the dairy SNP were exported to China in 2018, with further significant growth expected (www.Bordbia.ie). The market in China is very aware of potential Chlorate contamination in SNP products and, if market value is to be maintained and increased, confirmation that products are within specification for Chlorate will be essential. So these potential residues need to be addressed at both farm and processing level.

Mitigation strategies to address TCM and Chlorate residues

The development of mitigation strategies to control TCM and Chlorate levels in dairy foods will have a significant impact on the capacity of the dairy sector to compete on the domestic and international markets and thus, impact on economic wellbeing and development. Mitigation strategies to reduce and control TCM and Chlorates in dairy foods are broadly similar. Current information includes recommendations on short storage periods for cleaning products containing chlorine, using registered products with chlorine levels of <3.5%, correct volumes of detergent-sterilizer and adequate rinse water levels (14 l/milking unit), rinsing the milking plant immediately after completion of the wash cycle, not re-using detergent-sterilizer solution more than once, not adding chlorine to rinse water, not dipping clusters in chlorine, not reusing rinse water, using Peracetic acid instead of chlorine, and avoiding teat disinfectants that contain chlorine dioxide/chloride. Current research is examining the impact of removing chlorine-based detergents and using alternative cleaning protocols on the microbiological quality of milk and subsequent food products and ingredients. Additional planned work in relation to Chlorates includes:

- Establishing baseline data on Chlorates in dairy foods.
- Examining the potential for Chlorate to accumulate in foods from farm through to factory.
- Examining the efficacy of chlorine-free detergents.
- Investigating any potential new contaminants arising from the use of new alternate detergent formulations.
- Measuring the impact of different water disinfection technologies on Chlorate levels in water.

This challenge is being addressed at a group stakeholder level. Teagasc coordinates the Milk & Dairy Products Quality Working Forum, which incorporates the TCM and Chlorate Working Groups, chaired by Ornua and Teagasc, respectively. The Forum also includes representatives from the dairy companies, and Teagasc Research and Advisory personnel, in addition to other key stakeholders, such as the Department of Agriculture Food and the Marine (DAFM), Food Safety Authority of Ireland (FSAI), Irish Dairy Industry Association (IDIA) and Irish Milk Quality Cooperative Society (IMQCS).

Conclusions

Awareness and proactive management of the risk for TCM and Chlorate residues along the production chain, by quality specialists is a pre-requisite for the sustainable production of high quality and safe dairy products. While these residues can pose risks to dairy products, care must be exercised when changing to alternative chlorine-free cleaning products; firstly, that these products allow effective cleaning and do not lead to high microbial levels in the plant, and secondly, that they do not pose alternative residue risks.



Thermodurics: tips to minimize thermoduric bacteria in bulk-tank milk

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Summary

- Target to minimize transfer of thermoduric bacteria into milk at farm difficult to remove at processing stage.
- The risk of Thermoduric bacteria entering milk via the cow is higher during periods of very dry or wet weather.
- Focus on good hygiene of the cow and her environment.
- Focus on hygiene of the milking plant by following a recommended wash routine.

Introduction

Thermoduric bacteria (i.e spore-former *Bacillus Cereus*) can have serious implications for the quality of milk and subsequent dairy products. They can result in processing problems during product manufacture and quality issues in the final dairy product. Due to their ability to withstand pasteurisation, thermoduric bacteria can limit the shelf life of pasteurised milk. Additionally, some thermodurics are considered as food borne pathogens, thus their numbers in dairy products must be minimised. Ideally, thermoduric counts in bulk-tank milk should be non-detected or less than 200 cfu/ml and counts of 500 cfu/ml or greater are generally at the penalty threshold.

Thermoduric bacteria exist in the dairy cow's environment on-farm, e.g. in soil, bedding and faeces. These bacteria enter milk produced on-farm largely via the cow teats, during milking, in the first instance. Poor milking machine and bulk-tank cleaning can result in multiplication of these bacteria and can further exacerbate the problem. Therefore, the critical control points for minimizing thermoduric bacteria in farm milk are:

- A clean cow and cow environment.
- A totally effective cleaning regime for the milking machine.
- A totally effective cleaning regime for the bulk milk tank.

The presence of thermoduric bacteria is indicative of ineffective cleaning somewhere in the milk production process (cow, environment, milking plant). Detailed protocols for achieving clean cows and environment, clean milking machine and clean bulk milk tank are outlined below.

Cow and milking hygiene

Ensure that teats are clean and dry before milking. If the milk sock is soiled after milking, then teat preparation is inadequate. Where teats are washed pre-milking, they should be dried before cluster attachment.

- Maintain cows in a clean environment if the udders and teats look dirty, then there is a problem. Collecting yards and approach roads should be scraped regularly.
- Clip cow tails and udder hair minimum three times/year.
- Keep hands/gloves clean throughout milking.
- Keep milking clusters clean during milking and if they fall on the floor, flush out completely.

- Do not wash down clusters while still attached to a cow.
- Do not wash down the platform while cows are present.
- Cover meal bins in the parlour (some feed ingredients may contain thermoduric bacteria).

Milking plant hygiene

- Follow a recommended milking machine wash routine https://www.teagasc.ie/ animals/dairy/milk-quality/cleaning-guidelines-for-milking-equipment/.
- Ensure sufficient volume of detergent/water solution so that all surfaces will be in contact with the detergent solution (9 litres/unit)
- Maintain adequate turbulence (air injection for large plants) and vacuum level during the wash cycle.
- Hot water usage is critical (70/80°C) low wash water temperature can be associated with more variability in farm milk bacterial levels.
- Milk stone remover should be used once weekly at a minimum, and more often if water hardness is an issue, or install a water softener.
- After each (twice daily) wash cycle, the milking plant could be disinfected with Peracetic acid in an additional rinse.
- Thermoduric bacteria survive in perished rubber-ware replace milk liners twice yearly and milk tubes every second year.
- Debris can build-up in the plate cooler use clean filter sock during washing and get milking machine technician to clean plates.

Bulk milk tank hygiene

- Disinfect the bulk milk tank outlet regularly.
- Avoid having the milk supply pipe immersed in milk during milk transfer.
- Keep the bulk-tank lid closed at all times, especially during milking.
- Ensure sufficient volume of detergent wash solution for the size of the bulk-tankinsufficient volume will result in poor surface contact with detergent.
- Blocked suck-up detergent tubes will result in insufficient detergent usage, replace these tubes annually.
- Spray balls that are clogged or spinners not moving freely or missing will impact on effective tank cleaning.
- Cool milk to 3/4°C within 30 min of the completion of milking with the aid of a plate cooler, as some thermoduric bacteria will multiply at temperatures above 4°C.

Conclusions

Critical control points for minimizing thermoduric bacteria in farm milk include a clean cow and clean cow environment with an effective milking equipment cleaning regime.

How to choose the best teat disinfectant for your herd

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Summary

- It is important to consider the type of disinfectant along with the specific bacteria causing the infection issue on the farm.
- If disinfecting teats prior to milking always dry teats with paper before cluster attachment.
- Products should be used as recommended by the manufacturer.

Introduction

Teat disinfection is an important part of a mastitis control programme to help reduce the challenge from bacteria, promote good skin condition and produce high-quality milk. The use of post-milking disinfection has been found to reduce new intramammary infections caused by contagious pathogens by at least 50%. Teagasc research has shown staphylococcal bacteria account for 49% of all bacteria on teat skin, followed by streptococcal bacteria (36%) and coliform bacteria (i.e. *E. coli*) (15%).

Evaluation of teat disinfectant products

Teagasc studies have evaluated approximately 100 teat disinfectant products commercially available on the Irish market against mastitis-causing bacteria (*Staphylococcus aureus*, *Streptococcus uberis* and *Escherichia* coli). Some of the main disinfectant ingredients incorporated in products are iodine, chlorhexidine gluconate, chlorine dioxide and lactic acid, with many combinations of these ingredients. Teagasc research will further evaluate these products when applied to cow's teats. Initial results (Figure 1) from testing these teat disinfectant products within the laboratory (tested using the disc diffusion method which determines bacterial inhibition of the product by measuring zones of inhibition in millimetres [mm]) have shown:

- Chlorine dioxide (CD) products were the most effective against Staph. Aureus.
- Products which contained iodine combined with lactic acid (IO & LA) had high level of kill against Strep. Uberis.
- Chlorhexidine products were the most effective against E. coli.
- When all bacteria were considered, products containing chlorhexidine (CH) or a lactic acid and chlorhexidine (LA & CH) combination were found to be most effective.

Results also showed that Strep. Uberis was the most sensitive bacteria to the teat disinfectant products, whereas E. coli was the most resistant.

Overall, products containing chlorhexidine were the most effective against bacterial strains tested. It is important to consider the type of disinfectant along with the specific bacteria causing the infection issue on the farm. Teat disinfectant products may react differently when applied to teats and in the presence of organic matter. Further studies will be conducted on these products to measure the impact of applying disinfectants to teat skin.



Figure 1. Bacterial inhibition (in mm) of products grouped by active ingredient against Staph. Aureus, Strep. Uberis and E. Coli (The most effective teat disinfectant product will have the greatest level of bacterial inhibition (mm)). CD = Chlorine Dioxide, CH = Chlorhexidine, DE = Diamine, IO = Iodine, LA = Lactic Acid, SA = Salicylic Acid

Conclusions

- Refer to the list of teat disinfectant products on the market, which can be viewed on the on Teagasc website (https://www.teagasc.ie/animals/dairy/milk-quality/)
- Check if product is registered. The product will have either a PCS or IMB number on the drum label. This is important for cross compliance checks.
- Use products as recommended by the manufacturer/drum label. i.e. if pre-milking disinfecting, ensure product is recommended for both pre- and post-milking disinfection.
- Ensure the product is correctly diluted as recommended by the manufacturer. If there are any farm water supply issues with regard to water hardness, bacteria and/or pH then ready-to-use products should be considered as opposed to those that require dilution.
- Avoid adding additional emollients as this may have a negative impact on product efficacy.
- Take care when using iodine products and do not use iodine as a pre-milking disinfectant. Iodine products can lead to increased iodine levels in milk.
- Never disinfect teats pre-milking without drying teats with paper. This will reduce the possibility of residues entering the food chain.
- Store teat disinfectants in a cool dry area and do not allow disinfectants to freeze.

Effect of selective dry cow treatment in dairy cows at dry off on SCC in the following lactation Clare Clabby, Sinead McParland, Pablo Silva Bolona and Pat Dillon

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Summary

- Using an internal teat sealant alone compared to using an internal teat sealant plus dry cow antibiotics at dry off in cows that did not exceed 200,000 cells/mL in the previous lactation resulted in higher SCC in the subsequent lactation- however the increase was not large- 20,000 cells/mL.
- Milk recording data and recording of clinical cow mastitis cases are required to identify cows that are suitable to receive internal teat sealant at dry-off.
- Using internal sealants only at dry off requires high level of hygiene- proper teat end preparation and using the correct infusion technique.

Introduction

Antibiotic resistance is becoming a major global concern in both human and animal health. Antibiotic resistance is where bacteria develop immunity to antibiotics. These bacteria can continue to grow despite antibiotic treatment. Misuse and over use of antibiotics are major contributors to the prevalence of antibiotic resistance. In an effort to reduce antibiotic resistance, the European Parliament has passed legislation to restrict antibiotic use in animal production systems. This means only animals displaying subclinical or clinical signs of disease can be treated with antibiotics. Veterinary verification will be needed to treat animals not showing symptoms of disease but are at high risk of infection. Group treatment of animals with antibiotics as a preventative measure will not be permitted. This will come into effect in the year 2022.

Whole herd treatment with dry cow antibiotic at dry off has been a standard component of mastitis control and is currently used in the majority of herds in Ireland. Selective dry cow treatment (SDCT) is an alternative method to whole herd treatment. SDCT involves only administering dry cow therapy to cows showing subclinical/clinical symptoms of mastitis or those who are at high risk of reinfection during the dry period. Low risk cows are administered an internal teat sealant on its own without dry cow antibiotic. Internal teat sealants mimic the actions of the keratin plug which is produced by dry cows, providing a physical barrier against bacterial infection after administration.

Selective dry cow therapy study

A study was carried out on three Teagasc farms (Moorepark, Clonakilty and Curtins) over three years (2015–2017) to assess the effectiveness of treating cows with teat sealant only (ITS) compared to teat sealant plus antibiotics (ITS+AB) at drying off. Cows that did not exceed 200,000 cells/mL and had no clinical mastitis during the previous lactation (LowSCC) were randomly assigned to either ITS only or ITS+ AB. Cows that exceeded 200,000 cells/mL or had clinical mastitis during the previous lactation (HighSCC) were treated ITS+AB. The entire data set included 131, 128 and 395 cows in 2015, 2016 and 2017 respectively, of which 67, 69 and 177, were LowSCC, respectively. Individual animal SCC data was available for each week of lactation over the three years of the study. Individual quarter level samples were available on four occasions over lactation (at dry-off after enrolment, first milking post-calving, 14-days after calving and mid lactation) for cultured bacteriology analysis.

Results

The LowSCC cows administered with ITS+AB had a significantly lower mean SCC and test day SCC over the entire lactation compared to the LowSCC cows administered with ITS only. The mean SCC across lactation of the ITS and ITS+AB cows were 80,900 and 60,483 cells/ mL respectively. There was no significant difference in the mean or test day SCC between the LowSCC cows administrated with ITS only and the HighSCC cows administrated with ITS+AB. At the end of lactation the proportion of cows with SCC greater than 200,000 cells/ mL was similar for both the LowSCC cows treated with ITS+AB and those treated with ITS alone (30%), whereas a greater proportion of the HighSCC group exceeded 200,000 cells/mL (45%). Lowering the threshold SCC in the previous lactation from 200,000 cells/ mL, to 150,000 cells/mL and 100,000 cells/mL decreased the proportion of cows eligible for ITS only treatment from 48% to 38% and 25% respectively. However, regardless of the selection threshold imposed, LowSCC cows treated with ITS alone had a higher SCC than the LowSCC cows treated with ITS+AB.

Across the lactation, 6.0% of the quarters of the LowSCC cows treated with ITS, 2.6% of the quarters of the LowSCC cows treated with ITS+AB and 5.2% of the quarters of the HighSCC cows had bacteria present in the foremilk. The most abundant pathogen identified was *Staphylococcus aureus*.

Conclusions

Results from this study show that prophylactic antibiotic treatment at drying off does aid the reduction of SCC across the subsequent lactation. However, the SCC and infection level in the present study was not problematic. The results show that the proportion of cows which exceeded 200,000 cells/mL at the end of lactation was similar for both LowSCC cows treated with ITS alone and LowSCC cows treated with AB+TS while a higher proportion of HighSCC cows (ie those which had high SCC in the previous lactation) exceeded 200,000 cells/mL at the end of lactation. Bulk-tank SCC readings from all herds in the current study remained below 200,000 cells/mL throughout the majority of the study. This indicates that herds with good mastitis control programmes can use internal teat seal alone at drying off on cows which had SCC of less than 200,000 throughout the previous lactation with only small effects on herd SCC.

Routine milk recording and the recording of clinical mastitis cases in the previous lactation is required to correctly identify cows suitable for ITS only at dry-off (SDCT). Additionally, a high level of hygiene, proper teat end preparation and using the correct infusion technique is critical when considering SDCT as a dry-off practice.



Responsible antibiotic use in mastitis control Finola Mc Coy

Animal Health Ireland, Carrick-on-Shannon, Co. Leitrim

Summary

- The use of antibiotics in both animals and humans increases the risk of developing antimicrobial resistance.
- Improving animal health reduces the need for antibiotics.
- Use as little as possible and as much as necessary.

Introduction

The introduction of penicillin in the 1940's, which began the era of antibiotics, has been recognized as one of the greatest advances in therapeutic medicine. Antimicrobials, including antibiotics, have been life-changing and in many cases life-saving for both humans and animals. However, antimicrobial resistance (AMR) is fast becoming part of our everyday vocabulary, and it is now recognised as being a significant threat to human health. AMR is resistance of a microorganism to a drug to which it was previously susceptible, for example when a bacterium develops resistance to a particular antibiotic that used to kill it. It is now well recognised that the use of antibiotics in both animals and humans increases the risk of AMR developing.

National progress in udder health

Improving animal health reduces the need for antibiotics. Positive steps are already being taken, with an overall improvement in the udder health of the national herd in recent years. Since the commencement of the *CellCheck* programme in 2011, the proportion of herds and milk volume nationally with an annual average SCC <200,000 cells/mL has increased from 39% to 68%, and 46% to 71% respectively, between 2013 and 2017. The national average bulk-tank SCC has also reduced during this time, from a high of 272,000 cells/mL in 2009 to 175,000 cells/mL in 2017 (Figure 1).



Figure 1. Annual average bulk-tank SCC (2007–2017)

Analysis of national intra-mammary product sales data from 2003–2015 also shows a reduction in the number of in-lactation mastitis treatments sold. The 'defined course dose' per 100 animals per year reduced to 46.6 in 2015 from a high of 69.9 in 2008 (Figure 2).



Figure 2. Usage of in-lactation intramammary antimicrobials on Irish farms ('03-'15)

Antibiotic dry cow therapy

However, there is still potential to make even more prudent antibiotic choices in the area of mastitis control. 'Blanket' dry cow therapy (DCT), where all quarters of all cows are treated with antibiotic at drying off, was recognised until recently as best practice and has made a very positive contribution to udder health in many countries. Antibiotic DCT undoubtedly has an important role to play in treating infections that persist at the end of lactation and maximising cure rates. However, it has also traditionally been used to prevent new dry period infections. In January 2019, a new Veterinary Medicines Regulation was agreed by Europe, which states that antibiotics should not be used in a preventative fashion. Is it time, therefore, to consider an alternative to blanket DCT, such as 'selective' DCT? This is when only selected cows i.e. those with infected quarters, are treated with antibiotic before drying off. Internal teat sealer is often then used in the remainder of the herd as one of the measures to prevent new infections. While this is considered a more prudent use of antibiotic and would reduce antibiotic use on many farms, we need to ensure that such an approach does not negatively impact udder health.

Critically important antibiotics

In 2005, the World Health Organisation first classified all antibiotics into three different types or categories, based on their importance to human health; important, highly important and critically important. A list of "Highest Priority Critically Important Antibiotics (HPCAIs) for Human Health" was developed. These include some products that are licensed for mastitis treatment, such as third and fourth generation cephalosporins and macrolides. DAFM have subsequently adopted a policy on their use which states that they:

- should <u>not</u> be used in a preventative fashion, or as a first line of treatment.
- should only be used to treat an animal(s) where a milk culture and/or sensitivity result indicates that there is no effective alternative treatment.

Conclusions

While positive change is already underway in relation to antibiotic use for mastitis treatments, there are expectations and opportunities for us, as an industry, to do more. As custodians of animal health, it is important that we do our best to prevent disease in the first instance. When it comes to antibiotics, a good principle is to "use as little as possible, but as much as is necessary".

The importance of milk recording and the use of your milk recording reports to improve overall herd performance

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Summary

- Milk recording reports contain significant quantities of information but the usage of this information at farm level is low.
- Better use of milk recording reports combined with ICBF Sire Advice has the potential to assist in improving genetic gain by identifying the best animals from which to breed replacements.
- Improved interpretation along with better mastitis incidence recording will be necessary to make the correct decisions at dry off in a selective dry cow therapy environment in the future.
- Early milk recording i.e. first milk recording carried out within 60 days of calving is crucial to analysis of dry cow therapy during the previous dry cow period.

Introduction

Milk recording in Ireland is low with just 33% of herds and only 48% of cows recorded in 2017 (ICBF). This compares very poorly with other countries such as New Zealand (75% of herds) and Denmark (90%).

Milk recording reports provide a significant volume of information however; lack of interpretation and action upon results limits the potential to improve herd performance.

Rightly or wrongly, somatic cell count (SCC) management is one of the main reasons that people milk record. Failure to deal with high SCC results following a milk recording can have consequences in terms of milk production performance throughout the remainder of the lactation and increase the risk of spread of infection to other non-infected cows. Furthermore, failure to dry off cows correctly on the basis of their SCC performance throughout lactation could potentially carry an udder health problem from one lactation to the next. Many rely on the blanket dry cow therapy approach to solve problems encountered during the lactation at dry off. This is a strategy that will not work into the future as blanket dry cow therapy comes to an end from 2022. High new infection rates i.e. >10% is an indication that practices during the previous dry period were not adequate, thus highlighting the need for dramatic improvement in hygiene if selective dry cow is to be considered. It is important to note these high infection rates occur with the luxury of an antibiotic preparation and sealer. Milk recording is very important for identification of subclinical mastitis. Records of mastitis incidence are also important. Cows may have responded to treatment of mastitis and may not have elevated SCC at milk recording and therefore could be overlooked for antibiotic treatment at dry off. Mastitis incidence records are going to increase in importance due to the ban on blanket dry cow therapy in the future. There are numerous ways to record mastitis cases, text message to ICBF, use of farm software packages or simply a diary. What works best for an individual will be the best system. The most important thing is that mastitis cases are recorded as this could have a significant impact on milk quality into the future. Milk quality issues not only impact from a financial point of view but also can be a significant source of stress on farm and should be avoided if at all possible.

Along with SCC management, improving udder health and reducing the usage of antibiotics, milk recording provides excellent detail on cow performance. Prior to and following quota abolition the objective of getting stock on the ground has surpassed the requirements in terms of the quality of that stock with all cows being bred to dairy. As the expansion begins to slow, more and more are looking to now improve the quality of the stock in the herd to maximise herd performance. Interpretation of milk recording data and the information that it provides will have a critical role to play in the development of breeding plans on farm in the future. This information when combined with the revised Irish Cattle Breeding Federation (ICBF) Sire Advice programme launched in 2018 will help to maximise the rate of genetic gain at farm level which is strongly correlated to profitability.

Milk samples collected when recording can also be used to diagnose pregnancy as well as testing for disease such as Johne's at individual cow level.

Conclusions

The number of herds milk recording in Ireland is low relative to our international counterparts and needs to increase significantly. Its importance will become even more critical as blanket dry cow therapy is phased out. Combining milk recording information with ICBF Sire Advice will help accelerate herd genetic gain. Milk sampling at milk recording also allows the options to screening for Johne's and also to diagnose pregnancy.



Prediction of onset of calving from tail elevation — preliminary evaluation of a novel biosensor John Mee¹ and Lisa English²

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Summary

- A tail-mounted gravitational measuring monitor and accompanying software was developed to detect onset of calving.
- Testing in 30 cows showed that prolonged elevation of the tail +/- an abnormal standing pattern were observed within three hours of calving.
- This novel device (and its algorithms) and preliminary results, show the potential of predicting onset of calving using a tail-mounted biosensor.

Introduction

The timing of calving can be difficult to predict accurately. Ideally, farmers would like to be able to predict to within a few hours when a cow is going to calve in order to observe normal calvings or to intervene during abnormal calving and to care for the newborn calf. But, both the signs of impending calving and the ability of the observer to detect and interpret them are highly variable. In recent years there has been renewed interest in automated monitoring of calving. Some approaches only predict the day of calving while others attempt to predict the hour of calving. One area which shows potential promise is monitoring of tail elevations pre-calving as this has been shown by behavioural observations to uniquely change within hours of calving in cows.

Hence, the objective of this study was to pilot-test a new biosensor to predict the onset of stage two of calving in dairy cows. The study was also designed to detect any problems associated with *in vivo* testing of this pre-commercial prototype and to collect preliminary data from calvings to train the predictive algorithms.

Calving monitor

The device consisted of a tail-mounted sensor with rechargeable battery, charging dock and a base station (Figure 1). The monitor was attached to the upper side of the cow's tail approximately 6 cm below the anus using a self-adhesive bandage wrap. The accelerometer and other gravitational measuring devices within the monitor recorded data every two seconds on the time the cow was either standing or lying down, and percentage of time the tail was held at various angles from 0 to >90 degrees.





Cow study

The device was tested on 30 dairy cows (10 primiparae, 20 pluriparae). Cows were housed in a group pre-calving pen and adjoining individual calving pens, both straw-bedded. The device was attached to the cow's tail for between 4 and 0.5 days pre-calving. The actual time of calving was established by 24 hr staff supervision and CCTV.

Results

Of the 30 cows on which devices were placed, 29 calvings were monitored, (10 primiparae, 19 pluriparae); 23 unassisted, four easily assisted and two difficult. The reason for the incomplete recording was the loss of one of the tail units in the bedding. In recorded calvings, prolonged elevation of the tail (\geq 30–45 degrees for >20 seconds and four repetitions within 60 minutes), either alone or in combination with an abnormal standing pattern (within a 30 min. period) were observed within three hours of all calvings (unassisted calvings 1.5 hours; assisted calvings three hours).

Conclusions

It is concluded that prolonged tail elevation combined with increased restlessness was indicative of imminent calving. The monitor was able to detect and record the pattern of calving behaviours and the algorithm was able to detect distinct onset of calving-specific behavioural change up to three hours before birth. Thus this prototype device shows potential to detect the onset of stage two of calving. A further study in a larger population of animals with this device is required to confirm these preliminary results.

Effect of feeding pooled high quality colostrum on the health and performance of dairy calves John Barry and Emer Kennedy

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Summary

- Feeding pooled colostrum did not affect calf health or performance during the pre-weaning period.
- Only colostrum with >50 mg/ml IgG from animals with a clean health status should be used.
- A risk of disease transfer exists when pooling colostrum, and herd health status should be assessed before application.

Introduction

The structure of the bovine placenta prevents transfer of immunity between the cow and calf *in-utero*. Passive immunity must therefore be acquired by calves through the ingestion and absorption of antibodies (predominantly IgG) found in colostrum. Successfully acquiring passive immunity is influenced by a number of factors, which include the IgG content of colostrum, timing of feeding, as well as the volume provided. Failure to achieve passive immunity has negative implications, both short and long term, which include increased risk of health issues, as well as reduced growth rates and survival rates. A recent study by Teagasc Moorepark found that feeding pooled colostrum (i.e., combining colostrum from a number of cows) is commonly practiced (> 35% of commercial Irish dairy farms). Pooling colostrum can reduce the labour requirement during the calving season, as providing each calf with colostrum from a single cow can be laborious. Combining colostrum from a number of cows could increase the risk of both the spread of disease (e.g., Johne's) and failure of passive transfer occurring. Currently there is limited information available on the effect of pooled colostrum feeding on calf health and performance within seasonal calving systems. To investigate this, a study was conducted at Teagasc Moorepark.

Sixty calves (Holstein-Friesian (HF) and HF x Jersey) were enrolled in the study and assigned to one of three treatment groups; 1) received colostrum from their own dam, 2) received colostrum for a single cow which was not the dam, and 3) received colostrum pooled from three different cows using equal volumes from each. Cows from which colostrum was used were selected based on known immune status. Each calf received a volume of colostrum equivalent to 8.5% of their birth bodyweight, provided by stomach tube. Only colostrum with an IgG concentration >50 mg/ml, determined by Brix refractometer (>22%), was permitted for use in a feeding treatment. Colostrum samples were collected prior to feeding, while blood samples were taken from all calves immediately after birth and again at 24 hrs to assess passive immunity levels. During the pre-weaning period (0 to approx. 76 days of age), calves were examined twice daily and all cases of morbidity, and mortality, were recorded. Weighing was carried out immediately after birth, but also on a weekly basis up to weaning. The herd within which this study was conducted operates to the highest standards for maintaining herd health. This includes the application of comprehensive vaccination programs, as well as conducting disease testing on a regular basis, with any Johne's positive cows being culled immediately.

Results

No difference was found between the IgG concentration of colostrum provided to each of the treatments, which was almost twice that of the recommend threshold (≥50 mg/ml) for each group. Similarly no differences existed between birthweight, weaning weight and 24 hr serum IgG concentration between calves in each of the three treatment groups, which are summarised in Table 1.

Table 1. Mean colostrum IgG concentration, 24 hr serum IgG concentration, birthweight and weaning weight of calves that received colostrum from their own dam, from another dam, or pooled from a number of cows

Treatment group	Colostrum IgG (mg/ml)	24 hr serum IgG (mg/ml)	Birthweight (kg)	Weaning weight (kg)
Own dam	99.4	52.0	33.3	93.7
Other dam	95.2	55.6	34.3	91.7
Pooled	100.7	53.0	34.0	94.0

The number of calves which experienced health issues, and required treatments was not different among the groups, and there were no cases of mortality during the course of the experiment. The reported findings are from year one of the experiment, which will be repeated for a second year.

Preliminary findings indicate that when colostrum quality is assessed prior to feeding, and using only that with \geq 50 mg/ml IgG, pooling did not reduce the IgG concentration through a dilution effect. Findings also indicate that there were no associated impacts on health and performance of calves fed pooled colostrum, within a high health status herd. In such settings, feeding pooled colostrum could improve labour efficiency without any negative impact on calf health and performance. It must be noted, however, that this experiment was conducted in a controlled environment using a high health status herd (Moorepark Research Centre), where calf health was monitored regularly and prompt treatments provided where necessary.

Conclusions

Feeding pooled colostrum had no effect on calf health or performance, when only colostrum with \geq 50 mg/ml IgG was included. This is a feeding strategy which could be used to reduce the labour demand associated with calf rearing. It must however, only be conducted using colostrum from animals with a clean health status to prevent disease transfer within the herd.

Calf health and welfare on commercial farms; what's the current situation?

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Summary

Introduction

Herd expansion has created challenges at farm level, and particularly for the management of young calves which are born in large numbers in a relatively short period of time. Achieving good health and welfare standards for calves is important to reduce mortality rates, as well as the time requirement for nursing sick calves and the number of veterinary visits/treatments required. A Teagasc Moorepark study was conducted in 2017 which investigated calf health and welfare on 47 commercial Irish dairy farms. This study provided information on current risk factors to calf health, and allowed for welfare improvement options to be identified.

To ensure the herds visited were representative of dairy herds nationally a number of criteria were set;

- operating spring-calving, pasture based production systems.
- minimum herd size of 70 cows.
- subscribed to the HerdPlus® (50.3% subscription rate nationally).

Each herd was visited twice during the calving season. The initial visit occurred in the first six weeks of the calving season, while the second visit took place during the final six weeks of calving. During each visit an interview was conducted with the principal calf manager to assess management practices, and where possible differentiate between management of male and female calves, but also dairy and beef calves. Environmental measurements were also taken to assess the conditions in which calves were accommodated, while animal-based measurements were taken to directly assess calf health.

Management Practices

From the interviews it was found that on 32% of farms, calves were removed from the cow immediately after birth, and the majority (over 55% farms) feed calves 2–3 L of colostrum for their first feed. On 37% of farms, calves received colostrum from a pooled source. On approx. 28% of farms, calves received colostrum by sucking the cow, while colostrum quality was measured on fewer than 15% of farms. Lower rates of mortality were experienced in herds which treated scour cases by administering electrolytes, while continuing to offer milk as normal, compared to herds which deviated from this, for example by reducing the volume of milk offered, or withholding milk from calves identified as having scour.

Environmental conditions

Hygiene of feeding implements (e.g. teat feeders, stomach tubes) was assessed using swab test kits. These kits measure levels of milk residues and biological contaminants (bacteria and fungi) present. Hygiene results indicate that hygiene practices for feeding implements can be improved, and particularly in the latter half of the calving season. Results also showed that particular attention should be given to cleaning stomach tubes and feeding bottles — the first implements used to feed new-born calves. Space allowances per calf was also measured and mean values of 2.9 (range 1.00-9.02) and 3.1 (range 0.70-9.74) m²/ calf identified in visit one and two, which are almost twice that of the minimum legal requirement of $1.5 \text{ m}^2/\text{calf}$.

Animal measurements

Colostrum samples were collected to determine quality of colostrum. Mean colostrum IgG concentration was 85 (range 4.3–324.7) mg/ml; however, approximately 21% of the total samples collected had IgG concentrations below the 50 mg/ml threshold. Blood samples were collected from calves during both visits to assess level of passive immunity achieved. Mean serum IgG concentration in visit one was 30.9 mg/ml and 27.1 mg/ml in visit two, which greatly exceeds the minimum value for adequate passive immunity (10 mg/ml). No difference was found between the serum IgG concentration of male and female calves, or dairy and beef breed calves. No relationship existed between herd size (which varied between 73 and 373 calves) and calf mortality rate (which varied between 2.3 and 26.7% in the first 12 months of life). Of heifers which died within 12 months of birth, over 60% did so before four weeks of age. This highlights the importance of calf management during the early stages of life, as this is when calves are most vulnerable and losses are most likely to occur.

Conclusions

Colostrum quality is generally high on Irish dairy farms; however, large variation exists, which highlights the need for quality assessment prior to feeding. High rates of passive immunity are achieved among dairy and beef calves, both male and female. This indicates that calves are managed in a way which facilitates the achievement of passive immunity. While scour remains one of the most common causes of calf health issues, by providing the correct treatment in a timely manner, improved outcomes can be achieved.



Causes of death in calves — how accurate is our diagnosis?

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Summary

- The causes of death in dairy calves (n=120) diagnosed by the farmer and by postmortem examination were compared over seven years (2013–2019).
- In young calves (<7D old) there was moderately good agreement (69%) between the clinical and postmortem diagnoses.
- In older calves (≥8D old) there was poor agreement (38%); under-diagnosis of stomach and multiple organ infections contributed to this.

Introduction

According to the national report of the six regional veterinary laboratories, infections of the gut (scour), multiple organs (systemic infections) and the lungs (pneumonia) are the three most common causes of death in calves less than six months of age. Given that only a small proportion (~<10%) of dead calves are submitted for postmortem, farmers often rely on their own diagnosis to determine the cause of death. Hence, the objective of this study was to explore how well farmers' diagnoses aligned with postmortem diagnoses and how we could improve the former if they deviated greatly from the latter.

Research study

The data for this survey came from spring-born dairy calves (n=120) which died between 3 and 122 days of age (53% \leq 7D and 47% >7D old) and were submitted by farmers (n=35) to the Moorepark Postmortem Laboratory over a seven year period (2013–2019). Each ear-tagged carcass was accompanied by the calf passport/identity card and a submission sheet containing the history of calf illness and treatment. A complete postmortem examination was conducted on each calf with collection and submission of samples for laboratory examination as required. The 'symptoms' reported by the farmer on the calf submission sheet were compared with the outcome of the postmortem and laboratory testing (gold standard) for young (3–7D old), older (8–122D old) and all calves. The five most common farmer and the five most common postmortem diagnoses were compared for level of agreement.

Results

In total, there were 21 farmer and 18 postmortem diagnosis categories. For calves \leq 7D old, the five most common postmortem diagnoses were intestinal atresia (blocked bowel), systemic infection (multiple organ infection), aspiration pneumonia (colostrum tubed into lungs), enteritis (scour) and other congenital defects (deformed calves). There was very good agreement between farmer and postmortem diagnoses for atresia (82%) and other defects (75%), but poor agreement for aspiration pneumonia (50%), enteritis (40%) and systemic infection (0%). For calves \geq 8D old, the five most common postmortem diagnoses were systemic infection, enteritis, abomasal ulceration (stomach ulcers), navel infection and bloat. There was very good agreement between farmer and postmortem diagnoses for bloat (100%) and enteritis (78%), but poor agreement for septicaemia and navel infection (25%), and abomasal ulceration (0%).

Excluding congenital defects, the two most common causes of calf mortality across all ages diagnosed by farmers and by postmortem were scour (15%) and systemic infection

(21%), respectively. In cases of systemic infection (Figure 1), farmers most commonly reported these as scour and tended to underdiagnose the additional infections. Similarly, in cases where farmers diagnosed scour alone they tended to underdiagnose additional sepsis.



Figure 1. Systemic infection was the most common cause of calf mortality (enteritis — infection of the bowel on the left; and peritonitis - infection of the abdomen, on the right)

Conclusions

While farmers are good at diagnosing some causes of calf mortality such as deformed calves and bloat, they are less accurate in differentiating between uncomplicated scour and scour accompanied by other organ infections (systemic infection). Systemic infection should be suspected whenever a calf is diagnosed with a simple infection, e.g. scour or navel ill.

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Calf pneumonia — new technology to automatically monitor calf housing and its effects on calf health and growth rate

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Summary

- A new UCD-Teagasc calf pneumonia study is testing automatic monitoring of ventilation in calf housing.
- Eight farms (450 calves) with a history of calf pneumonia have been enrolled onto the three year study in 2019.
- Real-time, remote, environmental monitors have been installed both outside and inside the calf housing.
- The calves' immunity, infection, health and growth rates are being recorded every three weeks during housing.

Introduction

An exciting new animal health research project has just started at Moorepark. In collaboration with the Veterinary Faculty in UCD, Teagasc is participating in a multisite study on calf pneumonia in spring 2019. We are investigating the possibility of automatically monitoring both the external and internal calf house environments and how these affect calf growth, immunity and health, in particular risk of pneumonia. To-date, precision livestock farming (PLF) has concentrated on cow applications (e.g. automated heat detection); this is the first application of PLF for calf heath in Ireland.

Pneumonia is the primary cause of mortality and a major cause of illthrift and antimicrobial usage in calves of one month of age and older. While it is normal for dairy calves to carry respiratory pathogens, pneumonia is precipitated by various stressors. One of the critical stressors is the calf's environment, especially ventilation, particularly at calf-level (the microenvironment).

Research study

Eight dairy farms around the country which have automatic calf feeders and a history of calf pneumonia have been enrolled in this longitudinal three year study. On each site real-time, remote environmental monitors have been installed both outside and inside the calf housing. These weather stations will automatically record air temperature, relative humidity, wind speed and various gas concentrations (e.g. ammonia, CO₂) using multi-diagnostic sensors 24 hours/day for the entire housing period. Every three weeks, the farms are being visited and the calves (n=450) examined. All calves are being weighed, temperature-checked and health-scored. In a subsample of calves, thoracic ultrasonography is being used (for the first time in Ireland) to assess lung pathology and blood and nasal mucus samples are being collected. The blood will be examined for evidence of failure of passive transfer of colostral antibodies, inflammatory markers and antibodies to respiratory pathogens. The nasal samples will be used to detect inflammatory mediators and the presence of respiratory pathogens. The farmers are keeping records of feed intake and all calf treatments.

The data from the 450 calves will be used to establish the relationships between environmental conditions and mucosal immunity, pathogen carriage, pneumonia (whilst accounting for passive transfer) and calf growth rates. This is a pilot study the results from which will be used to design a cross-sectional study on a larger number of dairy farms nationally.

The ultimate aim of these studies is to develop evidence-based guidelines for the construction of new, and the modification of existing calf housing to reduce the incidence of pneumonia (Figure 1), improve calf growth rates and reduce antimicrobial use in Irish dairy herds.



Figure 1. Pneumonia is the number one cause of death in calves over month old Photo shows severe pneumonia (infection of the lungs) and pleurisy (inflammation of the lung surface)

Conclusions

Calf pneumonia is a major animal health problem on dairy farms contributing greatly to increased antimicrobial use. Prevention of respiratory disease in calves through automated housing environmental monitoring combined with modern diagnostic techniques may reduce antimicrobial use and hence, risk of anti-microbial resistance (AMR).

Are automatic calf feeders more labour efficient than manual feeders?

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Summary

- Automatic milk feeders are more labour efficient than manual feeders.
- Weight gain from birth to weaning was similar for automatic milk feeder and manual milk feeder.

Introduction

As post-quota expansion continues in the Irish dairy industry, more calves are entering the system as replacement heifers. To-date, the Irish dairy industry has faced a severe shortage of people in the workforce and must now search for alternatives, such as automation of different tasks e.g. calf feeding. Increased use of on-farm automation is seen as a labour efficient investment for farmers. Calf rearing is a labour intensive task on dairy farms. If management systems are adapted to use automatic milk feeders, improvements in the labour of calf rearing could be achieved, when compared to manually feeding calves. However, this feeding system cannot compromise calf welfare, health or weight gain in order to maximise the animal's potential in later life.

Study

In spring 2019 a study commenced at Teagasc Moorepark to investigate the effect of feeding calves using automatic and manual milk feeders on labour, welfare, health and growth rates. At birth, 60 heifer calves were divided into two treatment groups equal for breed, birth weight, and birth date. The two treatments were i) automatic milk feeding systems and ii) manual milk feeding systems.

Colostrum and transition milk management were the same for all calves; within an hour of birth heifers were fed three litres of good quality colostrum. Heifers were then fed six litres/heifer/day of transition milk for three days in an individual pen.

Heifers were grouped from three days and moved to a pen with either an automatic milk feeding system or a manual milk feeding system. There were two pens with automatic feeders and two pens with manual feeders, with 15 calves in each pen. The automatic feeding system used was a Volac Vario Feeder with automatic washing. The manual feeding system consisted of preparing and distributing milk manually using a compartmentalised teat feeder. Each calf was fed 26% crude protein milk replacer at a rate of six litres/heifer/ day (reconstitution rate 15%). Automatic calves were given three feeds of 2L spaced evenly throughout the day to prevent calves from over-drinking at one time. Manual calves were given two feeds of 3L/day; morning and evening. Ad-libitum water, concentrate and hay were offered from three days old. Calves were gradually weaned off milk replacer based on weight; 90 kg for Friesian and 85 kg for Jersey crosses.

During the trial, the time involved in food preparation, feeding, cleaning, bedding, health observations, calf care and training calves to their respective feeders were measured three days per week using a stopwatch. Measurements were taken by observing one labour unit completing each task. Calves were health scored twice per week as well as weighed and observed for behaviour weekly.

There were no significant differences between automatic and manual feeders in relation to the average number of days to weaning with calves fed using automatic feeders being weaned at approximately 81 days (11.6 weeks) and calves fed manually being weaned after an average of 79 days (11.3 weeks). There was also no significant difference between the two feeding systems in weaning weight (92.4 kg) or average daily gain (ADG) from birth to weaning (0.74 kg/calf/day).

Significant differences in labour were recorded between automatic and manual feeding systems. A lower labour input was required for calves fed via an automatic feeder 00:53sec/calf/day in comparison to manually fed calves, which had a labour requirement of 02:21sec/calf/day. The average time taken to complete various tasks per day differed between automated and manual feeders, in particular training calves and feeding inspection (Figure 1).



Figure 1. Average time/task/day for manual versus automated feeding system

Conclusions

Automatic calf feeders are more labour efficient than manual calf feeders. There was no difference in weight gain between either systems, however, data from this study in relation to welfare and health needs to be analysed before definite conclusions can be made about automatic calf feeders. A full economic appraisal will also be required as there is a large difference in cost between the two systems.



Do weaning age and post-weaning growth rate have an effect on replacement heifers achieving target weight?

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Introduction

Replacement heifers represent the future potential of the dairy herd. However, the cost of rearing a replacement heifer is high at €1,545; in addition calf rearing is one of the most labour-intensive tasks on a dairy farm so can also incur extra costs associated with additional labour. Weaning calves at an earlier age (e.g. 8-weeks) compared to delayed weaning (e.g. 12-weeks) and feeding a higher quantity of concentrate post-weaning could help overcome the demand for additional labour and contribute to reducing costs associated with rearing a replacement heifer. However, to ensure heifers realise their potential in the lactating herd they need to achieve target weights at specified time points in the first two years of life (Table 1).

Table 1. Bodyweight (Kg) targets for heifers at six months, breeding and pre-calving (HF = Holstein-Friesian, JE= Jersey) HF*JE 3 month old 115 80 100 10 month old 250 175 215 Pre-breeding 330 240 295 550 405 490

Study

Pre-calving

In spring 2018 a three-year study commenced at Teagasc Moorepark to investigate the effect of weaning calves at either eight or 12 weeks of age. At birth, 98 heifer calves were divided into four treatment groups making sure they were equal for breed, birth weight, and birth date. The four treatments were i) weaned at eight weeks and offered a high level of concentrate post-weaning; ii) weaned at eight weeks and offered a low level of concentrate post-weaning iii) weaned at 12 weeks and offered a high level of concentrate post-weaning and iv) weaned at 12 weeks and offered a low level of concentrate postweaning. It was expected that when weaned at 12-weeks of age calves would be heavier than those weaned at eight weeks, but the experiment aimed to investigate if weaning earlier (e.g. 8-weeks) and offering greater concentrate in the post-weaning period would result in similar weights at key time-points, such as at breeding.

Colostrum and transition milk management were the same for all calves; within an hour of birth heifers were fed three litres of good quality colostrum. Heifers were then fed six litres/heifer/day of transition milk for three days in an individual pen. Heifers were grouped from three days and fed 26% crude protein milk replacer at a rate of six litres/heifer/day using an automatic feeder (reconstitution rate 15%) until they were gradually weaned (over a week) off milk replacer at eight or 12 weeks old. Ad-libitum water, concentrate and straw were offered from three days old.

After weaning, heifers were managed in groups of 50. Heifers had full time access to pasture and were supplemented with 2.5 or 1.5 kg concentrate/heifer/day depending on their post-weaning feeding rate (high and low concentrate, respectively). Heifers in both the high and low post-weaning growth rate groups were fed a common diet of silage and concentrates over winter. At turnout in March, heifers previously on high and low concentrate were grazed to 4.5 cm and 3.5 cm post-grazing sward heights, respectively. Heifers were weighed twice a month until housing and once a month thereafter.

In the pre-weaning period, eight and 12 week weaned calves consumed 50.4 kg/calf and 75.6 kg/calf of milk replacer, respectively. Weight gain was not different between weaning groups up to week eight as calves were fed identical diets. From week 8–12, 12 week weaned calves gained on average 0.79 kg/day and eight week weaned calves gained on average 0.62 kg/day. As a result there was a 6.1 (± 1.81) kg weight difference between the eight and 12 week weaned calves at 12 weeks. This 6.1 kg weight difference remained until turnout in early February. However, by breeding at 15 months, 12 week weaned calves were only 3.2 kg heavier than eight week weaned calves (Figure 1).



Figure 1. Liveweight across weaning and breed groups

Conclusions

At 12 weeks the eight and 12 week weaned calves were on average 72.4 and 78.5 kg, respectively. The weight difference between the eight and 12 week weaning groups had reduced to 3.2 kg by breeding at 15 months. However, this is only data from the first year of the experiment and data from the next two years needs to be collected and analysed before definite conclusions can be drawn.

Acknowledgements

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Contract heifer rearing — the national research study

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Summary

- Contract rearing (CR) involves sending dairy replacement heifers away from their source farm to another farm to be reared for an agreed fee and duration.
- A four year national research study on CR has commenced in Moorepark involving 168 herds and 6,500 heifers.
- The majority of farmers send heifers to herds within the same county.
- The majority of calves go to the contract rearer at 2–4 months of age and return at 18–21 months of age.
- The research will establish the biosecurity risks/animal health problems/fertility/ growth rates/milk production associated with contract rearing.

Introduction

Ireland's national dairy herd expansion has prompted increased interest in collaborative farming practices. One such practice, contract rearing, allows dairy farmers to expand using their existing land base and labour resources and supplements the income of contract rearers.

However, a major biosecurity issue associated with CR is the movement of animals between farms. Depending on the type of CR arrangement, heifers from multiple sources may be co-grazed and housed, representing a potential route for disease transmission.

National Contract Rearing Study

A Teagasc/UCD research study commenced in 2018 focusing on the animal health implications of CR. This study will follow the progress of heifers sent from source dairy farms to contract rearers and those reared at home (control farms) from birth to the end of their first lactation. Farms are being visited twice annually to examine the heifers; body weight, body condition score and health score (for diarrhoea, respiratory disease, navel infection, and other illnesses). Various samples including blood, faecal and nasal mucous samples are being collected. In addition, bulk-tank milk samples are being collected and each farmer has completed a biosecurity risk assessment questionnaire relating to disease prevention practices on their farm.

A total of 168 farms (~6,500 heifers) were recruited to the study using animal movement data records and a national public awareness campaign; 60 source herds sending heifers to 57 contract rearers and 51 control farms (rearing their own heifers). Preliminary results are presented here.

Characteristics of contract rearing in Ireland

On average, source dairy farms (SDF) have more heifers (64 heifers/herd) than control farms (47 heifers/herd). The most common contract type is one source dairy farmer sending heifers to one contract rearer (70% of CR arrangements), with a small percentage (2%) of SDFs sending heifers to more than one rearer. (Figure 1). The majority (75%) of dairy farmers sent heifers to contract rearers in the same county.



Figure 1. Types of CR arrangements between source dairy farmers and contract rearers

The majority (53%) of source dairy farmers intend to send their heifers to the contract rearer between two and four months of age, and the majority (56%) expect to bring their heifers back between 18 and 21 months of age (Figure 2).



Figure 2. Age that heifers leave (left) and return (right) to source dairy farms (SDF)

Conclusions

Potential high biosecurity risk practices have been identified in this study. The implications of these CR arrangements on animal health, fertility and performance will be monitored over the life of the heifers.



How do we measure dairy cow welfare on-farm? Robin Crossley, Natasha Browne and Muireann Conneely

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Summary

- Measuring welfare helps to ensure that every cow's needs are being met and that her environment is suitable.
- Both animal-based (e.g. health scoring) and resource-based (e.g. facility design) measures of welfare are necessary.

Introduction

Animal welfare is a reflection of how an animal is experiencing its environment. There are three focal areas: health and biological function (e.g. absence of disease, maintaining milk production), expression of natural behaviour (e.g. sufficient lying time, heat expression, social interaction), and affective state (experiencing positive or negative emotions, e.g. pleasure, fear, hunger). To ensure that we are meeting the cows' needs in each of these areas it is important that we measure the state of the animals directly (animal-based measures), as well as the environment in which they live (resource-based measures). Animal-based measures of welfare (Table 1.) assess the animals' own experience of their environment and how they interact with it. Resource-based measures of welfare (Table 2.) assess environmental factors that are typically related to the design of their facilities.

Table 1. Animal-based measures of welfare and their importance				
Measure	How is it measured?	Why is it important?		
Body condition	Routine herd body condition scoring <i>Target:</i> 2.75–3.25 at dry off & start of breeding, 3–3.5 pre- calving	Loss/gain in body condition → indicator of health problems or feed availability		
Lameness	Routine herd mobility scoring Target: <2 on a 0–3 scale*	Early detection reduces pain, improves recovery and productivity		
Injuries	Hair-loss, skin abrasions and cuts	May be painful and indicate unsuitable environment		
Disease	Frequency/type of disease & signs of poor health	Healthy cows are free from pain and discomfort, productive and capable of performing natural behaviours		
Behaviour	Monitor lying time, social behaviours <i>Target</i> :10–14 hrs/d lying time	Changes in normal behaviour may indicate environmental or management problems		

Table 2. Resource-based measures of welfare and their importance			
Measure	How is it measured?	Why is it important?	
Milking system	Collecting yard stocking density Target: 1.5m²/cow	Adequate space → reduced aggressive behaviours between cows	
	Holding time pre- and post- milking	Long periods of time in the collecting yard \rightarrow longer standing times \rightarrow increasing lameness prevalence	
Roadways	Daily walking distance	Long walking distances can increase lameness and reduce body condition	
	Roadway condition	Dirty roadways \rightarrow increased mastitis. Loose stones and eroded areas \rightarrow increased lameness	
Paddock	Presence of clean, functioning water troughs	Ad-lib access to safe drinking water is critical for health and production	
	Quantity/quality of grass available	Ensures cows have sufficient grass to meet energy demands	
Housing	Cubicle stocking density and comfort (e.g. bedding type & thickness) Target: 1.1 cubicles/cow	Overstocked & uncomfortable cubicles \rightarrow decreased lying time \rightarrow increased lameness, reduced rumination time and production	
	Bedding cleanliness	Wet and soiled bedding → increases mastitis prevalence	



Figure 1. Examples of animal- and resource-based welfare measures.

Conclusions

Ensuring good animal welfare is a key factor in managing healthy and productive dairy cows and maintaining a sustainable dairy industry. Measuring animal welfare on farms is an important tool to assess how a cow is experiencing her environment. There are a variety of indicators that can be used to measure welfare, both animal- and resourcebased, that can help us understand whether a cow is experiencing good or poor welfare.

*https://dairy.ahdb.org.uk/resources-library/technical-information/health-welfare/ mobility-score-instructions/#.XN5dGo5Kg2w

Sub-optimal mobility in pasture-based dairy cows

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Summary

- Sub-optimal mobility refers to any abnormality to a cow's gait which causes a deviation from the optimal/normal walking pattern of a cow.
- Sub-optimal mobility is associated with economic losses due to decreased milk yield, elevated somatic cell count, prolonged calving intervals and early culling.

Introduction — why is sub-optimal mobility important?

Sub-optimal mobility has the potential to reduce the overall lifetime performance of dairy cows due to milk production losses and increased culling. Sub-optimal mobility has been identified as one of the most important health-related economic losses, whereby a severe case of sub-optimal mobility (lameness) has been estimated to cost up to \in 300 per case. The direct costs associated with sub-optimal mobility arise from reduced milk yield, discarded milk, veterinary bills and antibiotics, and increased labour, while the indirect costs arise from reduced fertility, increased risk of future mobility issues or other diseases, body condition losses, and increased culling. As well as being a concern for economic losses, sub-optimal mobility is also associated with pain, making it an important issue in terms of animal welfare.

Is sub-optimal mobility an issue in pasture-based systems?

A recent study of 62 Irish dairy farms in which all the cows were mobility-scored, found that 37% of all the cows had some form of sub-optimal mobility, whereby sub-optimal mobility refers to 'any abnormality to a cow's gait which causes a deviation from the optimal walking pattern of a cow'. Cows were mobility-scored twice (once during early lactation and again during late lactation) using the UK Agriculture and Horticulture Development Board four point scale. Using this scale; a score of 0 refers to a cow with optimal/perfect mobility. A score of > 0 refers to a cow with sub-optimal mobility, ranging from mild to quite severe deviations from the optimal walking pattern of a cow. The majority of cases of sub-optimal mobility are caused by claw disorders. Claw disorders can be either infectious or non-infectious types, and range in severity and are usually quite painful to the cow. Infectious claw disorders include; digital dermatitis (mortellaro) and interdigital phlegmon (foul) and non-infectious claw disorders include; overgrown claw, sole hemorrhage (sole bruising), whiteline disease and sole ulcer. Non-infectious claw disorders are by far the most prevalent in pasture-based systems. The most common non-infectious claw disorder was sole hemorrhage (sole bruising), followed by overgrown claw, whiteline disease and sole ulcers. It was found that even cows with mild forms of the various claw disorders are more likely to be classified as having sub-optimal mobility. It was also found that cows with lower body condition are more likely to have sub-optimal mobility compared to cows with relatively higher body condition, and that higher parity cows are more likely to have sub-optimal mobility.

What are the consequences of sub-optimal mobility?

Although it is well known that severe forms of sub-optimal mobility are associated with substantial losses in terms of milk production and increased culling, less is known regarding the impacts of mild and moderate forms of sub-optimal mobility, particularly in pasture-based systems. When comparing 305-day milk yields of Irish pasture-based cows with sub-optimal mobility, compared to cows with optimal mobility, milk yield losses of up to 320 kg per cow per lactation were found (Table 1). Cows with sub-optimal mobility were also found to be associated with elevated somatic cell count (SCC), whereby the average lactation SCC was increased by up to 1.4% for cows with sub-optimal mobility compared to cows with optimal mobility. Calving interval was longer for cows with sub-optimal mobility (up to 6.3 days longer) compared to their optimally mobile herd mates. It was also found that cows with sub-optimal mobility were more likely to be culled compared to their optimally mobile herd mates.

Table 1. Estimates and the standard error (SE) of the effect on 305-day, milk, fat, and protein yield for each level of sub-optimal mobility (mobility score 1, 2, 3) compared to cows with optimal mobility (mobility score 0)

	Mobility	7 score 1	Mobility	v score 2	Mobility	v score 3
Yield (kg)	Estimate	SE	Estimate	SE	Estimate	SE
Milk	20.00	17.26	-155.27**	42.23	-320.74**	94.64
Fat	0.35	0.81	-7.22**	1.99	-6.8	4.46
Protein	0.74	0.60	-4.85**	1.46	-10.2**	3.27

***, **, *, † Estimate is significantly or tends to be different from 0 (P < 0.001, 0.01, 0.05, 0.10).

Conclusions

Sub-optimal mobility is an issue in pasture-based dairy farms in Ireland, associated with economic losses (reduced milk yield, prolonged calving intervals, increased somatic cell count, earlier culling), and welfare concerns. The prevalence of sub-optimal mobility could be reduced by good management practices, appropriate infrastructure and by routine mobility scoring to facilitate earlier identification and treatment of problem cows.

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Schmallenberg virus — lessons learnt from the emergence of a novel virus

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Summary

- Schmallenberg virus (SBV) was identified in Ireland in 2012 A Teagasc/UCD research project was set up to monitor the virus in dairy herds using blood and bulk-tank milk samples and midge surveillance studies.
- From this research it is predicted that SBV, and other insect-borne viruses (e.g. BTV), will affect Irish herds in the future.
- Bulk-tank milk ELISA testing was demonstrated to be a suitable surveillance tool to monitor SBV infection dynamics in dairy herds.

Introduction

In Autumn 2011, cows with fever, diarrhoea, and drop in milk yield were observed near the German town of Schmallenberg. Blood samples revealed the presence of a novel virus which was named Schmallenberg virus (SBV). In late 2011/early 2012 an outbreak of abortions and congenital malformations in calves, lambs and goat kids spread across continental Europe. It soon became evident that SBV was an insect-borne teratogenic virus. The first Irish case of SBV was confirmed in Cork in late 2012 in a calf. Subsequently, an outbreak of congenital Schmallenberg disease occurred in the south and south east of Ireland in late 2012/early 2013. Hence, a joint Teagasc-UCD-DAFM research project was established with the aim to:

- monitor SBV circulation in dairy herds in the south of Ireland.
- evaluate the ability of bulk-tank milk (BTM) ELISA results to predict SBV seroprevalence within herds.
- investigate the species and abundance of *Culicoides* biting midges on Irish livestock farms and evaluate their potential role in the transmission of SBV and other novel insect-borne viruses.

SBV research project

A sentinel herd surveillance program (bovine serology and *Culicoides* entomology and virology) was established on 26 dairy cattle farms located in the south of Ireland between 2014 and 2017. Bovine serum samples and bulk-tank milk (BTM) samples were collected and analysed for SBV antibodies. *Culicoides* biting midges (Figure 1) were also collected and identified to species level on 10 study farms and a sub-sample of specimens was tested for SBV. Experimental laboratory viral studies were also conducted.

Results

During the two years (2014 and 2015) following the initial Schmallenberg outbreak in Ireland, there was little, if any evidence of SBV circulation in Ireland. However, SBV re-emerged and recirculated at a significant level in Ireland in late 2016 and early 2017 resulting in a second outbreak of congenital Schmallenberg disease. SBV continued to circulate at a low level during 2018. An abundance of putative *Culicoides* biting midge vectors was identified on Irish cattle farms. The re-emergence of SBV in Ireland in 2016 is likely a result of wind-assisted transport of virus-infected *Culicoides* into Ireland from continental Europe.

The future?

Given the relatively recent re-incursion of the virus and resultant boost in herd immunity, renewed SBV disease is not predicted nationally in 2019. Should a subsequent re-incursion occur in the future farmers can monitor their dairy herd status using the bulk-tank milk test (where available) and if a serious outbreak is predicted (or has already occurred in the rest of Europe), re-introduction of SBV vaccination may be warranted. Use of fly repellents has not been shown to prevent spread of the virus. The latest research indicates that the virus may overwinter in the midge population and so via trans-ovarian transmission may spread infection during the subsequent midge-active season meaning cyclical outbreaks are likely.



Figure 1. Midges spread the Schmallenberg virus to cattle and sheep

Conclusions

This project highlighted that SBV appears to circulate in a cyclical pattern every couple of years and is likely to continue this pattern of virus emergence and re-emergence on farms in Ireland. Bulk-tank milk ELISA testing was also demonstrated, for the first time, to be a suitable surveillance tool to monitor SBV infection dynamics in dairy herds.

Herd health approach to the transition period Niamh Field

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Summary

- Preventative herd health monitoring is an efficient method of achieving high standards of dairy cow health and performance.
- Herd body condition score, negative energy balance and calcium status are three key areas for monitoring transition cow health.
- It's important that herd health targets are set and if the incidence of herd health problems is greater than the targets, professional help should be obtained.

Introduction

In order to effectively improve the health and performance of dairy cows, dairy herd managers need to adopt a preventative herd health approach to managing cow health, rather than the traditional way of treating individual cows as they get sick. The transition period from calving into lactation is the most important period in terms of the health of a dairy herd. During this time, cows suffer production diseases such as ketosis, milk fever, fatty liver, retained placenta and displaced abomasum. These diseases can have huge effects on the subsequent performance of the cow for the rest of the lactation.

Preventative and monitoring approach

Three key areas should be considered in the herd health approach to transition cow management:

- Body condition score management (BCS).
- Negative energy balance (NEB).
- Calcium status (clinical and subclinical milk fever).

For each health problem area, performance targets should be set, and a monitoring plan put in place. Table 1 shows a checklist for transition herd health problems used in Australia (https://www.dairyaustralia.com.au/).

Table 1. Checklist for transition herd health problems				
Health Problem	Target	Seek help If		
Milk fever	<1% (old cows >8yrs; <2%)	>3%		
Clinical ketosis	<1%	>2%		
Abomasal displacements	<1%	>2%		
Clinical mastitic	<5 cases/100 cows	>5 cases/100 cows/		
Chincal mastrus	first 30 days	first 30 days		
Lamonoss	<2% with mobility score	>4% with mobility score		
Lameness	>2 out of 5	>2 out of 5		
Retained foetal membranes	<4%	>6%		
Vaginal discharge after 14	-29/	>10%		
days	<3%			
Assisted calving	<2%	>3%		

Table 1 demonstrates target incidence rates for important production diseases, and when to seek help from your veterinary practitioner Data gathered from monitoring each area must be recorded, so that shortfalls in performance can be recognised promptly and actions taken.

BCS

Maintaining an appropriate BCS is the most important aspect of transition cow health. A cow that is over-conditioned at calving is more likely to suffer from excessive negative energy balance, milk fever, ketosis, fatty liver and retained placenta. Optimal BCS for each stage of the lactation cycle are outlined in Table 2. Cows should be body condition scored at dry off, at calving and at breeding at a minimum. Changes to the diet can then be made for the herd, or for groups of cows that fall outside the target BCS.

Table 2. Target body condition score				
BCS at drying off	2.75–3.0			
BCS at calving	3.0–3.25			
BCS at breeding	2.75 minimum			

Negative energy balance

Negative energy balance (NEB) is a problem affecting early lactation cows, when feed intake is insufficient to meet the energy demands of milk production. Almost all cows will have a degree of NEB in early lactation, but excessive or prolonged periods of NEB can lead to conditions such as ketosis, fatty liver, and displaced abomasum.

To monitor NEB in the herd, indicators to be monitored are:

- Less than 15% of early lactation cows with milk protein <3.05%.
- Less than 15% of cows with a milk fat: protein ratio >1.4.
- <25% of cows with >0.5 units of BCS loss in early lactation.

Milk Fever

Clinical and subclinical milk fever are related to increased incidence of mastitis, slow calving, retained placenta, ketosis, and displaced abomasum. Key targets for monitoring are:

- Clinical milk fever cases of 0-2%.
- Retained placenta cases of <4%.
- Dietary Mg concentration of 0.4% of dry matter.

Where there is an increase in milk fever or retained placenta cases, further investigation can be carried out during the calving season by way of blood testing dry cows and fresh cows. Where dietary Mg is below 0.4% dry matter, steps can be taken well before the start of calving to increase Mg concentration in the diet.

Conclusions

The transition period is a challenging time for dairy cows, and poor herd health management at this stage can have significant consequences for the rest of the lactation. Focussing on prevention and monitoring health performance means farmers can reduce losses, improve animal health and welfare, and increase profits.
Improving herd biosecurity and effective Johne's control

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Summary

- An effective biosecurity plan for Johne's reduces the risk of infection entering the herd and identifies management practices to contain the spread of infection in herds where it is present.
- Remove infected and test-positive animals early to limit further contamination of sheds and pastures.
- Limit introductions to high assurance animals preferably from herds in the Irish Johne's Control Programme (IJCP), or close the herd.
- Feed clean colostrum and milk from test-negative cows to calves.

Introduction

Biosecurity describes the actions necessary to prevent diseases entering a herd (bioexclusion) and to limit their spread (biocontainment) if infection is unintentionally introduced.

An effective biosecurity plan is an insurance policy against infection establishing in a herd. By carrying out the suggested management actions a farmer is able to limit the spread of infection within a herd.

Biosecurity planning for Johne's

Most infectious diseases, eg. BVD, IBR and Johne's, may enter herds by way of a carrier animal. In the case of Johne's infection, the most likely source of infection is a carrier animal. At the time of introduction, such animals may appear healthy and be testnegative but still be capable of spreading infection. It is only with the passage of time and at subsequent tests that such animals are identified as infected.

This can occur some years after their introduction. During that time sheds, yards, and paddocks - wherever the infected animal has been - may have been contaminated with MAP, the bacterium which causes Johne's disease. Sometimes the carrier animal may have left the herd.

However, introduced animals are not the only source of infection and farmers should be alert to the risk associated with the spreading of slurry from other farms on pastures grazed by young stock, and by feeding colostrum or milk from an infected herd.

To prevent Johne's entering a herd

- Maintain a closed herd if possible.
- Limit the number of stock introduced to those purchased or leased from a herd and has an active risk management plan in place.
- Maintain a colostrum bank to avoid purchasing colostrum.
- If sourcing slurry, obtain this from pig farms.
- Provide visitors with clean protective boots and clothing to avoid transfer of infection from one farm to the other.
- Keep farm equipment and all vehicles away from the calf house.

To limit the spread of Johne's within a herd

A biosecurity plan should also focus on preventing the spread of infection within the herd. Practices which reduce the risk of infection spread are often cheap and easy to adopt, and improve calf health.

Like rotavirus, Johne's infection spreads in the dung of carrier animals. Calves become infected when they kept in an unclean environment or drink dung-contaminated colostrum, milk, or water.

- Calve cows (known test-positive cows) away from the main calving area.
- Remove calves soon after birth, ideally within 15 minutes.
- Avoid feeding colostrum or milk from ELISA test-positive or confirmed infected cows to calves.
- Use milking routine-best practice to collect colostrum.
- Wear clean clothing when handling and feeding colostrum.
- Limit foot traffic, through calf houses.

These biosecurity practices are easy to carry out and should be part of everyday animal health management. Biosecurity is not expensive to implement but may require a change of thinking about farm routines. A veterinary risk assessment and management plan (VRAMP), conducted by an Approved Veterinary Practitioner (AVP) as part of the IJCP identifies where your herd's health is at risk. Your AVP can also work with you to develop some practical risk management strategies.

Effective prevention and control of all diseases, especially Johne's, includes both biocontainment and bioexclusion (Figure 1). Prior to the diagnosis of any infectious disease, the emphasis should be on bioexclusion — avoiding the introduction of infection. After diagnosis, focus on biocontainment, to limit environmental contamination and the spread of infection. Farmers should pay attention to both bioexclusion and biocontainment at all times, even after a negative Whole Herd Test.



Figure 1. Herd-level biosecurity for effective disease control

Conclusions

The cornerstones of Johne's prevention and control are early removal of infected and test positive animals, feeding clean colostrum and milk for calves and separating calves from cows soon after birth. These practices combined with closing a herd, or limiting introductions are the basis of an effective Johne's biosecurity programme.

For information on the management of biosecurity and the Irish Johne's Control Programme visit http://animalhealthireland.ie/



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Advancements in genomic evaluations Deirdre Purfield¹, Jennifer Doyle¹, Joanna Newton¹ and Astrid Blom²

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Summary

- Genomic selection uses DNA information to help predict the future performance of an animal and its progeny.
- To minimise the risk associated with using genomic bulls, a bull team appropriate for the herd size should be used.

Introduction

Genomics is the study of an individual's DNA. All genes are composed of DNA, and it is the variation within the DNA that makes cows different. Therefore, knowing the DNA of a new-born calf, and how this DNA affects performance, enables prediction of how well that animal and its future progeny will perform. This is the basis of genomic selection, which incorporates DNA information into national genetic evaluations to more accurately identify the genetically superior candidate parents of the next generation.

How does it work?

The first step in genomic selection is to establish a reference population. The reference population is a large genotyped population of animals with accurate performance information such as milk yield or fertility. The associations between the DNA and performance measures are then derived from this population. Several thousand animals are required to form a good reference population; presently there are over 8,000 informative animals within the Irish Holstein-Friesian reference population. Increasing the size of the reference population is essential to ensure genomic prediction estimates are accurate. The average reliability of genomic proofs of young animals is now 63%. A recent validation exercise revealed the accuracy of genomic evaluations is 16%-35% more accurate than evaluations based solely on parental average. New research clearly shows that there is a further benefit if genotyped cows are also included in the reference population; the accuracy improves a further 5–10% over just using information on sires (Table 1).

Table 1. Accuracy of predictions for now proven bulls based on parent average, genomic evaluations based on just a sire reference population or also including cows							
TraitParentGenomic evaluations —Genomic evaluations —averagesire reference populationsire+cow reference population							
Milk	0.55	0.64	0.71				
Fat	0.44	0.59	0.65				
Protein	0.48	0.65	0.68				

Value of genotyping females in the herd

The current cost of genotyping all female calves in a herd is $\in 22$ /head (incl. VAT). This is considerably cheaper than overseas, where genotyping costs range from $\in 31$ in Australia to $\in 90$ in Canada. The cost of genotyping female dairy calves can be recouped through better selection of herd replacements. This is illustrated in the Figure 1, where the breakeven genotyping cost at a 21% replacement rate assuming 80% of females genotyped

are retained is €49, more than double the actual cost. For example, a herd that keeps 80% of heifer calves as replacements and has a replacement rate of 21% has an expected net benefit of genotyping of €33 per heifer retained. Genomic information can also be used to confirm parentage, identify lethal/major genes, estimate inbreeding and predict the breed composition of an animal.



Figure 1. The breakeven cost of genotyping females for different replacement rates

Minimising risk

Despite the recent increases in reliability with genomic selection, it is important to acknowledge that the EBI of an individual animal can still change over time as more information accumulates. To minimise the potential risk of using genomically selected bulls, a bull team should be used with the minimum team size being dependent on the herd size (Table 2); this achieves a bull team reliability of 95%. For example in a 100 cow herd, equal usage of eight unrelated genomic sires is recommended to mitigate proof fluctuation. While using daughter proven bulls instead of genomic bulls can reduce risk on an individual bull level, it reduces genetic gain. This was seen when comparing seven high EBI genomic bulls and seven high EBI daughter proven bulls from the 2011 active bull lists with their 2017 EBI. Results showed that, on average, the team of seven genomic bulls were €52 ahead of the daughter proven bull team in 2011 to 2017.

Table 2. Recommended bull team size by herd sizes				
Herd Size (Incl. heifers)	Recommended minimum number of unrelated bulls			
51–100	7			
101–150	8			
151–200	10			
201–250	11			
251–300	12			
301–400	14			

Conclusions

Genomic selection is accelerating the rate of genetic gain in EBI through the more accurate identification of genetically elite males and females. It is, however, important to minimise risk associated with genomic selection by using large bull teams.

Milking more information from DNA Áine O'Brien¹, Pierce Rafter¹ and Michael Keane²

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Summary

- Much more information can be extracted from DNA over and above that now routinely used in genomic evaluations.
- Identification of genetic mutation carrier animals using DNA information can minimise losses by strategic mating schemes.

Introduction

Genomics is the study of DNA and has been incorporated into genetic evaluations in Ireland since spring 2009. Genomic evaluations are arguably the most discussed benefit of genomics in dairy cattle, but many other benefits also exist (Figure 1).



Figure 1. Potential uses of genomics in dairy cattle

Parentage and inbreeding

Accurate parentage is crucial for both genetic gain and the development of optimal breeding programs to avoid inbreeding. The incidence of parentage errors in Irish dairy cattle is currently 8.5%. The impact of parentage errors on genetic gain is dependent on the (heritability of) the trait and the number of progeny per sire. For fertility, which has

a heritability of ~3%, and with an average of 66 progeny per sire, an 8.5% parentage error rate reduces genetic gain by 5.9%. DNA information can be used to identify and correct these parentage errors.

Inbreeding occurs when related individuals are mated and can result in inbreeding depression. Inbreeding depression is the opposite of heterosis and tends to compromise performance, particularly fertility, health, and survival. From pedigree information, the level of inbreeding of an animal is calculated as half the relationship between the parents but the exact relationship between animals cannot be known solely from pedigree information. The true relationship between animals can only be accurately determined where DNA information on both individuals is available. ICBF's sire advice now considers DNA information when advising matings.

Monitoring major genes and lethal mutations

Traditionally, animals that were carriers of genetic mutations were only identified following the birth of their progeny. The ability to identify carriers using DNA information before selecting replacement animals minimises losses due to unfavourable genetic mutations by strategic mating schemes. DNA can also provide information on a whole range of major genes. Interest is growing in the A1/A2 variant of beta-casein because of its perceived impact on human health. The A2 variant is often perceived to be a healthier variant for humans, and therefore has the potential to command a higher milk price and can open up new market opportunities. A cow with two copies of the A1 variant will produce pure A1 milk, while pure A2 milk is produced by a cow with two copies of the A2 variant. The frequency of the different cow types in the different breeds based on Irish data is in Table 1. The A2 variant is more common in Irish dairy cows.

Table 1. The frequency (%) of the A1 and A2 beta-casein protein genotypes in different dairy breeds based on Irish data						
Genotype	Holstein-Friesian	Jersey	Montbéliarde			
A1/A1	14.4	8.0	17.7			
A1/A2	45.3	30.4	48.7			
A2/A2	40.3	61.6	33.6			

Lethal genetic mutations are only expressed when an individual has received two copies of the unfavourable variant and results in death before or soon after birth. Mutations in genes of known lethal effects (e.g., CVM, BLAD or DUMPs) can be detected using DNA information. In the absence of DNA information, carrier animals can only be identified through analysis of the frequency of embryo loss or stillbirths in their descendants, as there are no other observable effects.

Conclusions

There are many uses for DNA information in addition to incorporation into genomic evaluations. The potential of the information gleaned from genotypes will be realised as more animals are genotyped. This will be particularly evident in the role of precision DNA-based matings.

Breeding for improved animal health Alan Twomey¹ and Siobhan Ring²

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Summary

- Significant genetic differences between cattle exist for a wide range of health traits.
- Breeding is a long term and sustainable strategy that can improve the resistance of cattle to many diseases.
- Selecting animals with better genetic merit for disease resistance will improve the health status of your herd, reduce production costs, and increase profitability.

Why breed for health?

As cow reproductive performance and longevity continue to improve, animal health is now a growing concern, especially as cow age increases. It is often believed that disease can only be prevented by farm management practices such as biosecurity, vaccination and hygiene. But even in some of the best managed herds, cattle can succumb to disease. Therefore, cattle vary in their genetic ability to resist infection to multiple diseases.

Genetic differences in animal susceptibility

Animal resistance to almost every health trait is under genetic control, and can therefore be included in animal breeding programs if sufficient data were available. Despite the low heritability, rapid genetic gain is achievable for all health traits. For example, recent research undertaken by Teagasc Moorepark revealed that 2% of the inter-animal variability in susceptibility to Johne's disease in dairy cows was due to genetic differences; this is similar to calving interval. Substantial genetic gain for calving interval has been achieved in the last 20 years, and this rapid genetic gain is therefore also achievable for Johne's disease.

New breeding values for TB and liver fluke

Since January 2019, following extensive research conducted by Teagasc Moorepark, breeding values for resistance to both TB and liver fluke have been available for AI sires from www.icbf.com. This enables identification of sires that will produce progeny genetically more resistant to TB and liver fluke. Just like the current health traits in the EBI, it is favourable to select sires that have lower breeding values for resistance to TB and liver fluke. Breeding values for resistance to TB and liver fluke are expressed as the expected prevalence of infection in that animal's progeny. Thus, if a bull has a breeding value of 2% for TB resistance, on average, 2% of his progeny are expected to become TB reactors in their lifetime if in infected herds. A similar system has been developed for liver fluke. The optimum use of breeding values for TB and liver fluke is to select sires that have the highest EBI but also have the lowest breeding values for TB and liver fluke resistance (Figure 1). In the future, it is planned that these breeding values will be available for all animals and included in the health sub-index of the EBI.





Do breeding values for health traits really work?

Genetic evaluations for health traits were validated by calculating a breeding value for each of the health traits for a group of animals using only data from their ancestors (i.e., no health data from any animal in this group were used to calculate their own breeding values). These animals were then followed throughout their lifetime to determine whether or not they were diagnosed as infected with TB, liver fluke, lameness or mastitis. As expected, animals with favourable genetic merit for resistance to the individual health traits (i.e., a low breeding value) were less likely to be diagnosed infected to the respective disease. The difference in prevalence between animals that were in the best 20% and the worst 20% based on their genetic merit for the individual health traits was 26% for TB, 17% for liver fluke, 58% for lameness and 44% for mastitis (Figure 2). Selecting animals with a lower breeding value for resistance to health traits will therefore reduce prevalence of the respective disease in your herd.



Figure 2. Prevalence of diseases in cows in the worst 20% and best 20% of the respective disease based on breeding values for each disease using ancestry information only

Conclusions

As cow fertility improves and cows live longer, animal health will become the main cause of involuntary culling. Animal breeding is a complementary tool to current herd health management practices, which is both an economically and environmentally sustainable way of reducing disease in your herd.

Breeding for improved efficiency in a growing herd Sinead McParland¹ Maeye Williams¹ David Kelly¹ and

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Summary

- The vast majority of life-time efficiency is already captured in the EBI; nonetheless, large exploitable variability among dairy bulls in efficiency metrics still exist.
- Successful breeding schemes require routine access to large datasets that are not always available for difficult to measure traits such as feed intake and methane emissions.
- Low-cost tools that are already routinely available are being investigated as proxies for use in breeding for efficiency.

Introduction

One of the easiest approaches to breeding for life-time efficiency is to breed for longevity in tandem with greater milk output, while simultaneously avoiding any increase in cow size; this is the approach adopted within the EBI, which also selects for longer lactations via improved fertility. In fact, approximately 72% of the variability in daily feed efficiency is already captured within the EBI; furthermore, every $\in 10$ increase in EBI is associated with a 2% reduction in the carbon footprint per kg fat and protein corrected milk yield produced. Notwithstanding this, inter-animal variability does exist in both feed intake and carbon emissions independent of EBI, and thus strategies to capture these warrant investigation.

The extent of variability in feed-related efficiency

Dry matter intake at grass, milk yield, body weight and body condition score are regularly recorded at Moorepark, thus providing a rich source of information to quantify interanimal variability in efficiency. The grass intake of mid-lactation grazing Holstein-Friesian dairy cows averaged by sire (where each sire had at least five daughters with feed intake measures) is illustrated in Figure 1; all cows were fed grass only. Clear differences exist, but of course, on average, larger cows that milk more tend to eat more. Once account is taken of differences in live-weight, body condition score and milk energy yield, large differences among sire progeny still exist as evidenced by the *feed difference* metric in Figure 1 (negative is deemed more efficient). Based on 1,801 records from 704 cows sired by 63 different bulls, a difference of three kg in grass dry matter intake per day existed even when adjusted to the same live-weight, body condition score and milk energy yield (Figure 1).

Genetic differences in methane emissions

While inter-animal variability in daily methane emissions is known to exist in Ireland, the proportion of this variability that is due to genetics is currently unknown for Irish cows. International studies in dairy cows suggest that up to 30% of the variability in daily methane emissions is due to genetics, indicating that it is possible to breed for reduced daily methane emissions. Research is underway to quantify the rate of genetic gain achievable to reduce methane emissions without sacrificing much in the rate of genetic gain for other traits within the EBI.



Figure 1. Average (a) dry matter intake, and (b) feed difference in mid-lactation dairy cow progeny of 63 Holstein-Friesian AI bulls

Potential breeding strategies for improved efficiency

The measurement of feed intake and methane emissions in grazing dairy cows is resource intensive, thus limiting the ability to achieve accurate genetic evaluations. Moorepark boasts the largest database globally on actual grass feed intake measures in grazing dairy cows, with feed intake records on 1,380 animals with accompanying genetic information. Far fewer records exist for methane emissions. Nonetheless, Moorepark pioneered research on predicting feed intake from milk samples. All milk samples taken in Ireland, either on individual cows or bulk-tank samples, are subjected to a technology called infrared spectroscopy. This entails shining light in the infrared region of the electromagnetic spectrum on each sample, and the pattern of absorbance is used to routinely predict milk fat, protein and lactose (globally). Moorepark has demonstrated that this technology can also be used to predict feed intake and energy balance. International research has reported that it is also possible to predict methane emissions; research has just started in Moorepark to test the latter hypothesis using grazing Irish cows. A genetic evaluation was undertaken for Moorepark cows based on their feed intake predicted from their milk sample; their predicted genetic merit for feed intake was subsequently correlated with their actual grass intakes with the conclusion that indeed genetic evaluations for feed intake based on milk samples do segregate animals on actual grass intake.

Conclusions

Although the vast majority of life-time efficiency is already implicitly captured within the EBI, there is still scope for improvement as evidenced by the large inter-sire variability in feed efficiency. Because milk samples are routinely tested for different constituents, the potential to use these data in a breeding program aimed at improving efficiency is well underway.

Potential to improve product quality Michelle Judge¹, Sinead Mc Parland¹, David A. Kenny¹, Jessica Coyne¹ and Thierry Pabiou²

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Summary

- Large genetic variability exists for milk quality.
- Up to 16% of the differences in meat quality are due to genetics.
- Up to 18% of the variability between cattle achieving the desired factory carcass specifications is due to genetics.

Introduction

The consumer desire for quality over quantity is intensifying. While significant improvement has occurred in both milk and meat quality in recent decades, through a combination of breeding, management and processing, considerable additional gains are still possible. In this paper, product quality refers to detailed milk quality metrics (e.g. concentration of different fatty acids and total omega-3 levels), meat sensory characteristics (tenderness, flavour and juiciness), and also carcass specifications.

Variability in detailed milk quality parameters

The cost of generating detailed milk quality parameters using gold-standard approaches on a sufficiently sized population to enable genetic evaluations is prohibitively expensive. All milk samples collected for milk recording are subjected to analysis using infrared light; the pattern of light absorption is used to predict fat, protein and lactose concentration. Research at Moorepark has also revealed that these patterns can also be used to predict individual fatty acid, protein components and processability. Large inter-animal variability has been detected for saturated fatty acid content (Figure 1).



Figure 1. Distribution of the variability in saturated fatty acid content for the national average (red) and elite (blue) Holstein-Friesians cows from the next generation herd.

Potential of breeding to increase meat quality

Ireland currently has the largest meat sensory database in the world; data on meat tenderness, juiciness and flavour are available on over 4,000 Irish cattle. Table 1 summarizes the heritability of the meat quality traits; the *heritability* of a trait is the proportion of the phenotypic difference between individuals that is attributable to genetics. Large variation exists in genetic merit for meat quality traits among Irish sires (Table 1). This means that the meat from the progeny of some sires is expected, on average, to be of superior quality (maximum (positive) breeding value) than the meat from the progeny of other sires (minimum (negative) breeding value).

Table 1. The heritability and range in genetic merit for Irish sires						
Troit (Scolo 1 10)	c merit					
ITAIL (SCALE 1-10)	пеннаошну	Minimum	Maximum			
Tenderness	16%	-0.35	0.30			
Juiciness	9%	-0.41	0.30			
Flavour	14%	-0.36	0.22			

Carcass specifications

The grading of beef carcasses for carcass weight, fat and conformation provides an indication of carcass quality, and is the basis for the payment system that incentivises the supply of carcasses with desirable yield and quality specifications. These desired specifications comprise of carcass weights between 270 kg and 380 kg, fat scores from 2+ to 4=, conformation scores of O= or better, and an age of slaughter <30 months. On average, only 40% of dairy-beef cattle achieved all specifications at slaughter. The ability to achieve the desired specifications is influenced by genetics (Table 2); 18% of the variability in the simultaneous achievement of all carcass specifications is due to genetics.

Table 2. Prevalence and heritability of the achievement of the desired carcass specifications in dairy-beef bulls, heifers and steers

Correspondentie		Horitobility		
	Bulls	Heifers	Steers	нептаршту
Weight (>270 kg)	83	53	93	5%
Conformation (≥ O=)	78	87	70	12%
Fat (2+ to 4=)	61	83	87	11%

Conclusions

Excellent product quality is critical for retaining customer loyalty and ensuring future markets for important Irish produce. Generating data from sufficiently large dairy and beef cattle populations to enable accurate genetic evaluations and derive appropriate weightings on these traits within selection indexes is essential for continued improvement.

Decision support tools: what your data can do for you Tara Carthy¹, Margaret Kelleher², John McCarthy² and Fíona Dunne¹

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Summary

- Three new complementary on-farm decision support tools have recently been developed:
 - » Cow's Own Worth (C.O.W) to assist with culling decisions.
 - » Sire Advice for mating decisions support.
 - » BLUE to evaluate farm-specific tailored breeding programs.

Introduction

Animal performance is a function of both the animal's DNA and the environment and management the animal is exposed to. While the genetic contribution to performance is captured within the EBI, other factors that affect performance have been largely ignored. The growing number and quality of available data sources in agriculture provide opportunities to develop value-creating tools to aid decision making on-farm.

Cow's Own Worth (C.O.W)

The C.O.W. decision support tool supports culling decisions. C.O.W. ranks females, within a given herd, based on each cow's expected remaining lifetime profitability taking into account factors such as age, level of heterosis, and calving date as well as the genetic merit of both the female herself and her future expected female progeny. The index considers a cow's expected profit from the current lactation, expected profit from her projected future lactations, and the net cost of replacing her with a heifer. The C.O.W. is generated using all available data at the time of execution, thus always exploiting the most up-to-date information. Farmers are encouraged to input all data such as health events and pregnancy diagnosis. Use of the index when making culling decisions increases profit on-farm. Since the launch of C.O.W. in 2017, >1,330 farmers have run the application for their farm.

Sire Advice

Sire advice is an online decision support tool provided by ICBF to support on-farm mating decisions. Genetic gain is based on the principle that the mean performance of the current generation should exceed that of previous generations. Sire advice aims to:

- Provide farmers with a bull selector tool to identify available sires that are consistent with their breeding goal.
- Identify the most complementary match between the chosen sires and females in the herd to maximise the chance of producing high genetic merit offspring but also a more consistent herd.
- Avoid excessive expected inbreeding in each advised mating.

Additional options available in sire advice include the potential to select cows for crossbreeding (by maximising the level of heterosis), mating to beef bulls (i.e. the lowest EBI cows in the herd), or for culling (i.e. the lowest cows ranked on the C.O.W. index). Since the launch of Sire Advice in 2018, >3,300 farmers have run the application for their farm.

Personalised breeding programs

Genetic evaluations are a method of estimating an animal's genetic potential. During this process, herd effects (i.e. environment and management) are simultaneously estimated, but until now, these effects have not been fully utilised. Herd effects, or what is termed best linear unbiased estimates (BLUEs), are analogous to milk or fertility proofs generated for bulls but instead are milk or fertility "proofs" generated for each herd. Recent research carried out in Teagasc Moorepark indicates that the response in cow performance to selection on EBI differs depending on the herd BLUE, a term often referred to as genotypeby-environment interactions (or GxE). For instance, increasing a herd's genetic merit for milk yield by 100 kg has a 20% greater impact on performance in high milk BLUE herds than in low milk BLUE herds. In contrast, the response to selection on genetic merit for fertility was almost five times greater in poor fertility BLUE herds than in the best fertility BLUE herds; poor fertility BLUE herds are underperforming relative to their genetic merit. Herd BLUE levels also impact the observed benefit from heterosis; herds with the poorest BLUEs realise, on average, the greatest benefit from crossbreeding, suggesting that crossbreeding helps mitigate poorer management. For example, the benefit of heterosis for calving interval in poor fertility BLUE herds was almost double the benefit in good fertility BLUE herds (Figure 1).



Figure 1. Holstein X Jersey heterosis effect on calving interval (days) in herds with the best, average and worst BLUEs for fertility

Conclusions

Decisions support tools have the potential to support more-informed management decisions on-farm. Utilising all sources of data, including information collected on-farm, increases the benefits of these tools.

Teagasc's Next Generation dairy herd Frank Buckley, Morgan O'Sullivan, Orlaith Quigley, Ben Lahart, Laurence Shalloo and Donal O'Brien

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Summary

- The Next Generation Herd represents a futuristic national herd, and is a strategically important resource providing a "forward view" of the performance of high EBI herds under varying grazing strategies.
- Results to date highlight productivity, fertility (and survival) and financial benefits that Irish dairy farmers stand to gain through improvements in EBI.
- Increasing EBI reduces environmental impact of milk production.

Introduction

The 'Next Generation Herd' was established as a strategic resource to validate that genetic selection using the EBI will increase productivity and profitability under intensive grass based systems. The herd is situated at the Dairygold Research Farm in Kilworth. The herd has two distinct EBI groups: 90 extremely high EBI (ELITE) and 45 national average (NA) females. All are exclusively Holstein-Friesian. All animals are genotyped. Genetic diversity (sire lines) has been maximised. The ELITE females are firmly inside the top 1% in the country based on EBI. The most recent breeding values for the herd are presented in Table 1.

Table 1. EBI, sub-indices and PTA values for ELITE and National Average (NA) cows within the Next Generation Herd (ICBF, January 2019)								
	Sub-Indices (€)							
FRI	EDI	Milk	Fertility	Calving	Beef	Maintenance	Health	Management
ELITE	214	61	102	42	-15	16	5	3
NA	110	38	39	36	-11	7	2	1

PTAs							
Milk Kg Fat Kg Prot kg Calv Int Survival							
ELITE	+36.7	+10.7	+7.2	-5.3	+2.9		
NA	+70.9	+6.3	+5.4	-2.0	+1.1		

Each year, the two EBI groups were evaluated under three contrasting seasonal pasturebased feeding treatments. This was undertaken to determine if their performance differs depending on feeding level. The results presented are from the first four years of the study.

Results

The NA cows had greater milk volume compared with the ELITE cows. The ELITE cows, however, had higher milk solids yield (+9 kg during first four years, but more recently increasing to +12 kg); 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. On average, the ELITE cows were slightly lighter

but had significantly higher body condition score over lactation. Large differences in fertility performance have been observed.

A simulation to determine the economic (at 29 c/l milk price) and environmental consequence at farm level was based on the biological data generated in the Next Generation Herd Study, extrapolated to simulate a 40 ha unit. The results indicate that the profit differences (over \in 200 /cow and over \in 600 /ha in favour of the ELITE cows) are in line with expectation based on EBI. Of note, ELITE cows are more profitable regardless of feeding treatment. The results estimate that ELITE milk generates 14% less emissions than NA milk. The low emissions intensity of ELITE milk indicates improving EBI has strong potential to improve the dairy sector's environmental as well as economic performance.

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				
Six 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				

There were no differences in daily feed intake between the ELITE and NA cows, but subtle differences in intake capacity, grazing behaviour and energy utilisation were observed. Intake capacity, expressed as total dry matter intake relative to body weight, production efficiency expressed as yield of milk solids relative to body weight and intensity of grazing activity were all greater in ELITE compared with NA. On the other hand, milk solids per unit intake, or the proportion of energy intake utilised for milk production having accounted for maintenance indicates a slight reduction in the utilization of ingested energy for milk production in ELITE compared to NA cows. This is considered desirable, however, as it facilitates more favourable energy balance in ELITE compared with NA, consistent with the greater body condition and reproductive success observed with the ELITE cows.

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. A number of young NEXTGEN bulls have been prominent on ICBF's Active Bull List. The most notable include 'NEXTGEN PHC Emer' (AI code FR2460) and 'NEXTGEN YKG Candy' (AI code FR2385), and more recently 'NEXTGEN Heatwave' (AI code FR4803).

Conclusions

The results provide confidence that the EBI is working to identify more profitable dairy genetics. The average Irish dairy farmer stands to gain financially from increasing herd EBI, and must continue to improve the genetic merit of their herds. Long term, this strategy will improve milk solids production, fertility and longevity to maximise profitability and environmental sustainability from seasonal pasture-based production.

Next Generation Jersey Orlaith Quigley and Frank Buckley

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Summary

- The introduction of Jersey cows into Teagasc's Next Generation Herd provides a comparison between high EBI Holstein-Friesian and Jersey genetics to determine the potential impact of crossbreeding with Jersey in the context of the genetic improvement being achieved within our Holstein-Friesian-based national breeding programme.
- Results to date highlight the contrasting yet complimentary attributes of high EBI Holstein-Friesian and high EBI Jersey, as well as the potential for higher efficiency and productivity per ha with Jersey.
- In light of concerns surrounding low value male calves, Jersey genetics should be exploited responsibly. Use sexed semen if feasible, and maximise use of high Dairy Beef index beef sires.

Introduction

The Jersey breed has many favourable characteristics for crossbreeding in Ireland: 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, and the genetic distance between the breeds results in greater expression of hybrid vigour compared to crosses of more closely related breeds. Previous research conducted at Teagasc Moorepark has consistently demonstrated that Jersey×Holstein-Friesian crossbred cows outperform their Holstein-Friesian contemporaries due to a combination of improved fertility and herd productivity. The economic advantage varied between studies, but was generally approximately €150 per cow per lactation.

Next Generation Jersey

In 2018, high EBI Jersey cows were introduced into the Next Generation Herd at the Dairygold Research Farm in Kilworth. Comparative EBI, sub-indices and PTA values for the 36 Jersey females that run alongside the 72 ELITE and 36 national average (NA) Holstein-Friesian cows is presented in Table 1. The 36 Jersey cows are all of New Zealand ancestry.

Table 1. EBI, sub-indices and PTA values for ELITE and National Average (NA) and Jersey cows within the Next Generation Herd (ICBF, January 2019)								
	PDI			S	ub-Indi	ces (€)		
	FRI	Milk	Fertility	Calving	Beef	Maintenance	Health	Management
ELITE	214	61	102	42	-15	16	5	3
NA	110	38	39	36	-11	7	2	1
JERSEY	185	64	58	39	-51	68	2	6

PTAs							
Milk Kg Fat Kg Prot kg Calv Int Survival							
ELITE	+37	+10.7	+7.2	-5.3	+2.9		
NA	+71	+6.3	+5.4	-2.0	+1.1		
JERSEY	-329	+13.2	+1.1	-2.5	+2.1		

All three groups of cows are evaluated under three pasture-based feeding treatments, which provide variable feeding levels at the shoulders of the grazing season. Both Holstein-Friesian groups are stocked at 2.75 cows/ha and the Jersey cows are stocked at 3 cows/ha.

Preliminary Results

The results for Year 1 (Table 2) of the study highlight the contrasting yet complimentary characteristics of the Holstein-Friesian genotypes (both the ELITE and NA) and the Jersey cows. Both Holstein-Friesian groups produce greater milk volume, but milk constituent values were considerably higher for Jersey cows. The Jersey cows are much lighter. The advantage of Jersey becomes particularly apparent when milk solids production is expressed per ha or per kg cow body weight. Extrapolated per ha, the Jersey cows produced 31 kg and 112 kg more milk solids per ha compared to the ELITE and NA genotypes, respectively. Yield of milk solids relative to mean bodyweight ranged from 0.82 for the NA cows to 1.10 for the purebred Jersey cows. Interestingly, body condition score was greater for the Jersey cows compared to both Holstein-Friesian groups.

Table 2. Cow performance details for year 1 of the study (2018)							
	ELITE	NA	Jersey				
Stocking rate (cow/ha)	2.75	2.75	3.00				
Milk yield (kg)	5,539	5,499	4,276				
Fat (%)	4.64	4.37	5.86				
Protein (%)	3.69	3.60	4.24				
Milk solids (kg)	462	433	434				
Body weight (kg)	520	524	393				
Body condition score	2.89	2.76	2.99				
Milk solids/kg of body weight	0.88	0.82	1.10				
Milk solids kg/ha	1,271	1,190	1,302				

AI Sires

Another aspect of the Next Generation Jersey Herd is as a source of Irish bred high EBI Jersey AI bulls. Recent recruits to AI include NEXTGEN HITMAN (JE4764), NEXTGEN FIREFOX (JE4759), NEXTGEN PAC MAN (JE4612), NEXTGEN ENIGMA (JE4539) and NEXTGEN RUBY (JE4409).

Conclusions

The results presented are based on a single year of data (2018), and hence should be interpreted with caution. The results are, however, in line with previous research, and continue to suggest that there are potential advantages of using Jersey genetics for crossbreeding within the context of intensive Irish pasture-based production systems. These advantages are borne out of increased production efficiency and productivity per unit area. In light of concerns surrounding the challenges associated with low value male calves, it is advised that Jersey genetics be exploited responsibly. Calculate the number of replacements required, use sexed semen if feasible, and maximise use of high Dairy Beef index beef sires.

A comparison of high EBI Holstein-Friesian (HF) to Jersey x HF and Norwegian Red x Jersey x HF crossbreds in spring milk production systems Bríd McClearn, Laurence Shalloo, Fergal Coughlan and Brian McCarthy

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Summary

- High EBI HF, Jersey x HF and Norwegian Red x Jersey x HF crossbred cows performed similarly in terms of milk solids, reproductive performance and health traits.
- Jersey x HF had the highest production efficiency (kg milk solids/kg bodyweight), Norwegian Red x Jersey x HF were intermediate and HF were lowest.
- There were benefits to be gained from crossbreeding in terms of production efficiencies and economic performance.

Introduction

The historical decline in dairy cow reproductive performance, particularly in Holstein-Friesian (HF) cows, has been linked to animal selection based mainly on milk production. This has negative consequences for the economic performance of pasture-based systems, due to the requirement for compact calving. Although milk solids production and reproductive performance of the national herd has improved, the average performance is still well below industry targets. The use of crossbreeding to improve herd reproductive performance, milk composition and animal health has gathered increasing interest in recent years. In crossbred herds, the optimum mating strategy after the first cross is unclear. There are three main options: (1) backcrossing using one of the parent breeds; (2) breeding using a crossbred sire; or (3) introducing a third breed into a 3-way rotational crossing system. Jersey (JE) has been the most common breed used to cross with HF dams. However other breeds such as Norwegian Red may offer additional benefits in a 3-way rotational crossing system.

The study

The experiment was conducted at Teagasc Clonakilty Agricultural College from 2014–2017. Three cow breeds were used for this experiment: HF, JE x HF and a 3-way cross of Norwegian Red × JE x HF (3WAY). The JE x HF cows were produced from HF cows mated with a JE sire. The 3WAY cows were produced from JE x HF F1 cows mated with a Norwegian Red sire. Each year 10 cows of each breed were assigned to one of four grazing treatments and balanced for parity (1, 2 or 3+), calving date and EBI. This created four herds of 30 cows per grazing treatment, with 10 cows of each breed used. Age structure did not differ among breeds for the duration of the experiment. All four sward types were grazed in a spring calving rotational grazing system stocked at 2.75 cows/ha receiving 250 kg nitrogen fertiliser/ha/year with a target of ~350 kg concentrate/cow/year. Cows were grazed day and night as they calved from February onwards when weather conditions allowed. The economic performance of the three breeds was modelled using the biological performance from this study with the Moorepark Dairy Systems Model.

Animal performance

Holstein-Friesian cows produced greater total milk volume compared to JE x HF and 3WAY cows. Milk solids production was similar for HF and JE x HF, but lower for 3WAY compared

to JE x HF (Table 1). Reproductive performance was similar between the three breeds, with no significant difference in average six week pregnancy rate and overall pregnancy rate for the four years. Health traits were also similar between the three breeds with no difference in calving difficulty, or in the incidences of mastitis or lameness. Throughout lactation, HF had the greatest average bodyweight followed by 3WAY and JE x HF, while 3WAY cows had a higher BCS throughout lactation compared to HF and JE x HF. In terms of milk production efficiency (kg MS/kg bodyweight), JE x HF had the greatest efficiency (0.98), 3WAY were intermediate (0.91) and HF were lowest (0.87). Jersey x HF had the highest profit per ha, 3WAY were intermediate and HF were lowest although the differences were not as large as previous research had shown.

HF (3WAY) on biological and economic performance (2014–2017)						
	HF	JE x HF	3WAY			
EBI	116	135	164			
Total milk yield (kg/cow)	5,718	5,476	5,365			
Fat content (%)	4.52	4.86	4.75			
Protein content (%)	3.72	3.87	3.88			
Total milk solids yield (kg/cow)	460	469	453			
Average bodyweight (BW; kg/cow)	530	478	499			
Average BCS	2.93	2.94	2.99			
Milk solids yield/BW (kg MS/kg BW)	0.87	0.98	0.91			
6 week pregnancy rate (%)	88.0	86.8	84.1			
Overall pregnancy rate (%; 12 wk)	96.8	93.1	93.0			
Economic performance						
Cow numbers	115	117	118			
Land use (ha)	40	40	40			
Net profit (€/40 ha farm)	98,706	104,230	99,671			
Net profit (€/ha)	2,468	2,606	2,592			

Table 1. The effect of Holstein-Friesian (HF), Jersey (JE) x HF and Norwegian Red x JE x HF (3WAY) on biological and economic performance (2014–2017)

Conclusions

The combination of similar milk solids production, reproductive performance and health traits indicate that all three breeding strategies are suitable for spring-calving, grass-based systems. The similar reproductive performance between the three breeds highlights the improvement made to traditional HF breeding in Ireland through the use of the EBI. There are still benefits arising from crossbreeding in terms of milk production efficiency and economic performance.

Oestrous activity in dairy cows Stephen Moore, Victoria Aublet and Stephen Butler

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

Summary

- 46% of cow heat events lasted < 8 h, highlighting the importance of using heat detection aids and 3–4 observations per day.
- Greater oestrous activity was positively associated with fertility sub-index and pregnancy outcome.

Introduction

Correctly identifying cows in heat and inseminating at the correct time is a major limitation to achieving three-week submission rates of 90% and six-week in-calf rates >75%. The Moomonitor is an activity monitor worn around the cow's neck that identifies cows in heat when their movement exceeds an activity threshold. The Flashmate Electronic Heat Detector is a stick-on device placed on the cow's rump that identifies cows in heat when the frequency of contacts exceeds a threshold. A study was undertaken to identify factors associated with oestrous activity. Moomonitor activity devices and Flashmate activity devices were placed on 530 cows in three research herds during the first four weeks of the 2018 breeding season. Cows were inseminated following detection of oestrus based on visual observation, rubbing of tail paint, or activation of the electronic activity devices.

Characterisation of oestrous activity using activity devices

The onset of activity monitor activation varied throughout the day but there were 3–4 periods when the onset of oestrous activity was concentrated (i.e. 02:00 to 03:00, 07:00 to 09:00, 11:00 to 13:00, and 21:00 to 23:00). The timing of oestrous detection differed between the devices. Whereas, 66% of Moomonitor devices were first activated between 19:00 and 07:00, only 40% of Flashmate devices were first activated during the same period.





The average duration of Moomonitor-recorded oestrous activity was 17 h 40 min (range 3 h 45 min to 34 h 45 min) and the average duration from the onset of Moomonitor-recorded oestrous activity to AI was 7 h 44 min. The average duration of Flashmate recorded heat events was 8 h 15 min (range 0 h to 22 h 56 min) and the average duration from the onset of Flashmate-recorded heat events to AI was 6 h 32 min. The average number of

Flashmate-detected contacts was 3.8 per hour during a heat event, and the average total number of contacts for a heat event was 16.7. The Moomonitor and Flashmate recorded periods of oestrous activity \leq 8 h in 8% and 46% of cows, respectively. The Moomonitor recorded periods of oestrous activity \geq 24 h in 18% of cows.

Factor associated with oestrous activity

Factors associated with the duration of Moomonitor recorded oestrous activity included farm (2 h greater in Farm 1 compared with Farm 3), parity (~2 h shorter in parity two cows compared with parity 1, 3 and \geq 4) and Fertility sub-index (1 h 48 min shorter in cows with poor Fertility sub-index compared with cows with good Fertility sub-index; Table 1).

Table 1. Factors associated with the duration of Moomonitor-recorded oestrous activity					
	Farm		Parity	Fert sub-ind	dex quartile
1	18 h 42 min	1	18 h 6 min	- €14 to €41	16 h 30 min
2	17 h 36 min	2	16 h 21 min	€42 to €58	17 h 42 min
3	16 h 40 min	3	18 h 20 min	€59 to €78	18 h 18 min
		≥4	18 h 2 min	€78 to €164	18 h 18 min

Days in milk at AI was associated with the duration of Flashmate-recorded oestrous activity, whereby late-calving cows (14 to 67 d) had a shorter period of oestrous activity compared with early-calving cows (92 to 115 d). The total milk yield during the first five weeks of lactation and the pregnancy outcome following AI were associated with the total number of contacts recorded by the Flashmate device (See Table 2).

Table 2. Factors associated with the total number of contacts recorded by Flashmate device during period of oestrous activity					
5 week milk	Pregnancy outco	ome following AI			
290 to 723 kg	19.8 contacts	Pregnant	17.7 contacts		
724 to 845 kg	15.5 contacts	Not Pregnant	13.3 contacts		
846 to 987 kg	12.4 contacts				
988 to 1,469 kg	14.5 contacts				

Conclusions

Almost half of the cows displayed mounting activity for <8h, highlighting the importance of conducting 3–4 periods of oestrous observation daily. The positive association between the duration of oestrous activity and the fertility sub-index indicates that improving EBI fertility sub-index resulted in stronger oestrous expression, and this in turn was associated with greater pregnancy rates.

End of season management to improve cow performance Stephen Moore and Stephen Butler

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

Summary

- Stop breeding in July to avoid a prolonged calving season.
- Pregnancy check 5–7 weeks after the breeding season finishes.
- Record BCS in October, identify thin cows and develop a management strategy to improve condition before calving.

Introduction

A compact calving season (<12 weeks) requires a compact breeding season. The breeding season should stop in July, 12 weeks after the farm mating start date. This is necessary to ensure that all cows are calved before the start of breeding next year. Excellent breeding records and a pregnancy check after the breeding season allow an assessment of the herd's reproductive performance. Use expected calving dates and BCS to determine dry-off dates and inform appropriate nutritional management. Knowledge of the expected calving pattern will also help preparations for the calving season.

The breeding season ends in July

It is important to implement a breeding management plan that allows for breeding season duration of 12-weeks or less. Most herds will have completed 12-weeks for a breeding during July (Table 1). Upload all breeding dates to farm software/ICBF.

Table 1. Breeding season and pregnancy check dates				
Breeding start	Breeding stop	Pregnancy check		
April 15 th	July 8 th	Aug 12^{th} to 26^{th}		
April 22 nd	July 15 th	Aug 19 th to Sept 2 nd		
April 29 th	July 22 nd	Aug 26 th to Sept 9 th		
May 6 th	July 29 th	Sept 2 nd to 16 th		

Complete pregnancy checks in August and September

Pregnancy checks by ultrasound examination for the whole herd should be performed 5–7 weeks after the end of the breeding season. Having good breeding records from both AI and natural service events will help to confirm the pregnancy status, and to determine the stage of pregnancy. At five to seven weeks after the end of the breeding season, pregnancy can be determined for AI events that took place during the first six weeks of breeding (yes or no), and an accurate assessment of the stage of pregnancy is possible for cows that conceived to natural service during the second six weeks of breeding. Hence, an expected calving date can be calculated for all cows. If a herd pregnancy diagnosis is delayed until a later date (e.g., Nov), an accurate assessment of the stage of pregnancy is no longer possible.

Pregnancy status can also be determined using milk samples. This test is accurate from week four of pregnancy onwards, but it can only provide a yes or a no answer (i.e., it cannot indicate stage of pregnancy, twins etc.). There will also be some inconclusive results (~5%), which require retesting at a later date. The choice of method for pregnancy diagnosis will depend on labour availability, animal facilities, cost, and level of detail required (twins, stage of pregnancy). Upload pregnancy results to farm software/ICBF.

Assess body condition score in October

Cows should be dried off in the body condition score (BCS) they are expected to calve down in (BCS 3.0 or 3.25). Cows that are thin (\leq 2.75) when they calve down have poor subsequent fertility. Mid to late October is a good time to assess BCS because there is sufficient time to identify thin cows and take action to improve BCS. Cows that are thin (BCS \leq 2.5) in late October and due to calve early (i.e., late Jan or Feb) should be allowed a longer dry period and supplementation if necessary. Although placing these thin cows on a once a day milking regime will improve BCS, the improvement is small (<0.2 BCS units). The requirement to supplement the diet during the dry period should be based on silage quality analysis and BCS (Table 2). Where supplementation is required, rolled barley will suffice and avoid high calcium supplements.

Table 2. Dry period management of body condition score					
Silage	BCS ≤2.5	BCS 2.75	BCS ≥3.0		
DMD	10–12 weeks dry	8–10 weeks dry	8 weeks dry		
>72	Silage + 1 kg meal	Silage ad lib	Restrict silage		
68–72	Silage + 2 kg meal	Silage + 1 kg meal	Silage ad lib		
64–67	Silage + 3 kg meal	Silage + 2 kg meal	Silage + 1 kg meal		

End of season culling decisions

Early culling helps to extend the last rotation and prioritise pasture for the most productive cows. Cows to be culled from the herd should be identified using the Cow's Own Worth (COW) index. The accuracy of the index is improved by providing milk recording, health and fertility records, and genotype data. See paper on page 194.

Conclusions

End the breeding season in July to avoid a prolonged calving season. Schedule a pregnancy check to occur at five to seven weeks after the end of the breeding season to identify non-pregnant cows and derive an expected calving pattern. Combine pregnancy checks with breeding records to determine expected calving dates. Assess BCS in October and take action to improve thin cows. Target a BCS 3.0 at dry off, and maintain BCS at 3.0 or 3.25 during the dry period.



Uterine health in a pasture based production system

Rachel Doyle, Chloe Millar, Shauna Holden and Stephen Butler

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Summary

- Uterine infections reduce cow fertility.
- The metricheck device is a useful tool to assess the presence of uterine infections before the breeding season.
- Early identification of cows with endometritis allows time to take appropriate action.

Introduction

Reproductive performance is one of the most important factors influencing the profitability of dairy herds, with optimal financial performance arising from a 365 day calving interval. Following calving, the uterus of every cow becomes contaminated by bacteria. Most cows have the ability to clear these bacteria naturally without treatment. Around 10–20% of animals will be unable to clear these bacteria in a timely manner, and will subsequently develop clinical endometritis (with purulent vaginal discharge) or sub-clinical endometritis (without purulent vaginal discharge). Endometritis is a chronic infection of the uterus in dairy cows, often without symptoms of illness, and has an adverse effect on reproductive performance. Early identification of uterine infections allows treatment before the breeding season commences, and this in turn increases the chances of successful pregnancy establishment.

The Metricheck Process

Examination of vaginal discharge using the metricheck device should take place 3–5 weeks before the mating start date on all cows calved \geq 14 days. The metricheck device is composed of a rubber cup attached to a steel rod. Metrichecking is a simple procedure (Figure 1) that can be implemented as a routine practice before the breeding season begins. The vagina is cleaned and sanitized using cotton wool soaked in dilute disinfectant solution. The metricheck device is carefully inserted into the vagina and extended forward as far as the cervix, and the device is then removed at an upward 45 degree angle. The discharge collected in the rubber cup is then examined and a score is assigned based on Figure 2. Following each examination, the metricheck device should be sanitized in dilute disinfectant solution.



Figure 1. Procedure for conducting vaginal discharge exams using the metricheck device



Figure 2. Vaginal discharge scoring chart. Score 1 = clear mucus only; Score 2 = mostly clear mucus with small flecks of pus; Score 3 = mucus containing <50% pus; Score 4 = mucus containing \geq 50% pus and odour.

Cows diagnosed with clinical endometritis based on the vaginal discharge recovered in the metricheck device are at significantly higher risk of reduced fertility performance compared with cows without endometritis. The cows at risk of endometritis, the consequences for reproductive performance and the treatment options are outlined in Table 1. Research from the *Next Generation Herd* indicates that cows with a high genetic merit for fertility have a faster recovery from uterine infection following calving.

Table 1. The factors affecting uterine recovery and return to score 0 and possible treatment options for cows				
A	t risk cows	Consequences of failing to detect endometritis	Treatment	
•	Difficult calving	Lower submission rates	Cycling cows	
•	Twins	• Lower 6-week in-calf	» Metricure	
• •	Retained placenta Metabolic disease Dead calf Displaced abomasum	 rate Lower final pregnancy rate Reduced days in milk 	 » Prostaglandin injection • Non-cycling cows » Metricure 	
	Low fertility sub-index			

Conclusions

Examination of vaginal discharge score is a useful management tool that can aid identification of cows with clinical endometritis before the start of the breeding season. Failure to identify and treat these cows can result in reduced fertility performance. Uterine health and the fertility performance of the herd can be improved through the selection of sires with a high genetic merit for fertility traits.

Sexed semen: does timing of AI matter? Evelyn Drake, Victoria Aublet, Shauna Holden and Stephen Butler

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Summary

- A large sexed semen field trial conducted on dairy cows in 2018:
 - » Conception rates were 60% for conventional semen versus 45% for sexed semen.
 - » The average conception rate achieved with sexed semen was 76% of the average conception rate achieved with conventional semen.
 - » A quarter of the herds achieved better conception rates with sexed semen compared with conventional semen, suggesting that heat detection and timing of AI may impact conception rates with sexed semen.
- A 2019 field trial was undertaken to investigate if timing of AI relative to time of expected ovulation affected conception rates achieved with sexed semen.

Introduction

Sexed semen reliably produces a 90% sex bias. Despite recent improvements in the technology, sexed semen generally achieves poorer conception rates compared with conventional semen. Nevertheless, sexed semen is potentially a revolutionary technology for dairy farmers. In Irish pasture-based systems, fertility is a key driver of efficiency and profitability. To-date, compromised conception rates with sexed semen have reduced its attractiveness and utilisation by dairy farmers. Nevertheless, with low (or zero) value dairy bull calves, the need for a reliable sexed semen product has never been greater.

Timed AI Sexed Semen Study 2019

Sexed semen has a shorter duration of viability in the female reproductive tract (12–16 h) compared with conventional semen (>24 h), which is largely attributed to damage sustained during the sorting process. In the 2018 field trial, 25% of the farms achieved fertility performance with sexed semen that was equal to or greater than that of conventional semen. One possible explanation for this observation was that those particular farms had decision rules for the timing of AI that was particularly suited to sexed semen (i.e., delayed AI relative to heat onset).

In spring 2019, a trial to examine the importance of timing of AI on fertility performance in lactating cows was carried out. Fixed-time AI protocols synchronise the timing of ovulation, and represent a useful tool to test the effect of altering the timing of AI. Approximately 2,250 cows on 24 farms were synchronized with a Progesterone-Ovsynch fixed-time AI protocol (Figure 1). All enrolled cows were younger cows (parity 1–4 only) and early-calving (>50 days calved on day of AI). Three semen treatments were evaluated:

- Conventional semen 16 h after second GnRH injection (CONTROL).
- Sexed semen 16 h after second GnRH injection (SEXED_16).
- Sexed semen 22 h after second GnRH injection (SEXED_22).

All cows were inseminated by an AI Technician, and all cows were scanned for pregnancy diagnosis 35 to 40 days after fixed-time AI.



Figure 1. Synchronisation protocol and semen treatments. Cows assigned to CONTROL and SEXED-16 treatments were inseminated 16 h after the second GnRH, and AI was delayed until 22 h after second GnRH for the SEXED-22 treatment.

The final dataset had records from 2164 cows available for analysis. Overall, the conception rate to first service was 61.1%, 49.0% and 51.3% for CONTROL, SEXED-16 and SEXED-22, respectively. This corresponds to relative conception rates of 80% and 84% for SEXED-16 and SEXED-22, respectively (i.e., relative to the conception rate achieved in the CONTROL treatment).

The 24 study herds were ranked based on the relative conception rate for sexed semen versus conventional semen. For the 18 herds with the best performance, the mean relative conception rate was 90% (range 75% to 121%), but was much poorer in the remaining six herds (mean relative conception rate = 64%, range 48% to 73%). Of note, these six herds had numerically better mean conception rates with conventional semen (66.1%) than the remaining 18 herds (60.2%). Hence, the cows were fertile, the semen was fertile, and inseminations were conducted at the optimum window of time. More research is needed to identify the reasons for poor performance with sexed semen in a subset of herds that achieve excellent performance with conventional semen.

If the six herds with the poorest relative conception rates are omitted from the analysis, the conception rate was 59.9%, 52.6% and 54.7% for CONTROL, SEXED-16 and SEXED-22, respectively. This corresponds to relative conception rates of 88% and 91% for SEXED-16 and SEXED-22, respectively.

Conclusions

In a timed AI programme, acceptable fertility with sexed semen can be achieved by delaying the timing of AI to between 16 and 22 h after the second GnRH injection. At the levels of fertility performance obtained in this study, sexed semen is a viable strategy for generating replacement heifers.

IRISH DAIRYING | GROWING SUSTAINABLY

Prediction of bull fertility Shauna Holden and Stephen Butler

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

Summary

- Current semen assessments can identify infertile bulls, but are not sufficient for identifying sub-fertile bulls.
- Detailed laboratory assessments may aid identification of sub-fertile ejaculates.
- Semen assessments will need to be tailored to the semen processing method (i.e., sexed or conventional).

Introduction

It is necessary to achieve excellent reproductive performance with artificial insemination (AI) events to achieve a compact calving pattern. Therefore quality control of semen used for AI is critically important. Typical quality control measures carried at AI stations include ejaculate volume, sperm concentration, pre- and post-thaw sperm motility and sperm morphology. These tests are generally sufficient for identifying ejaculates with very poor semen quality (which are discarded), but are poor at distinguishing between ejaculates of average and high fertility, thus resulting in variable conception rates.

Factors affecting sperm quality

Semen production and sperm quality can be affected by age and breed of the bull, and also by external factors, such as elevated temperature due to excessive fat or fever, trauma to the testicular tissue, diet and exposure to toxins. These issues likely become more critical when semen is also sex-sorted. Even though quality control standards are higher for sexsorted semen (before and after processing), there is inevitable sperm damage, and the low number of sperm per AI straw leaves little room to compensate for low fertility.





Large sexed semen field trials were conducted in 2013 and 2018. Large variation between and within individual bulls was noted in conception rates achieved for both conventional and sex-sorted semen (Figure 1).

Fertility prediction

Many studies have tried to relate laboratory sperm assessments to conception rates in bulls. The most common assessments include motility, viability and DNA fragmentation, but accuracy of fertility prediction has been variable. Moorepark research aims to develop a predictive model using detailed sperm assessments to predict fertility. As sperm fertility relies on a number of different factors, assessments will focus on specific physiological characteristics of the sperm to provide an overall picture of the fertility potential of a particular ejaculate. One such assessment is acrosome integrity; a sperm cell with a ruptured acrosome is unable to fertilise an oocyte (Figure 2a). Other assessments such as mitochondrial function and membrane fluidity are related to the ability to maintain motility inside the female reproductive tract. Conventional sperm have lower viability and more sperm with intact acrosomes and a lower population with high membrane fluidity compared with sex-sorted semen (Figure 2b). More research is required using both conventional and sex-sorted semen straws to develop a suite of tests that can predict bull fertility.



Figure 2. (2a) Sperm cells being analysed for acrosome integrity. The purple/red halo on the sperm head indicates a ruptured acrosome membrane, resulting in inability to fertilise (100x magnification). (2b) Assessments of sperm physiology for both conventional and sex sorted-semen

Conclusions

Detailed measures of sperm physiology — in particular viability, acrosome integrity and membrane fluidity — vary between conventional and sex-sorted sperm populations. These differences may be used to identify markers of subfertility, and thus predict the fertility of a particular ejaculate before being used in the field. Further analysis using more assessments is required to develop a model to accurately predict fertility.

A dairy-beef index (DBI) to rank beef bulls on profitability for use on dairy females Nóirín McHugh¹, Thomas Condon¹ and Siobhán Ring²

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Summary

- The dairy-beef index (DBI) ranks beef bulls for use on dairy females based on their estimated genetic potential to produce high quality profitable cattle, with minimal impact on dairy cow performance.
- Traits included in the DBI relate to: 1) calving performance, 2) carcass traits, 3) feed intake, 4) docility, and 5) polledness.
- Research is on-going on the inclusion of additional traits such as calf health, meat quality and environmental traits.

Introduction

The expanding dairy herd, coupled with improving cow fertility, imply that a greater quantity of beef in Ireland will originate from dairy herds. This requires a tool that sorts beef bulls based on suitability for use on dairy females. This ranking system should ideally rank bulls on estimated genetic potential for a high-value carcass produced in an efficient manner with minimal repercussions on the dairy cow in terms of milk, health and reproductive performance. With this in mind, the DBI was launched in January 2019 by the ICBF.

Construction of the Dairy Beef index

Traits included of the DBI are listed in Table 1. The contribution of genetics to the variability in these traits is also outlined in Table 1, as is their relative emphasis within the DBI. The relative emphasis on each trait within the DBI is a function of the costs and prices experienced by dairy and beef farmers. Example, 53% of the relative emphasis is placed on calving difficulty as calving difficulty can have a large impact in terms of labour requirements and also on the welfare and subsequent performance of dairy cows. Research is on-going on other traits that may be considered for inclusion in the DBI including, amongst others, calf vigour and health, life-time methane emissions, novel measures of meat quality and nutritive value, as well as saleable red meat yield.

Table 1. List of traits and their sub-indexes included in the DBI					
Sub-index	Trait	% under genetic control	Relative emphasis in DBI		
	Calving difficulty	10%	53%		
Calving	Gestation length	35%	10%		
_	Calf mortality	2%	1%		
Efficiency	Feed intake	33%	5%		
	Carcass weight	35%	17%		
Caraaaa	Carcass conformation	35%	6%		
Carcass	Carcass fat	35%	1%		
	Carcass bonus		3%		
Capital	Docility	20%	1%		
SUCIELAI	Polled	100%	3%		

Benefits of the DBI

To illustrate the benefit of the Dairy-beef index to both dairy and beef farmers, the performance of progeny from the top five beef bulls ranked on the DBI active bull list was compared to the performance of progeny from the five most commonly used beef bulls in Irish dairy herds between the years 2015 and 2018 (Table 2). The results showed that the top five DBI beef bulls were easier calved on dairy cows (1 percentage unit easier) and generated a higher calf price (€18 more) compared to the five most used beef bulls on the dairy herd. The five most used beef bulls were, however, easier calved on dairy heifers (1 percentage unit easier) and had a slightly shorter gestation length (1 day). In economic terms, however, the additional benefits in calf price and easier calving in the top five DBI bulls would offset this and would result in the generation of a greater profit for the dairy farmer of €9.67 per calf produced. Based on the beef traits, the top five DBI beef bulls generated progeny that produced heavier carcasses (17 kg heavier) and had superior conformation scores (one grade higher), which would result in the generation of an additional €104.54 profit to the finisher. Hence, the total benefit arising from using the top DBI bulls over the most used beef bulls was €114.21.

used beef bulls in dairy herds						
Benefit	Trait	Top DBI bulls	Most used beef bulls			
	DBI (€)	100	43			
Dairy	Gestation length (days)	284	283			
Calving difference heifers (%)		9	8			
Calving difference cows (%)		3	4			
	Calf mortality (%)	2	2			
	Calf price (€)	242	224			
Finisher	Carcass weight (kg)	330	313			
	Carcass conf.(grade)	R-	O+			
	Carcass fat (class)	4-	4-			

Table 2. Mean performance of the progeny from the top five DBI versus the five most used beef bulls in dairy herds

Conclusions

The DBI is a new selection tool available to help improve the beef quality of calves from the dairy herd with minimal repercussions on cow performance.

Dairy-beef performance under three stocking rate intensities

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Summary

- High stocking rate (SR) has a significant effect on carcass weight in heifers and lifetime average daily gain (ADG) in heifers and steers.
- Preliminary economic analysis shows higher net margin/ha for medium SR heifer and steer systems.

Introduction

Previous research at Johnstown Castle identified blueprints for dairy-beef production systems. The most significant factor determining profitability of these production systems was output per ha. The current research programme is evaluating the effects of stocking rate on the performance of dairy × beef crossbreed cattle.

Experimental design

Each year, 216 reared dairy-beef crossbred calves are purchased and assigned to a SR treatment; low (2.65 LU/ha), medium (2.92 LU/ha) and high (3.18 LU/ha). Each treatment consists of 36 heifers and 36 steers, and all treatments are balanced for breed (AAX, HEX and LMX). All animals were finished off grazed pasture and received 2.5 kg of concentrate for 60 days pre-slaughter. The heifers begin their finishing period in August/September and are finished by December/January. The steers are all housed for the second winter, turned out in the spring and killed off grass in June/July.

Results to date from the stocking rate trial

ADG was similar for the high, medium and low SR treatments during the first season at pasture, first winter and third season at pasture (steers only). ADG during the second season at pasture (heifers and steers) and the second winter (steers only) was lowest for the high SR treatment. Carcass weight was higher in the low and medium SR heifers, but there was no effect of SR treatment on carcass weight in steers. Conformation and fat scores and days to slaughter were similar across the three SR treatments for both steers (Table 1) and heifers (Table 2). A preliminary economic analysis compared the 21 month heifer and 26 month steer systems across the three SR treatments. The assumptions included a calf price of €200, a finishing period of 60 days on 2.5 kg concentrate/day and a meal price of €257/tonne. The medium SR system produced the greatest net margin/ha (Figure 1.)

Table 1. Performance of 2015 and 2016 born steers					
	High	Medium	Low		
ADG 1 st season at pasture (kg)	0.82	0.81	0.79		
ADG 1 st winter (kg)	0.60	0.64	0.59		
ADG 2 nd season at pasture (kg)	0.83	0.94	0.86		
ADG 2 nd winter (kg)	0.49	0.60	0.55		
ADG 3 rd season at pasture (kg)	1.26	1.20	1.16		
Lifetime	0.68	0.71	0.70		
Carcass weight (kg)	330	339	340		
Fat score (1–15)	9.0 (3+)	9.0 (3+)	8.5(3=)		
Conformation score (1–15)	5.3 (O=)	5.5 (O=/+)	5.2 (O=)		

Table 2. Performance of 2015–2017 born heifers					
	High	Medium	Low		
ADG 1 st season at pasture (kg)	0.68	0.73	0.68		
ADG 1 st winter (kg)	0.64	0.64	0.65		
ADG 2 nd season at pasture (kg)	0.84	0.90	0.93		
ADG finishing period	1.18	1.16	1.17		
Lifetime	0.72	0.74	0.75		
Carcass weight (kg)	250	257.5	259		
Fat score (1–15)	8.5 (3=)	8.7 (3=/+)	8.7 (3=/+)		
Conformation score (1–15)	5.5 (O=)	5.7 (O=/+)	5.7 (O=/+)		



Figure 1. Economic analysis for 21 month heifer and 26 month steer systems under three stocking rate treatments on a 40 ha farm

Conclusions

Significant differences between the SR treatments were observed for carcass weight, second season ADG and lifetime ADG. This was a result of the greater herbage allowance available to the low and medium SR treatments. On a whole farm basis, the high SR treatment had greater gross margin/ha as a result of greater carcass output. However, high fixed costs associated with higher stocking rates resulted in the medium SR treatment achieving the highest net margin per hectare. Additionally, a reduction in housing and feeding requirements for 21 month heifer systems resulted in greater margins compared with 26 month steer systems.
Can beef genetics play a role in your dairy herd? Stephen Connolly^{1,3}, Andrew Cromie² and Padraig French¹

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Summary

- Dairy beef carcass conformation is decreasing on the quality pricing system (QPS) grid.
- Beef calves sired by high genetic merit beef bulls could increase profit as much as €17,800 to a 100 head dairy beef production system.
- Dairy farmers have the potential to increase the marketability of their beef calves through selection of higher genetic merit beef bulls using the Dairy Beef Index (DBI).

Introduction

Dairy farmers are selecting beef sires for their herds predominantly on calving ease and gestation length. Research by ICBF and Teagasc indicates that this bull selection policy is causing a decline in the quality of the beef cross animals coming from the dairy herd for important economic traits for beef farmers.

The Teagasc/ABP dairy beef programme

The Teagasc/ABP programme, in collaboration with the ICBF dairy beef Gene Ireland programme, has three primary objectives: 1) to identify the most suitable beef bull genetics for crossing on dairy herds; 2) to genetically improve the main breeds supplying beef bulls to the dairy herd; and 3) quantify the carbon efficiency variation between sires. 650 calves are purchased from farms at 2–4 weeks of age. Calves are reared by ABP Blade, and at 15 weeks of age 400 calves are moved onto the ABP trial farm in Carlow until slaughter, and 250 calves are reared and finished at Teagasc, Johnstown Castle. Animal performance is measured throughout the production cycle and meat quality evaluations are conducted in collaboration with Meat Technology Ireland. Over 3,250 calves have been purchased as part of the programme, and 1,700 have been slaughtered at ABP Cahir and Slaney Foods.

Results of the Teagasc/ABP dairy beef programme

The results show large variations in progeny performance between individual sires for key economic carcass traits across the Angus, Hereford, Limousin and Shorthorn breeds.

How much is the right sire worth to a beef farmer?

Based on the results from Table 1, if a beef farmer purchased Angus calves sired by AI bull AA2309 rather than ZLT, there will be an increase in carcass weight per animal of 38 kg. The carcass conformation was better for ZLT progeny and fat score was similar for progeny from both sires. Progeny from AA2309 would leave an increased carcass value of €112/head, or €11,200 in a 100 head dairy beef herd. Based on the ICBF Terminal Index, AA2309 is a 5-star bull for the carcass weight sub-index, whereas ZLT is a 1-star bull. Progeny from AA2309 were slaughtered 22 days younger than ZLT progeny at a heavier carcass weight. Based on a cost of €3/day, progeny from AA2309 would have a reduction in on-farm costs of €66. Therefore, progeny from AA2309 could increase farm profit by €178/ animal or €17,800 in a 100 head dairy beef herd.

Table 1. The	effect of An	gus and Here	eford sire on	carcass weig	ght (Cwt), car	cass			
conformation (Conf), carcass fat (Fat), kill-out% and carcass value									
		Ct	C f	P-+	T 7 - 1	٨			

Ciro	Prood	Cwt	Conf	Fat	Value	Age
5116	DIeeu	(kg)	(1–15)	(1–15)	(€)*	(days)
ZLT	AA	279	7.18 (R-)	7.58 (3+)	1,090	647
ZTP	AA	281	5.74 (O+)	8.12 (4-)	1,074	644
KYA	AA	294	5.64 (O+)	7.56 (3+)	1,133	639
TKR	AA	304	6.28 (O+)	7.74 (4-)	1,188	634
AA2309	AA	317	6.37 (O+)	8.42 (4-)	1,202	625
FPI	AA	323	5.70 (O+)	7.33 (3+)	1,247	651
CRP	HE	289	5.44 (O=)	8.29 (4-)	1,100	640
HE2463	HE	294	5.02 (O=)	8.70 (4=)	1,084	634
HWP	HE	309	4.76 (O=)	7.77 (4-)	1,155	633
GPZ	HE	310	6.36 (O+)	7.75 (4-)	1,210	638
HE2147	HE	327	5.93 (O+)	7.78 (4-)	1,267	638

*Carcass value is based on a €3.70/kg base price on the QPS grid, €0.12/kg quality assurance payment and €0.20/kg breed bonus payment

Why should the genetic merit of a beef calf matter to a dairy farmer?

There are many advantages for a dairy farmer that selects higher genetic merit beef bulls for carcass traits while also focusing on calving ease and gestation length by using the DBI.

- Based on the results above, it's clear a beef farmer can make a higher margin from calves bred from higher genetic merit beef bulls. Therefore, calves from higher genetic merit bulls should be a more marketable product.
- If dairy farmers selected higher genetic merit bulls for use on their dairy herd, it could aid the development of collaboration agreements with beef farmers to purchase all of their beef calves. An important initial step in the agreement would be identification of the most suitable beef bulls for use on your herd using the DBI. In addition, a health plan should be developed, and the price and age at sale agreed before the busy calving season starts.

Conclusions

As a dairy farmer, there is scope to increase the marketability and value of your beef calf crop by using beef bulls with higher genetic merit for beef traits. Due to labour and calf housing constraints on dairy farms, collaboration between dairy and beef farmers has the potential to provide advantages for both.

Grange dairy calf-to-beef system evaluation Nicky Byrne¹, Donall Fahy¹, Edward O'Riordan¹, Pat Dillon², Noirin McHugh² and Padraig French²

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Summary

- Dairy calf-to-beef systems require calves with high genetic potential for carcass weight and conformation.
- The Grange Dairy Calf-to-Beef System Evaluation has two primary goals:
 - » Provide direction for calf-to-beef production systems.
 - » Assess the contribution of genetics to physical and financial performance of calfto-beef systems.

Calving ease, gestation length and breed are (in order) the main selection criteria dairy farmers use to choose beef bulls for their herds, with little consideration given to the potential for carcass weight or conformation. The objective of the study at Grange is to compare the physical and financial performance of progeny from both Holstein Friesian (HF) and Angus (AA) sires used on the dairy herd that are divergent in breeding value for carcass weight and conformation, whilst maintaining calving ease, and managed within an efficient grass-based beef production system.

Holstein Friesian (Table 1) and AA sires (Table 2) were selected as they represent the main calf breeds coming from the dairy herd. 120 calves are purchased each year based on strict selection criteria:

- All born to Holstein Friesian dams.
- All resulting from inseminations between 27 March and 25 June.
- All claves from AI sires.
- Maximum sire calving difficulty PTA of 3.5%.
 - » AA sires: Minimum terminal reliability > 60%; divergent for carcass weight & conformation PTAs (i.e., high and low sires)
- HF sires: Top four EBI sires on the active bull list at time of insemination.

Table 1. Holstein Friesian sires of male calves purchased in 2019								
Genotype		Calvin	g traits		Carcass performance			
(AI code)	EBI (€)	Calving difficulty (%)	Gestation length (days)	Beef sub index (€)	kg	Con	Fat	
HF	302	2.5	-3.8	-11	-5	-0.51	-0.26	
FR2239	314	2.4	-5.29	-2	0	-0.53	-0.39	
FR2460	312	2.8	-2.38	-17	-9	-0.39	-0.13	
FR2385	291	2.3	-4.48	-6	-2	-0.46	-0.3	
FR4021	291	2.6	-3.07	-18	-9	-0.65	-0.2	

Table 2. HIGH & LOW AA sires of male calves purchased in 2019							
		Calvin	g traits	Carcass Performance			
Genotype (AI code)	Terminal Index	Calving difficulty (%)	Gestation length (days)	kg	Con	Fat	
HIGH	€86	2.5	-1.8	11	0.87	0.47	
AA2037	€76	3.8	-2.9	10	0.55	0.48	
AA4195	€78	1.8	-2.9	10	0.48	0.40	
AA4375	€119	2.8	-1.5	21	1.19	0.39	
RGZ	€66	2.5	-0.8	9	0.79	0.65	
WZG	€90	2.8	-1.8	8	1.27	0.32	
ZEP	€85	1.5	-1.1	8	0.95	0.57	
LOW	€51	1.4	-2.4	-3.2	0.57	0.60	
AA2123	€61	2.4	-3.9	6	0.33	0.39	
AA2259	€58	1.7	0.0	-2	0.76	0.77	
JZJ	€61	0.8	-3.2	-1	0.68	0.68	
KYA	€66	0.8	-4.8	-2	0.45	0.19	
SYT	41	1.8	-1.5	-4	0.56	0.78	
ZTP	19	0.7	-1.3	-16	0.61	0.81	

Herd management

Three animal genotype treatment groups were formed: 40 HIGH (sired by six high carcass weigh & conformation AA bulls), 40 LOW (sired by six low carcass weigh & conformation AA bulls) and 40 HF (sired by top four EBI HF bulls). Each genotype treatment has their own individual farmlet, managed under an intensive grass-based steer production system finishing under 24 month of age. Each farmlet is stocked at 2.7 LU/ha, consisting of 40 calves (0-12 months) and 40 yearlings (12-24 months). Calves arrive on-farm at approximately 21 days of age and are assigned to two different milk feeding levels: 4 L or 8 L per calf per day. Milk feeding treatments are balanced by sire, arrival weight and age. Table 3 summarizes up-to-date performance of the three genotypes of calves purchased in 2018 (not statistically analysed).

Table 3: Liveweight performance of yearlings for their second grazing season						
Genotype	DOB	19 February (1 week post- turnout	6 June wt. (kg)	ADG (since turnout)		
HF	9 th Feb 2018	318	422	0.99		
High AA	17 th Feb 2018	283	396	1.05		
Low AA	10 th Feb 2018	298	404	0.99		

All inputs into each system are fully costed and measured to determine the contribution of each genotype to farm profit. This will enable a full financial comparison to be made between the three production systems.

Conclusions

Calf-to-beef systems increasingly demand calves with high genetic potential for carcass weight and conformation. This trial will examine the impact of using elite beef genetics on the dairy herd, whilst developing system parameters for an improved blueprint for dairy calf-to-beef production systems.



PEOPLE FARMING SMARTER



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Useful metrics for labour efficiency on dairy farms

Bernadette O'Brien, Marion Beecher and Justine Deming

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Summary

- A key metric is total labour demand on farm.
- A second key metric is labour efficiency (h/cow/year) and this is useful for benchmarking across farms.
- A further key labour metric is number of hours worked per week.
- Labour time inputted by owner operator (farmer)/family or employees should not be a consequence of inefficient operations on farm.

Introduction

Labour productivity is a complex topic with a number of contributing factors. It is about optimising the use of available resources such as land, animals, equipment and people, to generate a profitable business, sustainable in social, animal and environmental terms. While management of land, animals and equipment is a critical issue, it is relatively straightforward compared to management of the labour resource and input. The latter is complex, since in addition to impacting on all aspects of the business, in some cases, it can become part of the fundamental question of the overall survival of the dairy farm business. To efficiently manage this essential input, the following questions need to be asked: how much labour is required by the farm system; how many people are available to work; how much labour can be supplied; what is the financial cost of labour. To answer these questions, labour input on farm needs to be measured using the correct units to make appropriate judgements on these parameters.

Total labour demand on the farm

Labour efficiency on farms has been measured in terms of h/cow per year and is a useful measurement for comparison across farms. However, to improve efficiency on individual farms the total labour demand on the farm and the number of hours worked per week are two key metrics. A recommended strategy is to conduct an estimate of the total labour demand (h/year) on the farm by recording start and finish times of the work-day and any significant non-work/break periods, on different weeks over the year, e.g. first week of each calendar month. This figure should be examined on the individual farm to establish if it can be reduced. The owner operator (farmer) and others working on the farm should also conduct a labour inventory of the practices, equipment and facilities on the farm. Even on 'labour efficient' farms, it is clear that facilities and practices on farms have a very significant impact on labour requirements. An organised approach to work and good time management by the owner operator/manager can also reduce work time input. This parameter is difficult to measure but a focused routine, optimum facilities and a good task management strategy can reduce labour requirement, e.g. from 3,107 to 2,561 h/year on farms of 140 cows approximately, as shown in a recent Teagasc study.

The farmer should then decide what amount of labour he /she wants to invest in the business themselves. Generally it is the h/week, length of the day, and a holiday period that dictate this. These are considered as important parameters in the industrial workplace, and are aspired to by current farmers, and particularly by young people considering farming as a career.

Hours worked per week

Data from Teagasc Discussion Group members indicated that a majority of dairy farmers (owner operators) are generally satisfied to contribute an average of 58 h/week, while other studies (reporting on questionnaires to farmers) suggest that they should have a target of 50–55 h/week, on average across the year. It is important that the owner operator is realistic about the amount of labour that he/she should contribute, taking into account health, safety, family time, and observations by potential successors. The owner operator will then need to fill the labour gap between the labour requirement and the level of labour that they are willing to supply themselves, with labour contributed by family members, contractors or by employees or a combination of any of these. The optimisation of efficiency in terms of facilities, practices and time management, means that payment to employees is for necessary work rather than for time due to inefficient operations on the farm. In certain cases, contracting out some routine tasks such as slurry spreading or calf rearing may be preferable to employing a person.

It cannot be assumed that a higher labour input is necessary to achieve higher cow performance (kg milk solids [MS]). Deming *et al.* (2018) showed that the most and least labour efficient 50% of farms (n=16) (range 14–21 h/cow/year and 22–34 h/cow/year) achieved 429 kg MS/cow and 426 kg MS/cow, respectively. It is also important that optimum standards of health and safety, animal welfare and environment are maintained, as these features can often be representative of labour saving practices.

Conclusions

To effectively manage labour demand on farm, it is necessary to measure labour parameters and identify appropriate changes. Labour input can be managed by reducing time required to complete tasks, re-scheduling tasks to even out demand and by contracting out tasks.



The 60 hour challenge Abigail Ryan¹, Marion Beecher¹ and Nollaig Heffernan²

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Summary

- The 16 members of the Greenfield Farm Academy (GFA 1) from various parts of Ireland developed the **60 hour** challenge to reduce the hours worked during the calving period to less than 70 hours/week.
- Actual hours worked were 69.5 hours/manager/farm owner.
- Through better organisation during the dry period and improved personal time management, some group members are aiming to achieve a 60 hour working week in spring 2020.
- Some members accept they have to work 70 hours/week in the peak period but that the challenge reduced their hours worked by becoming more focused on the day-to-day planning and management.

Introduction

Greenfield Academy 1 is a group of farmers (n=16) who want to efficiently expand their dairy herds (average herd size 300), and set up additional dairy units. With almost 33% of the total workload on a spring calving farm occurring in spring, the group set an eight-week challenge to cap work at 60 hours per week in the spring of 2019. A one-page worksheet was developed by the group, submitted weekly, via WhatsApp, by each member for the eight weeks. Most of the group had employed labour by contracting or full time labour which was not measured.

Greenfield Academy 1 "60 Hour Challenge" Worksheet

60 Hour Challenge	
	Time
Leave the house	AM
Start time of milking	AM
Daily finish time	PM
Number of straight hours sleep	Hrs
No. of nights out calving (last 7 days)	
No. of night checks on cows calving (last 7 nights)	
Hours worked/day	Hrs
Hours worked/week	Hrs
½ day/week off (yes/no)	
Office work — day or night (hrs)	Day/Hrs
Did you get all your work done this week that you had planned (yes/no)	
Did you have a hot meal every day?	
Mood (Score 1–5) this week	
5 is the best mood you could be in	
Reason for the level of mood; e.g. power outage, calf scour	
What saved time this week?	
What caused hardship this week?	

Factors to consider:

- Excellent weather of spring 2019.
- Variation in night calving management (contracted/no checks/a number of checks per night)
- The Hawthorn Effect informs us that people behave differently when monitored so participation alone may be responsible for some of the reported behaviour.

Table 1. Results of 60 hour challenge						
	Average	Range				
Avg. hours worked/week	69.5 hrs	50–82				
Avg. hours worked/person/day excl. breaks	10 hrs	9.7–11.20 hrs				
Avg. time leaving house	6.20 am	6–6.44 am				
Avg. time milking start	7.00 am	6–8 am				
Avg. time daily finish	6.23 pm	6.09–6.45 pm				
Avg. hours slept	6.17 hrs	5.78–6.75 hrs				
Busiest weeks — (week ending)	15 & 22 Feb					
Day/Night office work	mostly day					
Avg. office work week	0.5–1 day					
Avg. days off over the 8 week period	4	0–7 days				
Mood score (5 is the highest score)	4.5					

The most reported **time-savers** for the period were:

- the exceptionally fine weather allowing night and day grazing.
- being able to sell bull calves.
- Once-a-day feeding of calves from three weeks of age.
- several members had grass breaks set up ahead of the cows.

Questions raised by facilitator of the challenge:

- Is exhaustion, poor organisation or more help needed on farm causing the long hours?
- Where can efficiencies be gained: on farm or personal approach?
- What spring preparations should be carried out and when?
- How can mood be managed in poor working conditions e.g. spring 2018?

Examples of **time pressure creators** included, inability to sell male calves (reported as greatest hardship), broken machinery and tiredness.

Conclusions

The "60 Hour Challenge" was created and carried out by the GFA 1 discussion group for an eight week period during spring calving 2019. On average, the 60 hour target was exceeded (avg. hours worked = 69.5 hrs). It varied every week, but (50%) worked greater than 70 hours per week.

Strategic use of contractors for farm machinery work to reduce hours worked

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Summary

- Machinery work accounts for 20% of total hours worked on labour efficient farms.
- The farms with larger herds used a higher per cent of contractor machinery hours than farms with smaller herds.
- Using contractors more during the calving and breeding season can reduce hours worked by the farmer and create more time to focus on profitable milk production.
- Do the economics for your farm and ask yourself, can you afford not to use more contractors to do machinery work.

Introduction

Dairy cow numbers have increased by 327,000 in Ireland since 2010, to over 1.35 million in 2018. The number of young dairy stock currently in the national herd, as well as survey data of suppliers from milk processors, indicate further expansion is likely to continue into the future.

There has been a dramatic change in the structure of Irish dairying in recent years. Average herd size has increased from 54 cows in 2005 to 76 cows in 2016. The proportion of dairy cows in herds greater than 100 cows has increased from 13% in 2005 to 47% in 2016. The number of dairy farmers milking herds of greater than 100 cows is now over 4,200, up from 1,080 in 2005.

This rapid increase of herds greater than 100 cows has the potential to create conflict between the availability of family labour and the workload on farms. While the CSO Farm Structure Survey in 2013 highlighted that a large amount of family labour exists on dairy farms, there is no guarantee this labour exists specifically on the farms milking more than 100 cows where it is particularly needed, or that family labour is available at busy times in the season e.g. during calving in February and March. Hence there is a growing requirement for both full and part time employees to work on dairy farms.

Contractors to reduce workload

Table 1 below from Deming *et al.*, 2018 shows the total hours worked for 38 dairy farms that were previously identified as labour efficient. Machinery work took on average 20% of the total hours worked. This study found that as herd size increased the percentage of machinery work contracted out increases from 30% to 59%. Most farmers are at peak hours worked at calving time, reaching 70 to 80 hours/week. The next major task after calving is getting cows back in calf and achieving a six week calving rate of 90%. To have the time to manage calving's, rear calves and reach a six week calving rate of 90%, using contractors more for machinery work should be considered particularly for these two seasons.

contractor on 58 labour-encient dany latins							
	Herd size category						
	1 (<150)	2 (150–249)	3 (> 250)				
Total hours worked	3,015	4,499	6,023				
Machinery work total	680	959	1,128				
Contracted	207	348	663				
Farmer/family/staff	473	611	473				
% Contracted	30	36	59				

Table 1. Hours of machinery work performed by farmer/family/staff or by a contractor on 38 labour-efficient dairy farms

Relationship with contractor

Factors that are commonly discussed by farmers that contribute to a good relationship with their contractors are; paying on time, having a plan as to what work is contracted out for the year, a farm map and having paddocks ready for work to be carried out without interruption. These factors lead to good communication, respect, and appreciation. They are basic requirements but can be often forgotten.

Conclusions

Contractors play a very important role on dairy farms. Not only do they reduce hours worked by the farmer, they also do this at a time when peak workload is at its maximum. This in turn streamlines the farm and leaves the farmer and employees time to focus on achieving a profitable and enjoyable business. A cost benefit analysis should be completed when considering how much machinery work is contracted out. Solutions to overcome barriers for not fully utilising the contractor as a source of labour must be examined.



Contract rearing dairy replacements — the rearer's perspective

Tom Coll¹ and Seamus Nolan²

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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

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

The Sligo/Leitrim contract rearers' discussion group was formed in 2015 and now consists of 18 active contract rearers and two farmers who intend to contract rear in the near future. The farmers are beef and sheep farmers with good grassland management skills and infrastructure and look 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. In 2017 group members were asked to list the benefits associated with contract rearing from their perspective and those are outlined hereunder

- Ability to increase stocking rate with immediate effect, making better use of available land and buildings without the requirement to invest in stock.
- Improved cash flow while the risk associated with market and price fluctuations is eliminated and increased overall profitability makes farm planning easier.
- Clear guidelines are outlined regarding targets weights and pregnancy rates which keeps the rearer focused on the job.
- A means of building a long term trustworthy relationship with the dairy farmer.

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. These animals will be the ones that the rearer will continually struggle with to meet the targets and will reduce farm profitability. Dairy farmers need to ensure that all heifers sent out for rearing are on target 90–100 kgs at weaning.
- 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.

- Initial contract is difficult to set up 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 especially achieving the 60% of mature weight at bulling.
- 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.

Group members were asked to advise on key factors that should be agreed upon in advance of the first animals arriving on farm:

- A detailed written and signed 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 six weekly weighing of stock should be undertaken to identify underperforming animals for timely corrective action.
- In the first year of the contract agreement, both parties found it beneficial for the dairy farmer to hold onto 25% of the heifers and rear them himself as a means of comparison. This can be used as an aid in the trust building process.
- Use of heat synchronisation and tail paint/patches as an aid to heat detection to ensure pregnancy rate targets are reached.
- The use of an intermediary person such as an agricultural consultant appointed by both parties to dissolve disputes and find solutions when difficulties arise.
- Being part of a discussion group sharing experiences and acquiring additional knowledge.

Conclusions

Contract rearing is a win-win for dairy and dry stock farmers. The dairy farmer has the use of the contract rearer's land, labour and buildings which should reduce his/her own labour requirement and need to invest in additional building for heifer rearing. Dairy farmers should carry out a cost benefit analysis of contract rearing on their own farms. 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.

PICK your projects: plan your outcomes Nollaig Heffernan

Independent Management Consultant

Summary

- There are many easily used tools to help decision making regardless of the size of your dairy operation.
- One tool from Lean Management, the PICK Model, simplifies the decision of where to invest resources.
- Once the PICK model has helped you decide where to invest, it is critical to carefully plan that investment to maximise the outcome.

Introduction

The **PICK Model** comes from the discipline of Lean Management and can be used to categorise potential projects for their investment potential.

The PICK Model has two axes creating four quadrants and considers the **Return on Investment** versus the **Level of Difficulty** of any task/project.



- Level of Difficulty +

Progression of the investment depends on how it is categorised:

- **P**ossible Low Return/Low Difficulty **Caution (orange**) → may need volume to create a return.
- Implement High Return/Low Difficulty **Best option (green**) → proceed, low hanging fruit.
- Challenge High Return/High Difficulty Stop (red) \rightarrow needs planning and clear understanding.
- Kill Low Return/High Difficulty **NEVER attempt (black)** \rightarrow haemorrhages resources.

Each farm's PICK model entries will differ depending on farmer capability, herd profile, farm size, land quality, location, business maturity and financial stability.

Planning

While the **PICK model** points out the best projects to Implement for quick wins and high impact (High Return/Low Difficulty), at certain points in every farm's lifespan there is a need to invest in High Return/High Difficulty or Challenge projects, but these carry greater risk. To reduce these greater risks, you should only start Challenge projects when you have converted them to Implement projects or as close as possible to Low Difficulty through careful planning.

Table 1. Well planned or poorly planned Challenge projects Farm Building

Well Planned \rightarrow Implement \rightarrow Fit-for-Purpose, on-time and on-budget

- expert advice \rightarrow best location for build, best specifications, etc.
- planning → finance secured, planning permission, preparation for start date in summer for continuous build, project schedules, etc.
- best shed erectors.
- project manager to allow farmer get on with own workload.

Poorly Planned \rightarrow Kill \rightarrow building not right, over time and over budget

- poor or no advice → site unsuitable, poorly thought out design.
- lack of planning → delayed/limited finance (cut corners), planning objections, not ready for start date, wrong time of year (calving, weather), project not managed (finish date drifts), etc.
- best shed erectors not available \rightarrow attempt self-build on top of daily workload.

Employing Staff

Well Planned \rightarrow Implement \rightarrow towards Employer of Choice status

- self-development → learning people management skills in advance.
- business awareness → employee roles, work offer, employment law in place, good working conditions, etc.
- planning for role \rightarrow rosters definite daily finish time, holidays, etc.

• timely selection \rightarrow positive stress-free induction, patience, etc.

Poorly Planned \rightarrow Kill \rightarrow really struggle to attract and keep staff

- poor people management skills.
- no business awareness \rightarrow undefined role & job offer, no H & S, etc.
- no planning for role \rightarrow no rosters, no set finish time, etc.
- poorly timed selection \rightarrow panic hire, stressful induction, intolerance.

Conclusions

For improved decision-making for on farm investment:

- apply a PICK model to possible investment opportunities on farm.
- always invest in High Return/Low Difficulty (Implement) projects.
- move High Return/High Difficulty (Challenge) projects to High Return/Low Difficulty (Implement) projects through excellent planning.

Becoming an employer of choice Thomas Lawton¹, Suzanne Groome², Martina Gormley³, Pat Clarke³ and Marion Beecher¹

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Summary

- Good communication and training opportunities are the main characteristics employees seek from their employer.
- Of 315 dairy farmers surveyed, 77% did not issue payslips to employees.
- Improvements are required regarding fair treatment and respect of employees, including compliance with employment law.

Introduction

The limited availability of highly skilled labour is challenging farmers to review their work management practices. A clear set of work practices enables employers to provide a positive and efficient working environment that will in turn ensure top quality employee performance. Effective employment management can improve profitability, decrease employee turnover and lead to a satisfactory employment relationship. The attractiveness of dairy farming as a career relies on the satisfactoriness of the employment relationship between the employer (farmer) and their employee.

Materials and methods

Two studies were conducted to ascertain the characteristics of a positive working environment;

Study 1

Seventeen semi-structured interviews were carried out with dairy farm employers and employees, nine with employers and eight with employees, all of whom were in separate employment relationships. A thematic analysis was then carried out on the data to understand what characterises a satisfactory employment relationship for both the employer and employee.

Study 2

Three hundred and fifteen dairy farmers representative of location and herd size were surveyed regarding work organisation and employment practices. Of the farmers surveyed, 62% were employing one or more people. Herd size ranged from 25 to 700 cows. Participation in the survey was voluntary, and the responses were collected by post or by phone.

Results and discussion

The results of the two studies are summarised below. According to the interviews, the top two characteristics an employee looks for in an employer are:

Good communication skills and training

According to employees, to be considered a satisfactory employer, it is necessary to be a good communicator and provide appropriate training opportunities. One of the ways farmers can improve their communication skills is by incorporating standard operating procedures (SOPs) onto their farms. Standard operating procedures provide employees with a framework for completing jobs while minimising dependence on the employer for constant direction. Results from the survey indicate that 30% of the farmers surveyed (n=315) use written SOPs on their farm with herd sizes ranging from 40 to 550 cows. Milking and feeding SOPs were the most commonly used SOPs on farm.

Compliant with employment law

A common theme that persisted throughout the interviews was the fair treatment and respect of employees in terms of pay and holidays. Compliance with the regulations of the Workplace Relations Commission in Ireland is compulsory for employers. It is the farmer's responsibility to ensure that they are providing a good working environment regarding animal and employee facilities, fair working hours and holiday provisions for employees. Farmers keeping track of hours worked and payroll can be the difference between satisfied and dissatisfied employees. Results from the survey indicate a substantial proportion of farmers do not comply with employment practices such as not issuing a payslip to employees after each payment or recording employee details (Figure 1).



Figure 1. Employment practices on Irish dairy farms (n=315)

Conclusions

There is scope for improvement regarding employment practices on Irish dairy farms. The results of both studies highlight that by improving communication skills, offering appropriate training opportunities and complying with the employment law, farmers can become better employers.

Farm succession and inheritance planning James McDonnell

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Summary

- Farm succession and inheritance are issues for every farm family.
- 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 begin at an early stage to ensure that the process is successful.
- Communication is one of the most important factors which contributes 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. 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, there are two processes. These are 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. 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. The farmer and spouse will try 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. It 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 regard to the farm business.





Communication

Effective communication is the key ingredient to successful succession planning. 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. This means 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?



Figure 2. Three key discussion areas for a successful plan

Conclusions

Communication is the key to effective succession planning. It is important to have the discussion early and with all family members. This should prevent any disagreements and ensure that all family members have had the opportunity to discuss their needs, fears and requirements about the farm business.

Collaborative farming:options to consider within the family farm

Thomas Curran¹ and Paidi Kelly²

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Summary

- Succession is the transfer of management responsibility and should begin initially at an early age in the farm family. A registered family partnership is an integral part of succession planning of the family dairy farm.
- Capital Gains Tax Restructuring Relief can be used to consolidate fragmented farms but careful planning is needed.

Registered farm partnerships

A registered farm partnership is a profit sharing business arrangement between two or more farmers that are registered on the Register of Farm Partnerships managed by the Department of Agriculture. In the context of the family dairy farm, registered farm partnerships are an excellent transition business arrangement that facilitate the succession process. Succession is the transfer of management from one party to another and is often linked to, but is different from, inheritance, which is the process of transferring assets between parties. Succession planning on Irish dairy farms is a vital process and is covered in detail in another paper in this book.

Teagasc research 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 an advanced 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. Effective succession planning allows the family to approach farm operation as a team to achieve the family's goals. The partnership can provide the platform to blend the experience of the parents with the youthful enthusiasm and modern thinking of the future successor.

A gradual approach is important to succession as in most cases parents are not immediately in a position to transfer either the farm or full management responsibility to a son or daughter that has returned home after completing their agricultural education for a number of reasons. Firstly, the young person is relatively inexperienced and there are other 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 at a later date.

There are financial advantages to forming a registered partnership for both the parents and the son or daughter. Splitting farm profits between multiple parties helps to reduce the income tax liability. Registered partnerships are eligible for more than one TAMS grant for farm development. Succession farm partnerships are a new structure which began 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.

Capital gains tax - restructuring relief

This scheme provides Capital Gains Tax (CGT) relief 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 before 31st December 2019. 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.

Conclusions

Family partnerships are an excellent way to formalise the succession process and Restructuring Relief should be considered by those with a fragmented farm. Specimen template agreements for all the collaborative arrangements featured in this (and the next) paper are available in the Collaborative Farming section of the Teagasc website.



Collaborative farming: options to progress the farming business

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Summary

- Partnership provides a sustainable business model for farmers to amalgamate farming businesses and can allow young trained farmers establish a career in dairy farming.
- Share Farming provides an avenue of entry to dairy farming for young trained people and an option to continue in farming for farmers with no family successor.
- Land Leasing gives security of tenure to the lessee and access to income tax benefits to the landowner.

Registered farm partnership — Non-family

In the context of non-family situations, two or more farmers can combine their respective dairy farming operations into one single operation as a partnership. One of the key drivers of these partnerships can be improved work/life balance for a number of reasons. A consolidated larger scale farming business tends to be more labour-efficient, two people working together can get a lot more done than two individuals, there is less need for hired labour and it is much easier for any partner to take time off. This can result in a better lifestyle with more time for family and other personal interests. A partnership must provide the opportunity for increased scale as the farm will have to sustain two incomes. In many cases, partnership affords the opportunity to increase the scale of operation and reduce farm fragmentation. A partnership can allow for lower risk expansion via making use of the existing facilities on farm, which may reduce the level of capital expenditure.

For a young trained farm manager, after 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 can facilitate progression to business ownership. Working in partnership means there is often a better and broader range of knowledge and skills available to the partnership business. This facilitates 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. The key challenge for any farmer considering a partnership or any collaborative arrangement is to develop and nurture a strong working relationship with other people. 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; the business of the landowner, and 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 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/cash flow plan for their own respective businesses to make sure the

venture makes financial sense for themselves. Share farming as a structure could suit 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 farm performance. 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. 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. 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 taxfree income subject to the limits. €18,000, €22,500, €30,000 or €40,000 is available tax free for five but less than seven, seven but less than 10, 10 but less than 15 and 15+ years, respectively. These can be doubled where more than one party owns the land. 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. The key benefit to the lessee is that the long-term lease provides security of tenure to expand their business and even undertake capital expenditure on the land if term and rental price allow this.

Conclusions

Partnerships, share farming and leasing are attractive options to progress the farming business but they require excellent communication skills, detailed planning and reliable financial and legal advice.



No farm? No problem! Advice on new pathways into dairy farming

Paidi Kelly and Marion Beecher

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Summary

- Milk quota removal and the resulting expansion have created exciting and varied career opportunities on dairy farms in Ireland.
- There is a variety of employed career roles available on Irish farms from part-time relief work to full-time assistant or management positions.
- There is also a growing number of progression opportunities via leasing, partnerships or share farming arrangements.
- Key to having a successful career in dairying is having the skills needed to farm effectively.

Dairy farming in Ireland is changing rapidly. The national dairy herd averaged 1.44 million dairy cows in 2018 (+400,000 cows or +38% since 2010) and over half of these cows are milked in herds of >100 cows. Teagasc expects that if the national dairy herd increases to 1.6 million 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 both opportunities for employment and progression in Irish dairying. The most important resource available to any business is its people, and there are exciting opportunities for people with the right skills and work ethic to be successful employees or farmers.

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 is for the demand for dairy products to continue to grow, based on a growing world population and the increased westernisation of diets in developing countries. Ireland, with its grass-based system of milk production, is well positioned to capitalise on this growing demand.
- Profitability of dairying compared to other enterprises: The 2018 e-profit monitor figures show that the average dairy farmer made a net profit of €1,590/ha. The top 25% of farmers made €2,500/ha (This figure excludes subsidy income along with a charge for the farmers own labour, tax and capital repayments). This is far in excess of what was achieved in other enterprises.
- Increased interest in collaborative farming models: There is a large and growing interest in this area. The creation and subsequent success of the Macra Land Mobility Service, which has facilitated the change of land use of over 47,000 acres in five years is evidence of the strong interest of Irish farmers in collaborative farming. Successful business arrangements involving farms that have been converted to dairying and also existing dairy farms which 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/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 2016 CSO data showed that 30% of Irish farmers were aged 65 or over and more than 50% of farmers are 55 or older. In dairying, 16% of farmers were aged 65 or older. Macra surveys have identified that

50% of farmers over 50 also have no identified successor. Hence Irish farming is facing a lack of successors and a shortage of people with the necessary skills to take on the running of farms. If farmers have no successor, many may consider employing labour or entering a collaborative farming arrangement in the future to continue in dairying.

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. You no longer have to own a farm, or even be from a farm to be a successful dairy farmer; the key requirement is the skills. Whether someone is interested in an employed position or owning their own stake in a farming business, there are many 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, lower living costs and commute times when living in rural Ireland.
- the opportunity to work both on your own and as part of a team while using the latest science to try and improve farm performance.

It is possible to start from a non-farming background and become a successful dairy farmer (there are multiple examples farming today) but it can be challenging. Having an excellent support network, saving effectively, developing a strong work ethic and developing good people skills are some of the key ingredients for success.

Skills required

Key to having a successful career in dairying is having the skills needed to successfully fulfil each career role. Education (e.g. the Teagasc Advanced Dairy Certificate and Dairy Farm Management Diploma) combined 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.

Conclusions

There are exciting career opportunities in Irish dairy farming. Key to success is developing the grass, cow, people and business skills required.



Lessons learnt to date from NEWBIE and NEFERTITI projects Redmond McEvov

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

Summary

- Teagasc is involved in two EU projects looking at encouraging new entrants to farming (NEWBIE) and promoting farming as an attractive career (NEFERTITI).
- New entrants can bring innovation, entrepreneurship, practical skills and positivity to the dairy industry.
- Current dairy farmers can play an important role in encouraging new entrants/ successors to the industry.

Introduction

Falling farmer numbers and the decline in young farmers is a constant threat to the agricultural sector. A Central Statistics Office report in 2016 showed that there were 137,100 farms in Ireland, down from a total of 141,527 farms in 2000. On 30% of Irish farms, the farm holder was over 65 years of age. Teagasc have reported that 6,000 people are required to enter the dairy industry by 2025. These numbers highlight the importance of new entrants to Irish farming. New entrants can bring innovation, entrepreneurship, practical skills and positivity to the industry.

New entrants face considerable challenges in entering the sector. The NEWBIE project aims to address the challenge of enabling new entrants to successfully establishing sustainable farm businesses while a theme from the NEFETRITI project aims to promote careers in dairy farming.

Lessons learnt from New Entrant farmers

New entrants face quite a number of barriers with the most common hurdles including access to land, access to capital and access to labour. Ten in depth case studies in Ireland were conducted (90 in total across Europe) and success factors of new entrants were compiled. Some success factors/ways of overcoming challenges for new entrants included:

- Collaborative farming models e.g. partnerships: Led to easier access of finance and to an increase in knowledge through multiple personal involved in the farm business.
- Funding supports for new entrants: Examples include young farmer capital investment scheme, young farmer's scheme, national reserve, collaborative farming grants, succession farm partnership scheme, leader funding etc.
- Access to knowledge: There are a number of courses and supports available to new entrant farmers such as 'Teagasc Dairy Start Up Course'. New entrants also stated that discussion groups offered them support and back-up.

Key aspects for farmers to promote careers in farming

One of the themes of the NEFERTITI project is promoting farming as an attractive career. Current dairy farmers play a key role in promoting careers in dairy farming to younger generations. They can display dairy farming as a positive career through a number of different actions:

- Promote a positive image of dairy farming to their children. Encourage it as enjoyable work that offers the potential to earn a high income when done correctly.
- Open their farm to demonstration events to promote dairy farming. Target audiences could include local school children.
- Share their story on how they became a dairy farmer this can be particularly interesting for the audience if they come from a non-farming background. A possible method to do this would be through social media platforms that farmers are active on.

Conclusions

Sustaining a cohort of new entrants is crucial for the agricultural sector. While there are many challenges for new entrants, especially when starting their farm business, there are ways of overcoming these challenges and supports are available. Dairy farming must be portrayed as a positive career with multiple opportunities to encourage new entrants/ successors to enter the industry.

Acknowledgment

NEWBIE is a an EU horizon 2020 project aiming to create a network that offers guidance of overcoming challenges for new entrant farmers. Register on http://www.newbie-academy. eu/ to join the NEWBIE network, keep up-to-date with the project and to see new entrant examples from Ireland and across Europe.

NEFERTITI is an EU horizon 2020 project aiming to networking European farms to enhance cross fertilisation and innovation uptake through demonstration. 10 themes are addressed with one them being Farm Attractiveness. Register on https://nefertiti-h2020.eu/ keep upto-date with the project and demonstration events that will be ran in your region!



Dairy Start Ups Abigail Ryan

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Summary

- Since the abolition of milk quotas in 2015 a number of dairy conversions have taken place. In one co-op region up to 10% of suppliers are now new entrants to dairying. Dairy Start Up farmers have converted their owned or leased farms to a dairy farm.
- The reason why people are converting to dairying is because they want to ensure the family farm is sustainable into the future.
- The question many Dairy Start Up dairy farmers ask is what type of stock would you buy? Firstly, it's much easier to buy excellent quality stock in 2019 compared to ten years ago as nationally the herd has improved genetically (EBI 90+/cow) and cows are much healthier.
- Borrowings should be kept minimal and enough should be borrowed initially; don't depend on funding everything through cash flow, take on manageable debt you and the business can manage.
- Create a budget then get prices, many prices will overrun so have a contingency or rethink where the investment can be made to get best return.
- The 'big bang' approach is much better than slow expansion for two main reasons (1) easier to manage the farm if it's stocked higher (2) banks will give a larger amount day one rather than going back looking for a second amount.
- Grass measurement and soil fertility management is an area many dairy conversions struggle with.

Introduction

A number of new dairy conversions have attended third level education and worked off farm in an unrelated career before converting. There is a high level of knowledge adoption within this group of farmers.

Dairy Start Up course

Teagasc are running annual short Dairy Start Up courses for people thinking of converting their farms. It's a four day course based in Moorepark and a new dairy Start Up farm and in the local Teagasc region. The participants then attend the Greenfield Academy each month for 12 months learning the basics on grassland management. Click on https://www.teagasc.ie/animals/dairy/dairy-expansion-service/dairy-start-up-course/ to register for the course.

Lessons learned by recent dairy conversions

Select an excellent mentor to get the right advice. Travel to a high performing dairy farm that you can bench mark against. Working on a good dairy farm for a period is crucial. Dairy conversions will require a lot of time commitment and everyone in the family needs to be aware of this. Some are now joining really good dairy discussion groups a year before they start. Cost of set up on these farms was €2,500/cow (excl. stock). Second hand parlours were installed on some farms. Parlour decision was based on budgetary availability. Always, think of future expansion when designing the parlour and bulk-tank. Most of these farmers have sheds and slurry storage that can house the stock. The main investment is where the highest return is and that is from stock, grazing infrastructure, milking parlour and a bulk-tank.

Challenges

One of the biggest challenges on the Dairy Start Up farms was sourcing the right type of stock. The Dairy Start Up farmers wanted a cow that was robust, healthy, and fertile. A high number of the Greenfield Academy participants choose to buy in-calf crossbred heifers.

On average, the first lactation animal will only produce 70–80% of the milk production of the mature cow (320 kg milk solids).

Table 1. Criteria when purchasing young breeding stock						
	Friesian	Cross-Bred				
EBI (in calf heifers/calves)	≥170	≥170				
Fertility sub-index (€)	100	65				
Milk solids (% B. fat/% protein)	+0.15/0.10	+0.20/0.15				
Maintenance sub-index (€)	20	20				
Health sub-index (€)	Positive	Positive				

By selecting breeding stock using criteria in Table 1, will result in very high quality stock purchased (top 10%). Understanding the EBI report is crucial, hiring an independent person that understands the EBI is important. The local vet will be very helpful in the herd health decisions (check TB status). Nationally, **herd health** is good with BVD almost eradiated. The national Johne's programme is available which is highly recommended. Ask what management procedures the source herd has in place on Johne's management, particularly at calving.

Animal behaviour is also a key factor when deciding whether to buy cows or heifers. It's a little easier to train heifers in a herringbone parlour by letting the heifers through the parlour about two weeks before calving.

Project planning the conversion can be challenging due to planning permission, ESB, grant application, and banking delays.

Conclusions

The abolition of milk quotas created a sustainable future for all the Dairy Start Up's farmers, which gave them the option to become a viable full time dairy farmer. In some cases partners were able to give up their full time employment to focus on their young family.

In order for the business to be successful the main areas to focus on are investing in the right stock, grassland infrastructure, develop the farm yard so that it can be labour efficient and phase the development depending on budgets.

Four key mistakes in business planning for dairy farms

Patrick Gowing

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Summary

• The Dairy Expansion service is now in operation over three years and has developed over 400 business plans for new entrants and expanding dairy farms to date around the country.

The Expansion Service, with the help of the local Teagasc Dairy advisors develops a suitable and viable business plan for the client's farm and family. Over this time we have identified some key areas where farmers make mistakes in their farm development and business plans. This article highlights five of these key mistakes.

No. 1: No money in expansion

In any business the expansion phase can be very difficult on cash flow and it's a vulnerable time for the business. Take a suckler herd moving from 50 to 100 cows. There will be an increased replacement rate on farm to allow the herd to build numbers which will reduce sales off farm. There may also be a reduced cull rate that will also reduce farm sales. Invariably there will be capital investment required in growing more grass for the increased stock. Also there may be the need to construct additional housing. All these combined will mean a potential reduced output with increased fixed costs during the expansion phase. There is a time lag before the farm returns to "full production" after the expansion and this needs to be considered in your business plan. The same will happen in an expanding dairy herd as they will have the increased cost of carrying additional heifers and a potential lower output per cows based on having a young herd. Again it will take time after the expansion before the farm will revert to its true potential. So developing a business plan. There is no money in Expansion, but there should be increased money when expanded if you have developed a good business plan.

No. 2: From here to there

Most farmers considering converting their farm to dairying start the planning phase two years prior to the start-up of the first cow milking. There are a lot of considerations in developing both your physical and financial farm plan. Normally we see when reviewing the plans that there is a good physical plan on how to develop the farm for conversion. So they will know when and where reseeding has to take place for example or the positioning of the new parlour. However, when we review the business plan it normally starts in the year that the parlour starts and does not show the potential cashflows from the farm in the conversion years. This can also lead to a poor business plan as you have ignored the farm operating costs in the years prior to the cows starting to milk. This usually means the farmer over values the stock he has on hand that is available to be reinvested back into the farm. Some of the value of the herd will be required to pay on-going bills. So your Business plan should map the conversion phase right through the early years of your dairy enterprise.

No. 3: Capital budget

An accurate capital budget is essential to develop a farm business plan. While the large ticket items like the parlour and bulk-tank are easily calculated they smaller items are often forgot about. The capital budget should be developed to reflect all investment required on your farm to enable you achieve your expansion plans. Breakdown the capital budget into a number of headings. The headings we use are: Growing grass, Accessing grass, Milking premises, housing and others. Also develop a timeline of when you will need to invest the capital. Often the "small items" can increase the cost of the budget substantially like three phase connection or a new well. Also build in a good contingency fund into your budget. Typically we use 10–15% of the overall capital budget. Most capital projects overrun the budget. Adhere to your capital budget as best you can. The add-ons during the construction can drive the capital required. If the capital budget is too low for the expansion plan it will be not be funded properly. The shortfall then will normally have to be financed from cash flow. This will put increased strain on the cash flow of the business and may result in the farm running up short term debt.

No 4: Overbudgeting

While setting targets and goals for your farm to achieve are an excellent management tool the targets in your business plan should be more realistic. Are plans based on a high milk price viable? Be realistic in your business plan regarding the potential kg Ms Output of your herd. Increasing the milk solids sold per cow will make the plan viable but can it realistically be achieved? The combination of a high milk price on your plan and high milk solids sold can gloss over what may not be a viable plan. Another consideration is to do a sensitivity analysis of your plan. After you have expanded and finishing developing if your plan is not in a position to cope with a low milk price year is that a good plan? The decision to expand your farm and invest into your business should leave your farm in a stronger position after the expansion phase rather than a more vulnerable position. One of the largest costs on any farm is the drawings figure required for the family off the farm. This is an essential piece of information to develop any business plan.

Conclusions

Finally the plan should be discussed with your accountant for any potential tax implications of what you are planning to do. An unexpected tax bill can also put financial strain on the business.



Agricultural science students' attitudes to careers in dairy farming Marion Beecher and Abigail Ryan

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Summary

- More people from farms choose to study agricultural science than from any other background.
- Dairy farming is perceived as a physically demanding job, with a poor work/ life balance without extra financial rewards compared to other careers.
- Students viewed dairy farming positively regarding variety of tasks.
- Parents have the greatest influence on adolescents' career choices.
- Based on these findings, a co-ordinated multi-stakeholder (farmers and farm organisations, milk purchasers, industry bodies, educators etc.) approach is needed to address negative perceptions by better informing students and parents about the positives of dairy farming careers.

Introduction

Dairy farming has an ageing population which is linked both to younger people staying longer in education, and older people remaining longer in the workforce due to improved health and rising longevity. Attracting people to the dairy industry is vital for generational replacement and also to enhance innovation. The growing economy in Ireland means that dairy farming is facing increased competition for employees from other industrial sectors while having a greater requirement for employees than ever before. To attract greater numbers of high achievers to dairy farming is it important to establish their views of a career in dairy farming.

Survey

Agricultural educational programmes are considered as essential for recruitment into third level agricultural education programmes and potentially into an agricultural career. Students in secondary schools studying agricultural science are generally more knowledgeable about farming and express more favourable beliefs about agriculture than those without such exposure. To ascertain the views of Irish adolescents studying agricultural science in both urban and rural secondary schools a postal survey was conducted.

Student background

A total of 976 students studying agricultural science in 44 secondary schools completed the survey. The majority of students were in fifth or sixth year while 7% were in fourth year or Leaving Certificate Applied. Overall, 43.7% of students studying agricultural science were living on a farm, 38% living in a rural area but not on farm, while 18.2% were living in an urban area or city. Although 16.5% of those surveyed had no relative involved in dairy farming, 68.7% of students said that they knew a dairy farmer well.

Influencers on career choice

The study found that parents have the greatest influence on the career choices of adolescents (41%). Parents can influence youth through the activities they encourage, along with the agricultural stereotypes held by the parent. Educating parents about dairy farming careers is essential as neither teachers nor counsellors can replace the influence parents have on their children's career plans.

Perceptions of a career in dairy farming

Dairy farming is perceived as a physically demanding job (92%) requiring hard or really hard work by 81% of students. Students associated dairy farming with a poor work/life balance (66.3%) without any extra financial reward (43.9%) compared to other careers. Students' responses to statements regarding attitudes to dairy farming are presented in Table 1. There were differences in perceptions depending on where the student was living. City dwelling students had the least awareness of the available career opportunities, and were least likely to recommend a career in dairy farming. Students viewed dairy farming positively regarding flexible working hours and involved a variety of tasks. However, students perceived dairy farming as an unsafe industry with limited career opportunities.

Table 1. Agricultural Science students' attitudes to dairy farming							
Statements	Total Responses (n)	Farm dweller (yes %)	Rural non-farm dweller (yes %)	City dweller (yes %)	Urban dweller (yes %)		
Equal opportunities for male and females	964	75.2	63.1	53.5	64.1		
Dairy farming can allow you to have flexible working hours	959	24.1	27.2	34.2	24.4		
Dairy farming is a safe industry	957	41.5	35.6	45.2	35.4		
Dairy farming involves a variety of tasks	968	95.9	95.6	97.7	98.5		
Dairy farming requires high skill levels	962	69.2	66.6	74.4	71.5		
To be a successful dairy farmer it is necessary to own your own farm	956	53.0	50.0	38.1	47.7		
Dairy farming offers many career opportunities	961	42.5	28.1	20.9	28.2		
Would you recommend dairy farming as a career to a young person?	952	62.2	51.8	39.1	43.1		
Dairy farming is strongly promoted to young people	961	28.7	16.7	18.6	14.5		

Conclusions

The results suggest that, for the industry to attract a sufficient number of high quality recruits, significant additional efforts must be made to address negative perceptions by better informing students and parents about the benefits of dairy farming careers. This will require a very deliberate and co-ordinated multi-actor (farmers and farm organisations, milk purchasers, industry bodies, educators etc.) promotion of dairy farming. The increased emphasis on workload concerns among students suggests that the industry should invest significant resources in programmes to further reduce the workload and improve work/ life balance on dairy farms.

Education options for a career in dairy farming Emma-Louise Coffey¹ and Frank Murphy²

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Summary

- The continued growth and sustainability of the Irish dairy industry is dependent on highly skilled dairy farmers.
- Formal agricultural education is associated with greater farm size, income per hectare and overall farm efficiency compared with those with no formal agricultural education.
- The Level 6 Advanced Certificate in Dairy Herd Management and the Level 7 Professional Diploma in Dairy Farm Management (PDDFM) equip the next generation of dairy farmers with the skills and technical knowledge required for success.
- There are a number of roles available on dairy farms including relief work, farm operatives, and farm management. Furthermore, there are a number of progression opportunities such as leasing, partnerships and share farming.

Introduction

The Irish national dairy herd is continuing to grow, both within existing herds and through dairy start-ups. The sustainability of the expanding industry is reliant on skilled farmers who have the ability to manage financials and people as well as day-to-day farm tasks. Furthermore, due to the rapid and significant change that is occurring within the industry, farmers need to keep up-to-date with skills and knowledge, adopting new technologies and methods relevant to their farming system. The next generation of farm owners and managers should avail of every training opportunity available to them in order to achieve the requisite knowledge, skills and experience to secure the long term future of their dairy business. Work experience with high quality dairy farmers reinforces learning experiences and offers mentors throughout future farming careers.

Advanced certificate in Dairy Herd Management

The Level 6 programme provides graduates with the knowledge and technical skills required to operate dairy herds. Having completed one year in agricultural college, students typically spend a further year completing the Advanced Certificate which consists of 22 weeks college and 16 weeks of practical learning with a host farmer in Ireland or abroad. Course content is a combination of technical (grassland management, breeding, nutrition and health) and farm business planning modules. Students who successfully complete the Level 6 programme have the skills and competencies to join the dairy industry as a skilled operative. Progression from the Level 6 programmeincludes Professional Diploma in Dairy Farm Management (PDDFM) or agricultural courses in the Institutes of Technologies.

Professional Diploma in Dairy Farm Management

The Level 7 specific purpose programme is the gold standard for farm ownership and farm management training. The programme aims to provide enthusiastic dairy farmers with the latest research and best practice management knowledge to successfully run dairy operations.

The main component of the programme is two years paid professional work experience based on high performing dairy farms in Ireland, with an opportunity to complete a placement abroad. During this time there is approximately 20 days course work, where students further develop a broad range of skills in technical farming as well as developing a greater understanding of business and financial skills and people management. Course days are typically delivered at the Teagasc, Animal & Grassland Research and Innovation Centre at Moorepark and Teagasc, Kildalton Agricultural College. Course days incorporate both formal (lectures) and informal (discussion groups) training, delivered by an integrated team of highly specialised Teagasc staff including Moorepark researchers, college teachers and dairy specialists. Guest lectures are invited from key industry stakeholders and highly successful commercial dairy farmers. Students who successfully complete the PDDFM have the skills and competencies to successfully manage large scale dairy farms to a high level.

Applicants to the PDDFM programme must possess a Level 6 Advanced Certificate in Agriculture or an equivalent agricultural award.

Continuous training opportunities

Due to the considerable change that is occurring within the Irish dairy sector, farmers must respond through continuous learning in order to meet new skills and knowledge requirements. Teagasc offer a wide range of both formal and informal training opportunities to meet future needs to improve the environmental, social and economic sustainability of dairy farms. Such training opportunities include discussion groups, short training courses workshops, information days and conferences.

Conclusions

Agricultural education is linked to greater farm profitability and therefore, farmers should avail of all learning opportunities that can further progress their farming career.




DAIRY FARM INFRASTRUCTURE



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The design of land drainage systems and their performance

Pat Tuohy¹, Owen Fenton² and James O'Loughlin¹

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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.
- With appropriate drainage, grass production has been shown to increase by between 4 and 7 t DM/ha/year.

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 and grazing season, increases the utilisation of grazed grass by livestock and improves 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.

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 drain to be installed will depend entirely on the interpretation of the characteristics revealed by the test pits.

Groundwater drainage system

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

Performance analysis

Performance analysis of drainage systems installed on Heavy Soils Program (HSP) farms allows examination of the impact of the type of drainage system, soil type and seasonal variations in soil moisture on drainage system performance. All of the systems installed reduce the overall period of waterlogging and control the water table, thereby improving the conditions for both the production and utilization of the grasslands they drain. Drained sites increased grass production by between 4 and 7 t DM/ha/year. Deeper drain systems with direct connectivity to groundwater discharge greater volumes of water and maintain a deeper water table compared with shallow drainage designs. The differences in drainage capacity observed between the different drainage design types is dictated largely by the hydraulic capacity of the soil within the drain's catchment and connectivity to different water bodies. This work is allowing a more complete understanding of the capacity of individual drainage systems, and providing useful information on appropriate drainage design practices for poorly drained soils.

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".

Key considerations for good grazing infrastructure Tom Ryan and Pat Tuohy

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

Summary

- Grazing infrastructure will need to change for increased herd sizes.
- Ensure farm roadway network is appropriate for herd size and soil type.
- Upgrade 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.

Grazing infrastructure

Improved grassland management relies upon robust grazing infrastructure; suitably sized and shaped paddocks with multiple access points serviced by roadways of sufficient quality and adequate drinking water. It is vital to consider the quality of your grazing infrastructure and acknowledge where deficits have arisen in recent years. Maximum grazing efficiency will not be achieved unless all grazing infrastructure is sufficient.

Paddocks

Paddock size 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 the planned number of cows in the herd. During mid-April to August, a three grazing system is preferred as this maximises pasture intake and milk production. The guideline paddock area is 1.2 ha/100 cows for two grazings and 1.8 ha/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 (two grazings) or 14 (three grazings) paddocks are required. 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.

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, adequate crossfall, raised above the grazing area and sweeping bends at corners and junctions. The main roadway should be wide enough for good cow flow (e.g. 100 cows - 4 metres wide; 200 cows - 5 metres wide).

New farm roadways must be laid in good weather and with dry soil conditions. Construction costs can vary, from $\in 18$ to $\in 30$ /metre, depending on the cost of materials, the width, depth of material and the construction method. Cow tracks (spur roadways) are a cost effective way ($\in 8$ to $\in 11$ /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. When this happens, 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

Ask the following questions when assessing 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/cow/minute and a trough volume of about 5-7 litres/cow is generally recommended. For example, a flow rate of 20 litres/minute and approx. 600 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 excessively increases 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 should 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 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. Isolate, monitor, locate and repair leaks. Troughs on roadways will slow cow movement and make roadways dirty. Allow trough space for at least 5% of the herd to drink at once. Assess costs in advance; 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, and plan the system to aid grassland management. Some paddocks may need two strands for calves, and farmers in Glas need to have these fences right. It should be easy to quickly set up access to paddocks between grazings. The fence should be designed so there is no danger that the electric current is off if gateways are left open. Good maintenance is essential.

Infrastructure workbook

A new Infrastructure workbook is being launched today. This workbook will aid assessment of the status of existing infrastructure and help prioritise investment in the coming years. It is available at the Dairy Farm Infrastructure Village.

Decision support for dairy farm energy projects John Upton¹, Michael Breen¹, Philip Shine² and Michael Murphy²

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Summary

- Teagasc has partnered with CIT and SEAI to develop the Dairy Energy Decision Support Tool to aid farmers in making decisions regarding energy efficiency and renewable energy investments.
- This on-line tool can be used to obtain farm specific recommendations related to energy use, technology investments, CO₂ mitigation and renewable energy generation.

Introduction

The average cost of electricity on Irish dairy farms is $\notin 5/1,000$ litres of milk produced. There is a large variation in that figure — from $\notin 2.60$ to $\notin 8.70/1,000$ litres produced, or from $\notin 15- \notin 45/cow/year$. The main drivers of electricity consumption on dairy farms are milk cooling (31%), the milking machine (20%) and water heating (23%). It is challenging to deliver a set of generalised recommendations to farmers to improve energy efficiency, because every farm is different in some key areas. These include herd size, infrastructure specification, farmer age and eligibility for grant aid and availability of grant aid for specific technologies. Hence, it is necessary to evaluate the cost/benefit of key energy efficient and renewable technologies on a case by case basis on individual farms.

Dairy energy decision support

Teagasc has partnered with Cork Institute of Technology and the Sustainable Energy Authority of Ireland to deliver an on-line decision support tool to aid farmers making decisions regarding energy efficiency and technology investments. The tool, known as the Dairy Energy Decision Support Tool (DEDST) is available to use for free at: http://messo. cit.ie/dairy

The DEDST can be used to obtain farm specific recommendations related to energy use, technology investments, CO_2 mitigation and renewable energy generation. It is an interactive and easy to use tool aimed at farmers, farm managers and farm advisors. It provides information to the user regarding key decisions that determine the energy efficiency and cost effectiveness of the milk production process, such as investment in certain technologies and changes in farm management practices. It can also be used to support government bodies in forming new policy relating to provision of grant aid for energy efficient and renewable energy technologies.

Description of the tool

The DEDST operates as a web based platform. The user enters details of a specific farm, including farm size, milking times, number of milking units, milk cooling system, water heating system and electricity tariff. Details of an alternative technology to be evaluated on that farm can then be entered. Possible alternative technologies include plate coolers, variable speed drives, heat recovery systems, solar photovoltaic systems, wind turbines and solar thermal water heating systems. The user may also enter economic details regarding potential future grant aid for specific technologies, as well as renewable energy feed-in tariffs and inflation. All energy and economic calculations are then computed, and the outputs are displayed on an easy to interpret output screen.

Example — Investment in a solar photovoltaic system

Solar photovoltaic (PV) cells generate electricity using energy from the sun, which in turn can be used by the farm. These systems can be stand-alone (i.e. the generated electricity is only used by the farm) or grid connected (where surplus electricity is fed into the national electricity grid). Unfortunately, in Ireland there is no payment for export of electricity to the grid from small scale PV systems. Hence, the most logical solution for Irish farmers would be a stand-alone system, sized so that all electricity generated is consumed by the farm. For a 100 cow spring calving herd, the ideal PV system size falls at around 6 kW of installed capacity, which would cost in the region of ϵ 7,500. In the absence of a capital investment grant, this system would have a payback period of 13 years. If a 40% grant was available, the payback period would fall to eight years, while a 60% grant would make the payback period fall to five years. The inclusion of a 6kW PV system would result in 28% of the farm's electricity being provided by a renewable source and would offset more than 2.4 tonnes of CO₂ per year. PV systems qualify for accelerated capital allowances (i.e. the entire cost of the installation can be written off against tax in the year of purchase), which would further reduce the payback period.

Conclusions

The methods deployed in the development of this tool utilised resources from multiple sources to package a suite of scientific outputs into a user friendly decision support tool. The DEDST can now be used by farmers and advisors to make informed decisions around energy use and technology investments on a case by case basis. It will also allow policy makers to conduct macro-level analyses to inform decisions regarding provision of grant aid for energy efficient and renewable technologies.



Efficient milking facilities John Upton¹ and Francis Quigley²

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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.
- 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 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 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.
- 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 improve cow's 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.

- 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 to install cluster removers at a later date, swing arms should be installed first day, making 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 first 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.

Advantages of well-designed drafting facilities at exit from the parlour:

- 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 that cows have adequate space in front of them when they are being drafted 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.



Efficient milking practices

Padraig O'Connor

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Summary

- Milk must be produced to the highest standard possible.
- Implement good work practices so milking is safe for both the milker and the cow.
- Changing hands and a correct routine when attaching clusters will help reduce Repetitive Strain Injury (RSI).

Introduction

The milking routine from start to finish has an important bearing on the efficient and hygienic removal of milk from the udder. Milking starts when you begin collecting the cows from their housing or the field.

The importance of routine cannot be overemphasised. Cows are creatures of habit, and the more you can make each day exactly the same as the previous day, the more relaxed and productive they'll be. Getting your milking routine right is good for you, your cows and your business. The benefits are threefold:

- Maximum product quality.
- Safety for milker and cows.
- Efficient use of time spent milking.

Preparing for milking

Before the cows are brought in for milking, the parlour should be ready. Hose down the parlour, parlour walls and collecting yard to allow easier cleaning and wash down afterwards. Check availability of teat dip (prepare if necessary), ensure that the meal hoppers, where used, are filled and that the milking plant is rinsed out and ready for milking. When this is completed, bring in the cows from the paddock or house for milking.

A proper milking routine requires clean milking garments (i.e., disposable nitrile gloves and a clean parlour apron/parlour suit). This helps prevent the spread of mastitis and ensures that the operator is clean and safe from any excretions. Rinse and disinfect gloves regularly throughout the milking.

The cow's teats should be clean and dry before milking. If dirty, they must be washed and dried. A dry wipe with some paper towel is sufficient for clean teats.

Preparing cows in batches

Preparation of cows should take place in groups of 4–6 starting from the front of the row and working downwards towards the end. Preparation of each cow takes place first, followed by cluster attachment to the same group in the same sequence.

Cluster attachment

Hold the cluster with the hand closest to the cow exit side (usually the hand nearest to the dairy). This means that you will change hands to hold the cluster depending on which side you are attaching the cluster as illustrated in Figure 1. Changing hands will help minimise the risk of (RSI).



Figure 1. Milker position when attaching clusters

Removing Clusters

Manual cluster removal should start when a single stream of milk is visible in the claw piece. This minimises the risk of over milking. Remove the cluster without causing air blasts. Turn off the vacuum by kinking the long milk tube close to the claw piece or using the button on the claw piece and allow the cluster to become limp on the udder

Teat Disinfection

When a batch of 4–6 units has been removed, teat spray or dip the teats of that batch of cows in the same sequence. Ensure that at least 15 mls of teat spray or 10 mls of teat dip are applied evenly to the teats of each cow after milking. Ideally this should be done as soon as possible after cluster removal. Cover the entire teat from tip to top.

Conclusions

Milking cows requires doing the simple things well and attention to detail. Milkers need to remember that they are producing a food and the quality of this food is paramount in sustaining existing markets and creating new markets. A good milking routine is a key driver of milk quality and creating a safe environment for both milkers and cows.

Transitioning from conventional to automatic milking

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Summary

- Transition to automatic milking systems (AMS) requires careful consideration and planning.
- Additional training of farmers/farm staff is required to transition to AMS.
- The majority of farmers that have transitioned to AMS recommend others to do so.

Introduction

An AMS can milk cows without need for a human worker to be present. Cows choose when to be milked and detailed data about each milking is recorded by the AMS, which can be accessed remotely by computer or on a mobile device by the farmer. The role of the stockperson is still critical to the farming operation to ensure excellent cow performance, health and welfare. It is frequently claimed that an AMS improves the working conditions and lifestyle of the dairy farmer, reduces the cost of milking labour, and is beneficial for cow health and welfare. It is important to note, however, that ownership and management of an AMS may not suit everybody, and there is a large investment associated with installing an AMS.

Once the decision is made that an AMS is an option, the first step is to visit and talk to other AMS farmers to understand how they adapted their farming systems and how the AMS changed their work routines and lifestyles. A clear understanding of the changes in daily farm management routine is important, including pasture management, feed allocation, cow traffic and training of heifers. The experience of existing AMS farmers is extremely valuable, as they can provide knowledge and practical advice on daily routines and key performance indicators. The second step is to contact commercial companies for technical information and costs. All of the commercially available AMS's will milk cows, but other factors may have a large influence on the best AMS to invest in (e.g., service reputation, technical support, trust). The third step is to develop a detailed financial assessment and business plan to establish if an AMS is a viable option economically for that specific farm.

Key elements of success

- Proper planning that will result in good farm layout.
- AMS can operate automatically, but it is necessary to monitor its operation at least twice a day, on site or by remote link (on site at least once, and possibly twice for grass allocation).
- Initially, focus on cows being comfortable and at ease, not 'how many milkings a day' or 'higher production per cow'.
- Quiet, calm cows are required for faster cluster attachment
- It is important to have someone else learn to operate the AMS with the farmer; time away can then be rotated (essential if the owner works off-farm).

A UK study (2012) examined how AMS changes human-animal relationships, and how this affects agricultural practices and knowledge. Some of the key reasons identified for changing to AMS were lifestyle, flexibility, labour (cost and availability), attractiveness to younger generations and increased productivity. Some interviewees said the AMS did not lessen the workload, but the workload was different and not time specific. Others saw the AMS as a means of prolonging their working life. For young dairy farmers, the opportunity offered by the AMS to allow off-farm work was important. Installing an AMS is not a cheap alternative to a conventional milking system, but it can be economically viable when budgeted correctly.

Farmers who have adopted AMS need to assign some of the extra time available to grass allocation and management. They should also embrace changes to farm management systems associated with the technology; otherwise, they will not experience the time saving advantages of the AMS. Many of the interviewees in the UK study who used AMS indicated they only made use of a very small amount of the data available. More training for farmers on the appropriate use of data generated by the AMS is required, as well as exploring new ways to analyse and use the data on an on-going basis.

A Canadian study (2018) reported the experiences of dairy producers (n = 217) following transition to AMS technology. Producers perceived that AMS improved profitability, quality of their lives and their cows' lives. Importantly, they reported that the AMS had met their expectations, despite experiencing some challenges during the transition such as learning to use the technology and data, cow training, and a demanding period for the first few days. The vast majority (86%) of the producers would recommend others to transition to AMS. They also advised the following approach:

- Changes can be made to improve AMS performance (e.g. change time of the gates, etc.). One should not be too proud to change things, or manage something differently.
- Operating parameters should not be changed very frequently let conditions settle, evaluate and then change if necessary.
- Many of the problems are perceived by the farmer. Do not over-react to different situations and be flexible.
- The possibility of sharing staff between AMS farmers should be considered.

Conclusions

Transitioning from a conventional to an automatic milking system can have a very positive impact on the farm family lifestyle and different aspects of the farm system. However, the change has to be chosen carefully, with sufficient preparation in relation to yard layout, animal and data management, finance and general suitability.



Increasing automatic milking system performance with milking management practices

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Summary:

- Teatcup removal settings can help reduce milking time by variable amounts. The removal criteria used depends on the manufacturer.
- Milking permission can be modified according to stage of lactation.
- Focus milking permission on more efficient cows.

Introduction

In automatic milking systems (AMS), it is important to maximize the amount of milk harvested per robot per day to increase profitability. One strategy to increase milk harvested per AMS is increasing milking capacity, which is the number of milkings performed by the robot in a day. Maximizing milking capacity can be achieved by managing incentives (mainly feed) to achieve a constant flow of cows arriving at the milking shed to be milked or by reducing the time it takes for each milking to be performed. Research has identified two of the most important factors driving milk production per robot per year: (1) average milk flowrate during a single milking; and (2) the number of cows milked in the robotic unit. Therefore, fast milking cows increase milk production per robot per year.

One strategy explored for reducing milking time has been to modify the teatcup removal setting so that teatcups are removed earlier. A common concern is the impact this practice might have on milk production and udder health. This practice has been applied in conventional milking systems with a successful reduction in milking time without a negative impact on milk production or somatic cell counts (SCC).

Teatcup removal settings in AMS

Depending on the brand of the AMS, different strategies exist for adjusting the teatcup removal setting. The impact of this practice will depend upon the criterion for teatcup removal. Usually, teatcup removal occurs when the quarter milk flowrate is below a certain value.

At the Teagasc robotic milking facility, an experiment was carried out to compare the impact of three teatcup removal settings relative to the average milk flowrate of the quarter (Table 1) on box time (i.e. time that the cows are inside the robot), milking time, milk production and somatic cell counts.

Table 1. Teatcup removal decision: quarter flowrate below a percentage of the quarter average milk flowrate

	Teatcup removal setting		
	Early	Normal (default)	Delayed
Percentage of quarter average milk flowrate	50%	30%	20%

Normal and early removal strategies had similar milking times and box times, and both were on average 9 to 10 seconds shorter than delayed removal strategies. Over a full day, this time saving could allow for more than three extra milkings per day or one extra cow in the system. No negative impact of the teatcup removal setting was found on milk production per milking or somatic cell count (Table 2).

Table 2. Impact of three percentage based teatcup removal settings on milk production, box time, milking time and somatic cell count

	Teatcup removal setting		
	Early	Normal	Delayed
Milk production/milking (kg)	11.7	11.9	11.9
Box time (s)	420	418	429
Milking time (s)	342	341	350
SCC (n)	32,359	31,622	35,481

In a study using an indoor AMS, mid-lactation dairy cows had a reduction in milking time of 0.9 minutes when using a teatcup removal setting of 0.48 kg/min compared to 0.06 kg/min, with no negative impact on milk production or SCC. An absolute milk flowrate removal setting might be more effective in reducing milking time.

Other management strategies

Research has shown that increasing the milking permission from 8 to 10 hrs in mid lactation cows (175 days in milk) had no impact on milk production. Additionally, paying attention to "efficient" cows (few incomplete milkings, high milk flowrate, shorter box times, good milk production, etc.) and allowing this sub-group of cows greater access to the AMS could increase milk output from the AMS.

Conclusions

Modifying teatcup removal settings to the specified parameters can provide reductions in milking time, increasing robot efficiency. Other practices can include differential milking permission according to stage of lactation and prioritizing milking of more efficient cows.



Automated methods for recording body condition score and animal location

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Summary

- Automated body condition scoring is accurate and objective.
- animals at pasture.

Introduction

As dairy farms in Ireland continue to expand, the availability of labour and the time a farmer has to spend on each cow decreases. Digital technologies can provide a solution to these problems. Two digital technologies are being tested in Teagasc: i) automatic measurement of cow body condition score; and ii) precise localization of animals while at pasture.

Body condition score (BCS) is a measure of how much fat an animal has stored and is a very useful tool for management. Fertility is a key aspect of cow performance affected by BCS, and BCS loss is an indicator of negative energy balance and susceptibility to metabolic disorders. Teagasc are currently testing a device that aims to automatically record BCS using multiple cameras.

The second technology aims to track animal movements while at pasture. This information could improve our understanding of grazing behaviour, and aid farmers to locate animals in need of attention more efficiently. This is achieved using a wireless sensor network of masts placed throughout the grazing platform communicating with ear tags worn by the animals.

Automated body condition scoring

Currently, the standard method for body condition scoring involves a trained observer assessing an animal on a scale from 1 to 5 with 1 being extremely thin and 5 being excessively fat. Scores are based off the fat cover around the backbone, pins, tail head and ribs. The problem with this method is that often two scorers can give the same animal a different score; additionally body condition scoring a large number of animals can be labour intensive. The automated BCS system uses cameras to create a 3D image of the animals back as the animal walks past the system (Figure 1). Each animal can then be identified by their electronic identification (EID) tag. An experiment conducted on the research farm in Kilworth aimed to investigate the accuracy of the automated BCS system compared with the current standard (manual BCS). Two independent, highly experienced scorers recorded BCS measurements on approximately 500 cows, and these were directly compared to the output of the automated BCS device. The results indicated that the BCS device was highly accurate, and that the agreement between two experienced operators was equivalent to the agreement between a scorer and the BCS device. This indicates that the automated BCS device could be used to accurately and objectively measure BCS with little effort.



Figure 1. Camera positioning of the automated BCS system

Localization of cows at pasture

There is currently a wireless sensor network in place on the automated milking system on the Kilworth research farm. The system consists of a series of masts spaced evenly across the grazing platform. An ear tag is worn by each cow that can communicate with each mast in order to identify the location of each animal. Every mast has a solar panel and a battery to power all the necessary electronics on the masts. One other sensor technology that currently exists for locating animals at pasture is GPS collars. To calculate the position of an animal, GPS relies on satellites orbiting the earth, which the farmer does not have control over and therefore inaccuracies can occur. GPS tracking can be quite accurate when an animal is moving, but when stationary, the difference between the true location and the GPS location can increase up to 5.5 m, which is known as drift.

An experiment was undertaken in Teagasc to investigate the accuracy of the wireless sensor network and whether drift occurs. Tags were evenly spaced across the entire grazing platform and each tag was left in place for 10 minutes. These locations were compared to a calibrated GPS device that recorded the true locations. The results indicated that the wireless sensor network could identify the locations of the tags to within 2.75 m 95% of the time. These results show that the wireless sensor network could be a useful localization tool for commercial and research purposes.

Conclusions

Digital technologies have the possibility to increase labour efficiency as dairy farms in Ireland expand, and improve decision making processes. Two of the technologies that have potential applications are automated body condition scoring and automated localization of cows at pasture.

Acknowledgements

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KEEPING YOU AND YOUR FAMILY SAFE ON THE FARM



Health and safety management on dairy farms

Health and safety management on dairy farms John G. McNamara¹, Francis Bligh¹, John Paul Murphy² and Denis Jones²

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Summary

- There are strong legal duties in place requiring management of safety, health and welfare on dairy farms.
- Injury levels have increased on dairy farms in recent years.
- Completion and implementation of a Risk Assessment Document is a key step to managing farm health and safety.

Introduction

Injury or ill-health causes tragedy, pain and suffering. It also impacts on the farm as a business due to loss of production, poor productivity and reduced levels of motivation. Most accidents and illnesses in farming are preventable and can be managed through risk management, planning and careful work organisation. The owners/managers of all workplaces have legal duties to manage safety, health and welfare under the Safety, Health and Welfare at Work Act 2005 and associated regulations. Non-compliance with these legal duties leaves the persons responsible liable to criminal prosecution. Excellent standards of safety, health and welfare should always be the aim and these can greatly support meeting business goals and attracting and retaining staff. Dairy farming in Ireland has undergone major expansion following milk quota removal which is set to continue into the future. This expansion has led to increased labour input of both family and employed labour. Good time management, farm buildings, equipment and facilities allows work to be completed in a well-organised and safe way.

Accident profile of dairy farming in Ireland

Fatal farm accident data shows that 19% of fatal accidents occurred on dairy farms which is higher than the proportion of farms in dairying (16.7%). By age; 49% of accident victims on dairy farms were aged 60 or older (Figure 1).



Figure 1. Profile of Dairy farm fatalities by County and Age (Source: H.S.A.)

Teagasc NFS estimates farm injury levels at regular intervals. The most recent survey in 2018 indicates that accidents on dairy farms were 50% higher than for the survey completed six years previously. The 2018 survey found that 18% of dairy farms had an accident over the previous 5-year period compared with 12% for the previous survey. The accidents reported were associated with: livestock 37%; farm vehicles/ machinery 23%; chainsaws and timber 13%; buildings 5% and other 7%.

Legal duties of Dairy farmers and employees to implement SHWW

The purpose of the Safety Health and Welfare at Work Act, 2005 is to ensure that work is organised and carried out so that the risk of accidents and ill-health is reduced to the minimum level. Welfare refers to such issues as organising work to manage stress and providing washing facilities and conveniences for persons at work. The Act requires that safety, health and welfare be secured 'so far as is reasonably practicable'. An employer has the predominant duty for protecting the safety, health and welfare of their employees and all affected by work activity. This includes providing and maintaining; a safe place of work, safe machinery and equipment and safe systems and organisation of work. The employer must provide information, instruction and training to staff on workplace hazards and risks. Where a risk cannot be eliminated, suitable personal protective equipment (PPE) must be provided and maintained. Emergency plans such as arrangements to contact emergency services, first aid and fire precautions must be prepared and updated. An employer must seek competent advice if they do not know the solution to a safety, health or welfare problem.

Employees have the following duties: co-operate with their employer; take care to avoid injury to themselves and others; report to their employer defects in the place or system of work which might be a hazard and use all items of equipment or PPE in a safe manner. Employers and employees must safeguard persons who are not their employees such as members of the public. Self-employed farmers must apply the Safety, Health and Welfare at Work Act 2005 (2005 Act) legal requirements to all who live and work on the farm.

Duty to complete a risk assessment

A Risk Assessment and Code of Practice have been prepared for the Agricultural sector under the 2005 Act and these are available on the HSA and Teagasc websites. Teagasc and accredited consultants provide half-day training on completing the Risk Assessment document. Completion of the Risk Assessment document is also a requirement for both Quality Assurance Schemes and TAMSII grant payment.

Conclusions

Active and on-going management of farm safety, health and welfare is both necessary and mandatory in law. It is also a vital component of operating and managing a progressive dairy enterprise. Further information and guidance on all aspects of farm safety, health and welfare is available at www.hsa.ie and at www.teagasc.ie/health_safety/

FARM SAFETY NOTICE



No unauthorised persons allowed beyond this point

BEWARE Livestock can be dangerous

CAUTION Farm machinery in operation

This is not a playground!

THINK SAFETY FIRST!

VISTAMILK



VistaMilk — precision dairying from soil to society

VistaMilk — precision dairying from soil to society

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Summary

- VistaMilk aims to be a world leader in fundamental and translational research for precision pasture-based dairying.
- The research program will include the areas of soil and pasture, cow and food.
- The opportunities that arise at the interface between Agri-Food and technology will be the basis for the competitive advantage and international reputation of the centre.

Introduction

Globally, agriculture is undergoing disruptions arising from the competing challenges of food security and increasing societal demands. The dairy sector is not exempt from this disruption as it faces a confluence of challenges including: (a) the rapidly increasing global demand for dairy products, (b) the growing concern over the impact of agriculture on climate change and water quality, and (c) the long-term volatility of global dairy markets. Fortunately, solutions to these challenges are emerging from a parallel revolution in smart and precision agriculture. For Ireland, this disruption presents major threats and opportunities as traditional dairy production needs to quickly transform itself using these new technologies.

Centre profile and vision

The VistaMilk SFI Research Centre aims to be an agent of growth for the Irish dairy industry by being a world leader in fundamental and translational research for precision pasture-based dairying. VistaMilk represents a unique collaboration between Agri-Food and Information and communication technologies (ICT) research institutes and leading Irish/multinational food and ICT companies. The centre is hosted by Teagasc, in partnership with the Irish Cattle Breeding Federation (ICBF), Tyndall National Institute, the Telecommunications Software & Systems Group (TSSG), and the Insight Centre for Data Analytics. VistaMilk's vision is to be a world leader in the Agri-Food technology sector through innovation and enhanced sustainability across the dairy supply chain, positively impacting the environment, animal well-being and the health of consumers. This will be achieved by greatly improving the soil to gut supply chain connectivity.

Research Program

To advance the state-of-the-art in Agri-Food and information sciences, VistaMilk has divided the problem domain into: (i) soil & pasture, (ii) cow, and (iii) food. Combined, these three areas cover the entire supply chain from soil to society. Within each of these areas, the centre has several Targeted Projects each of which will leverage the combined expertise of the VistaMilk partners. Each targeted project involves at least one industry partner.

The VistaMilk research program will particularly address:

- Soil & Pasture: Knowledge and tools to sustainably grow a greater quantity of higher quality herbage consistently for consumption by grazing cows.
- **Cow:** Achieving a greater volume of chigher quality milk onsistently through scientifically-supported optimised management and breeding strategies.
- Food: Develop higher value-add dairy products for human consumption, optimised for the predicted milk supply and quality based on predicted grass growth profiles and cow performance from earlier projects.

In addressing these areas, VistaMilk will combine biological sciences with cutting edge ICT:



- **Sensors:** The development of robust highly sensitive sensor infrastructure based on;
 - » (i) nano-electrochemical,
 - » (ii) spectroscopic and/or
 - » (iii) mechanical sensors integrated with control electronics, firmware, edge computing data analytics and data communications.
- **Communications & Networks:** The development of efficient and reliable end-to-end communication protocols for transporting information from various sensors all the way to the fog and cloud computing infrastructure.
- Data & Data Analytics: The development and application of machine learning and statistical modelling techniques, across the dairy supply chain, to predict optimal outcomes for pasture, for cows, and eventually for food production.
- **Decision Support:** Develop and deploy modular-based decision-support resources informed by the multilevel data and associated analytics for use by producers in the pursuit of consistently better performance.

Conclusions

The VistaMilk SFI research centre will consist of >200 research scientists across >40 research and commercial partners. The opportunities that arise at the interface between Agri-Food and ICT will be the basis for the competitive advantage and international reputation of the centre. VistaMilk looks forward to progressing many new advances that will be of benefit to farmers and the industry nationally and internationally.



Visionary

Industry focused

Cohesive

Building capabilities

VistaMilk

Co-creative Co-productive

Leaders

Innovative

TEAGASC FOOD RESEARCH PROGRAMME



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Milk: The ideal nutritional base for beverage applications

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Summary

- Milk is well-established as a natural, safe and nutritious food, providing essential nutrients to maintain health status across all stages of life.
- The nutritional profile of milk can be used as a base to produce beverages with specific composition. For example, beverages can be tailored to meet specific nutrient requirements for infants, medical, sports and lifestyle/health applications.
- Ireland is a leading manufacturer of high quality functional dairy ingredients that can form the nutritional platform upon which these nutritional beverages are built.
- Ireland produces ~ 12 % of global infant formula exports, providing a vital channel for utilisation of its dairy ingredients (skim milk, milk and whey protein ingredients and lactose).
- Manufacturers of nutritional beverages (across the life categories) have access to an increasingly wide range of whey protein based ingredients. Depending on location, these can be available in liquid, concentrate or powdered formats.
- Advances in processing technologies, coupled with an in-depth understanding of protein chemistry, has allowed Ireland to differentiate our dairy ingredient portfolio, generating new opportunities in export markets, where Irish milk provides consumers with the essential nutrients for growth and development.

The importance of the nutritional beverage sector to Ireland

The global nature of the nutritional beverage sector, and in particular the infant formula industry, is underpinned by strong brand representation from the multinational companies in Ireland. This provides Ireland's Dairy processors with a vital route to market across large geographical regions. This sector is recognized as an important channel for utilization of skim milk, whey and lactose. The dairy and nutritional beverage manufacturers have invested in significant processing infrastructure in Ireland, and this is used to produce high quality ingredients and/or finished nutritional (e.g., infant, adult and medical) and lifestyle products (e.g., sports and recreational). The investment in the latest processing technologies by the Irish industry coincided with the abolition of quotas in 2015 to maximise the value of the subsequent increased milk volume. This has placed Ireland in a strategic position to engage new and emerging markets, supported by science and innovation, to deliver new dairy ingredients that provide targeted nutrition from infant to adult. This strategy requires delivery of consistent quality milk, which enables manufacturers to meet consumer requirements based on macro- (protein, fat and carbohydrate) and micro- (minerals, vitamins and others) nutrient levels within a product, delivering targeted nutrition.

Teagasc research in the area of nutritional beverages focuses on two key areas: (i) product safety, both microbiologically and from a contaminants perspective, to protect the consumer; and (ii) ability to manufacture to a target composition based on a nutritional and/or functional requirement. Much has already been achieved technologically over the years. For example, the research carried out on the whey protein ingredient α -lactalbumin, which is now commercially used in infant formula. Furthermore, many ingredients (and beverages in which they are used) are preserved in spray dried powder form, and Teagasc has developed a major research program in powder technology and associated functionality.

Significant developments in whey ingredients for nutritional applications

Whey, the by-product of cheese, contains many nutritional components and has been a key focus ingredient with a wide variety of applications, including infant formula and sports nutrition. Technological advancements in concentration and separation of proteins from the whey stream have allowed a range of protein concentrates, isolates and hydrolysates to be produced, maximising the value of the co-product from cheese manufacture. Physiological function of components from whey has evolved as an important research area for Teagasc and the dairy industry. For instance, evidence that whey proteins and their peptides have health benefits beyond their basic nutritional value has increased markedly in recent years. Furthermore, a wide range of beneficial bioactivities can be linked to whey protein in its various derivative forms, including concentrate, isolate, hydrolysate, and individual protein and peptide fractions. This in turn has resulted in new nutrition products that support the early infant immune system. Infant formula incorporating whey protein hydrolysates are less allergenic compared to standard preparations, and there is some evidence to suggest that it may decrease the risk of allergies later in life. In other applications, whey protein concentrates are used for muscle development and repair, which is developing into a major market focused on sports applications. Studies led by Teagasc reported a significant diversification of the gut microbiota of the Irish rugby team, attributed to the consumption of a protein rich diet, compared to a cohort from the general public. More specifically, health benefits have been attributed to the presence of highly valuable individual proteins in whey. For Ireland, this has a particular focus related to the infant formula and sports sectors. Teagasc (and other research providers) have shown that whey protein may also play a role in influencing infant and adult gut microbiota.

New Teagasc infrastructure to support development of ingredients for nutritional beverage applications

Teagasc are investing in new infrastructure to support the Irish industry through the Dairy Research Programme at both Moorepark and Ashtown. These new investments will be complementary to the existing research infrastructure and expertise, and will facilitate science-based innovations and solutions for local and international nutritional beverage companies. As part of this expansion, Moorepark Technology Limited (MTL), which is the pilot plant facility at the Teagasc, Moorepark site, is currently undergoing a €10 million expansion. MTL is owned in partnership between the Irish dairy processing sector and Teagasc (57% share), and is capable of reproducing all dairy related products, ingredients and beverages, serving as an important conduit for research and development for the Irish dairy industry. The expansion includes investment in the latest state of the art processing equipment for separation, heating and drying of dairy ingredients and/or nutritional beverages, while working synergistically with the research capabilities within the Teagasc food program. The combination of the research support and pre-commercial scale pilot plant has also lead to the concept of the Food Innovation Hub for industry. This Food Innovation Hub integrates three major components: the state of the art pilot plant facility at MTL (the "hardware"); the research capability of the Teagasc Food Research Centre at Moorepark (the "software"); and custom designed secure company laboratory and office units (the "Industry Units"). This facility is currently at the design stage with building expected to get underway in Q3 of this year.

Teagasc have also made strategic investments in analytical instrumentation capable of measuring all the nutrients in dairy ingredients and finished nutritional beverages (e.g. infant formula). A key component here is the ability to determine powder reconstitution properties, which requires an understanding of food structure as a diagnostic tool. Powerful microscopic techniques are used to visualise the behaviour of these powders in water, which is a key quality attribute. These techniques give researchers at Teagasc the capability to map industrial processing parameters used during manufacture of nutritional beverages, and ultimately track how ingredients interact during the process.

Conclusions

Milk is a nutritional beverage that can be valorised into many different product streams such as cheese, whey, butter, yogurt and a variety of powdered ingredients. Advances in processing equipment such as membrane separation have led to the development of a wide range of dairy ingredients, which can be utilised as a source of nutrients for nutritional and lifestyle beverages with a range of applications. Many of these developments rely on whey ingredients because of their functional and nutritional characteristics. The diversity of processing equipment within Teagasc, including separation, concentration and stabilisation technologies, and associated research expertise is a key enabler supporting pre-commercial product and process development with the industry. Teagasc have developed a critical mass in dairy research, supported by the state's national investment policy through both Enterprise Ireland and the Department of Agriculture, Food and the Marine, to support the expansion of the ingredient and nutritional formulations sector within the food industry. The alignment of Teagasc's research programme with global trends in nutrition is strategically important, as it helps to underpin the research and development activities of dairy processors and infant formula companies in Ireland. The unique characteristics of milk which provide a diverse range of essential nutrients will continue to provide opportunities for significant economic growth in both the dairy and nutritional beverage sectors.



Pasture feeding improves the nutritional composition of milk

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Summary

- Pasture feeding has a beneficial effect on the nutritional composition of milk and dairy products
- A total mixed ration diet (TMR) increases milk yield.
- Pasture feeding resulted in milk with increased concentrations of true protein and fat, with increased content of Omega-3 fatty acids and other beneficial nutrients.
- TMR feeding resulted in milk with increased contents of Omega-6 fatty acids and palmitic acid; the latter increases the hardness of high fat products such as butter.
- Fresh pasture feeding produced butter with a characteristic "golden" yellow colour due to increased intake of ß-carotene in fresh grass.

Introduction

It is estimated that 10% of the global bovine milk supply is derived from pasture-based feeding systems. This allows Irish dairy manufacturers to capitalize on recent consumer trends for healthier more natural food products. There has been a recent surge in the availability of "Grass-fed" dairy products, often commanding a premium price. Recent research has shown that the typical Irish cow diet is composed primarily of pasture, accounting for 96% of the diet on a fresh matter basis and 82% on a dry matter basis. The objective of the "Profiling Milk from Grass" project carried out at Teagasc Moorepark was to compare milk and dairy products derived from cows fed pasture (perennial ryegrass and perennial ryegrass with 20% white clover) and total mixed ration diets.

Experimental design

Fifty four spring calving Friesian cows were allocated to one of three experimental treatments (n = 18 per treatment):

- Cows were housed indoors and fed a total mixed ration diet (TMR).
- Cows were maintained outdoors and grazed a perennial ryegrass (Lolium perenne L.) only pasture (GRS).
- Cows were maintained outdoors and grazed a perennial ryegrass/white clover (Trifolium repens L.) pasture (CLV).

Cows on the TMR were offered, on a DM basis, 7.15 kg of grass silage, 7.15 kg of maize silage and 8.3 kg concentrates daily. Cows on the two pasture-based systems were stocked at 2.74 cows/ha and were offered a pasture allowance of ~18 kg DM per day (> 4 cm). The CLV sward contained an average of 20% white clover across the grazing season. Milk fat and protein concentrations were determined weekly from one successive evening and morning milking. Milk solids yield (kg) was calculated as the yield of milk fat plus the yield of milk protein. Bulk milk samples were collected after the morning milking weekly throughout lactation. Bulk milk samples were also collected for the production of midlactation sweet cream butter and at the beginning of late-lactation for Cheddar cheese. 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.

Results and Discussion

Total mixed ration feeding resulted in higher annual milk yield and MS yield than the GRS and CLV treatments (Figure 1). Clover inclusion in the diet increased MS yield by 39 kg MS per cow compared with the GRS treatment. The TMR treatment had greater daily MS yield than both the GRS and CLV treatments.

The GRS feeding system produced milk with greater concentrations of fat (4.65% v. 4.39%) and crude protein (3.65% v. 3.38%) compared to the TMR system (Figure 1). Moreover, the GRS feeding system produced milk with increased true protein concentrations compared to the TMR system (3.46% v. 3.19%). The inclusion of CLV appeared to produce milk with comparable compositional concentrations to that of GRS, but CLV had greater non-protein nitrogen (NPN) compared with GRS and TMR.



Figure 1. Milk production and composition from pasture and TMR cows throughout an entire lactation

The impact of pasture vs TMR feeding on the fatty acid profile of milk is presented in Figure 2. Pasture feeding beneficially altered the nutritional status of milk, with approximately double the concentration of the healthy fatty acid cis-9, trans-11 conjugated linoleic acid (CLA). In addition, pasture feeding systems resulted in significantly greater contents of Omega 3 fatty acids and significantly lower contents of Omega 6 fatty acids than that of TMR milk. The collective changes in fatty acid composition resulted in pasture-derived milk samples having a more favourable thrombogenic index (an indicator of likely impact on human health) compared with TMR derived milk. Feeding system resulted in similar changes in the fatty acid (FA) composition of sweet cream butter. These alterations contributed to differences in textural, thermal, sensory and volatile properties of butter. Pasture-derived (GRS and CLV) butter had more favourable nutritional characteristics, including lower thrombogenecity scores and significantly greater concentrations of CLA and β -carotene.

Sensory panellist data for butter derived from the different feed systems identified several favourable attributes for the GRS butter, including "liking" of appearance, flavour and colour. The nutritional composition of Cheddar cheese was also improved through pasture-based feeding systems, with significantly lower thrombogenicity index scores and a greater than two-fold increase in the concentration of vaccenic acid and CLA, wheras

TMR derived cheeses had significantly greater palmitic acid content. Pasture derived Cheddar cheese had greater Omega 3 fatty acid content, while TMR cheeses had greater Omega 6 fatty acid content. The consumption of CLA has been associated with several potential health benefits, with recommended intake of 0.8 g CLA d per day. Adjusting for the mean fat content of the cheese derived from the different feeding treatments, 100 g of Cheddar cheese from TMR would provide 0.15 g of CLA, 100 g of CLV cheese would provide 0.35 g of CLA whereas 100 g of GRS derived Cheddar cheese would provide 0.44 g of CLA. The alterations in the FA profile also resulted in pasture derived cheese having reduced hardness scores at room temperature. Both feeding system and ripening time had a significant effect on the volatile and sensory profile of Cheddar cheese.



Figure 2. Impact of pasture vs TMR feeding on the fatty acid profile of milk

Conclusions

Cow feeding system has a significant effect on milk yield and milk solids yield. Pasture derived milk has significantly higher concentrations of total solids, driven by increased levels of fat and true protein. Pasture feeding has a beneficial effect on the nutritional profile of milk, with significantly higher concentrations of Omega-3 fatty acids, CLA, β -carotene and other beneficial nutrients.



Cheese structure-function — the basis for export growth

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Summary

- Irish cheese production continues to grow, and is now the focus of significant industry expansion and investment.
- Cheese is a highly complex and dynamic biological system produced from milk of seasonally changing composition.
- Cheese structure-function properties determine how it performs under various end use applications including requirements for shredding, slicing, melt profile, etc.
- Modifications to cheese manufacture and ripening processes have been shown to modify cheese functional properties.
- Cheese is a highly nutritious food providing much of the daily recommended allowance for protein and key minerals and vitamins. Recent research has also indicated that it could be considered a bio-functional food providing health benefits beyond basic nutrition.
- New research focused on casein-polymer interactions is targeting new markets for cheese such as China and other Asian markets.

Irish cheese production: An industry in flux

Irish cheese production has grown by over 250% since 1995, with exports of 225,000 tonnes in 2018, valued at €815 m (CSO). Traditionally, Irish cheese has been dominated by export of Cheddar to the UK, and although the reliance on the UK market is lessening, the UK still imports about 115,000 tonnes of Irish cheese annually. The outcome of Brexit has serious implications for this industry, not least the potential imposition of tariffs of €1,671/tonne of Cheddar, which is generally valued at approximately €3,000/tonne.

In a move to lessen the importance of the UK market, the Irish cheese industry has increased exports to other EU countries, the Middle East, North Africa and Japan. It is also substantially investing in processing facilities: co-location of a new Jarlsberg (continental-type) cheese plant at Dairygold Mogeely, Co. Cork by Tine; a \in 78 m diversification project including development of Mozzarella cheese production by Carbery; and, a joint venture between Glanbia and Leprino for a 45,000 tonne Mozzarella cheese plant in Portlaoise, Co Laois and with Royal A-ware for a \in 140m Continental cheese plant to process 450 million litres of milk annually at Belview in Co Kilkenny.

Cheese: A complex subject matter

Cheese differs from many other dairy products in that it is a highly complex and dynamic biological system, produced from a raw material with continuously changing composition. While products such as powders are relatively stable, cheese contains a live and continuously evolving microbiota and enzyme compliment that remain active throughout ripening, chilled distribution and ultimately to the point of consumption. Furthermore, cheese ripening and quality is the product of a complex interplay between the components (e.g. moisture, fat, protein), the physico-chemistry of the cheese matrix and the metabolic activity of pockets of bacteria dispersed throughout cheese blocks (Figure 1).

Cheese consumers and end-users are increasingly demanding enhanced functional properties, sensory and nutritional quality, and optimal usage characteristics, all at a reasonable cost. This is primarily driven by factors such as growing consumer awareness of the role of diet in health and well-being, the potential to use structure to influence flavour release and sensory experience, and the extensive use of cheese as an ingredient in food applications. Such expanding consumer demands have triggered the focus of food researchers and cheese producers to enhance the quality of existing products or the design of new innovative products. Producing diverse, market-led products of consistently high quality within the context of an Irish seasonal milk production system poses considerable technical challenges.

Cheese structure-function

It is now well recognized that many of the desirable properties of cheese are largely determined by its structure. For example, structure plays an important role in determining the mechanical, rheological, and cooking properties of heated and unheated cheese (e.g. Cheddar, Mozzarella), eye formation in several types of hard (e.g., Swiss type or Emmental) and semi-hard cheese (e.g., Maasdam type) and texture perception. Functional characteristics of importance include performance under shredding and slicing, and melt and flow properties under heating. The customer's requirement for these different properties reflects diverse applications in food service and as ingredients in prepared consumer foods, and also the growing market in Asian countries.

More recently, it has also been reported that food structure plays a key role in flavour release and in the digestion and the absorption of nutrients. Apart from containing basic nutrients, the nutritional value of food can also be enhanced by introducing health-promoting and bioactive compounds, such as polyphenols and peptides. In this context, the cheese matrix can potentially be used as a delivery vehicle for bioactives and probiotics. Thus, a better understanding of the complex interrelationship between structure and functionality (i.e., the so-called structure-function relationship) is necessary to design cheese types with specific functionalities.

Current research at the Teagasc Food Research Centre Moorepark has focused on the structural characteristics of cheeses (particularly non-Cheddar types) produced from Irish milk, and in particular, how these are influenced by the relative role of hydrolysis of a_{S1} -casein and β -casein or solubilisation of calcium during ripening. The results highlight that (1) inhibition of rennet activity during ripening; (2) reduction of rennet activity during ripening; and (3) reduction of ripening temperature decreased the hydrolysis of a_{S1} -casein by ~95%, ~45%, or ~30%, respectively, after 90 d of ripening. During the same ripening period, ~35% of β -casein was hydrolysed for all cheeses, except for those ripened at a lower temperature (~17%). The proportion of insoluble calcium as a percentage of total calcium decreased significantly from ~75% to ~60% between 1 and 90 d. Further results obtained showed that although modulation of a_{S1} -casein hydrolysis is an effective means to maintain the strength of the cheese matrix during ripening, maintaining higher levels of intact β -casein or insoluble calcium content (or both) within the cheese matrix results in reduced shortness or brittleness of cheese texture. Such approaches could be applied to design cheese with specific properties and to control functionality.

Cheese matrix effect

Dairy fat consumed as cheese has different effects on blood lipids than dairy fat consumed in other formats. This includes a favourable reduction in total cholesterol. It is unknown whether the effect is specific to fat interaction with other cheese nutrients (calcium, casein proteins), or to the cheese matrix itself. Further work is underway to better understand the net effect of calcium on fatty acid bioaccessibility. Eventually, the findings of this study could lead to additional evidence to further substantiate beneficial health claims, as well as the discovery of novel nutritional aspects that could be adapted for the food industry to control nutrient release and deliver bioactive molecules.
"Cheese for China"- Research on casein-polymer interactions

It has already been observed in Japan, Taiwan and South Korea that as consumers become more westernized, the proportion of dairy consumed as cheese increases significantly. Although its nutritional properties are desired, most Chinese consumers have limited experience of cheese, and the sensory properties of conventional cheeses may not appeal to them. Research is currently being undertaken to profile Chinese consumer preference for cheese sensory traits, and exploit colloidal and casein-polymer sciences to incorporate non-dairy ingredients familiar to Asian consumers into cheese formulations/ fermentations to achieve desired sensory properties (flavour and mouth-feel). The overall objective of this research is to develop a platform technology for cheese innovation to target emerging Chinese and Asian markets in a post-Brexit environment.

Conclusions

The portfolio of cheese types continues to increase and market demands are everchanging. The cheese research platform of the Teagasc Food Research Programme is focused on exploiting cheese Structure-Function interactions to provide an internationally competitive and innovative edge for Irish cheese products in export markets.



Figure 1. Fat globules and bacteria entrapped within the cheese protein matrix





Pasture Base RELAND Grassland Decision Support Tool

Tools include

- Grass Wedge
- Spring & Autumn Rotation Planners
- Feed Budget
- Fertiliser Recording

Additional features

- Offline App
- Projected Grass Wedge
- Share data with your discussion group
- Get your milk data sent to PBI

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Grassland Decision Support Tool

PastureBase Ireland (PBI) is an on-line grassland management programme for all grassland farmers. In operation since 2013, and with the on-going merger with AgriNet Grass since 2017, it offers farmers 'grassland decision support' and stores a vast quantity of grassland data from dairy, beef and sheep farmers in a central National Grassland Database.

The Grass Wedge



The Grass Wedge is the primary tool within PBI and is used for the day to day running of any grassland farm. The Grass Wedge displays the grass available on each paddock. The red demand line is determined by the number of stock, the grazing area, the grass intake of each animal and the rotation length. The Grass Wedge identifies grass surpluses and grass deficits as they arise. Paddock can be easily removed from the Grass Wedge and cut for surplus

bales in order to keep within the targets. Likewise, in a deficit situation, grass intake can be reduced and supplement added to the diet. The Grass Wedge can be downloaded or printed for your advisor or farm staff to make decisions.

Spring & Autumn Rotation Planners



The most efficient way to allocate grass in the spring and autumn is according to the Spring and Autumn Rotation Planners. The Spring Rotation plan allocates an appropriate proportion of the farm each day from turn out to early April (first rotation) while the Autumn rotation plan allocates an appropriate proportion of the farm each day from late September/early October to mid-November. Together with regular measurement of the farm, PBI will calculate the area grazed each week, and also farm cover. By using a spring and autumn plan to allocate

grass, this will ensure that there is sufficient grass until the end of the first rotation and the end of the last rotation respectively.

Sharing Data

The Farmer is the primary user of the system; however advisors can be granted access by a farmer to view or print their data but they cannot edit the data. A link can also be created between farmers. For example, if you are in a discussion group, you can share data with all discussion group members are run reports to benchmark results. Grass, fertiliser and milk data can to shared.

Annual Tonnage



At the end of the year the Annual Tonnage report will display the amount of grass each paddock has grown as well as the number of grazings and silage cuts. This will help you make decisions on the next paddock to reseed as they are producing less that the average. After a number of years measuring grass you will build up a profile for each paddock and you will be able to determine how much grass your

farm can grow on an 'average' year and set the farm stocking rate accordingly.





PBI has an offline app which is available for download from the App store and Google play store. Search for 'PBI Grass'. The app is free to download. Grass covers, graze dates, fertiliser application, livestock number/intakes as well as milk data can be quickly recorded while undertaking the task in the paddock whether mobile coverage is poor or not available.

The main benefits from measuring grass

- 1. Minimise costs to cope with volatile world markets for dairy, beef and sheep products.
- 2. Maximise the proportion of grazed grass in the diet.
- 3. Maximise pasture re-growth rates.
- 4. Improve pasture quality, feed more grass, and at a higher quality.
- 5. Graze more grass in the spring and autumn, shorten the winter period.
- 6. Achieve target average farm covers at key times during the year.

You cannot manage something you do not measure! Measuring grass enables the grassland farmer to make better informed and more effective grassland management and grazing decisions.

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

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