Agriculture and
Food Development
Authority

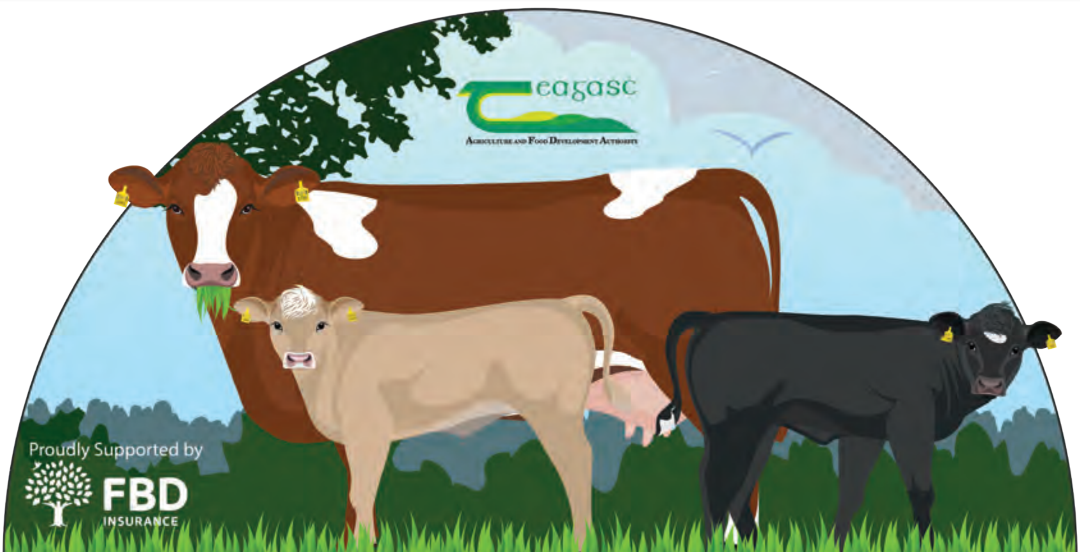
Grange

BEEF 2022

'Supporting Sustainable Beef Farming'

Tuesday, 5th July 2022

Teagasc, Grange, Dunsany, Co. Meath



teagasc
Agriculture and Food Development Authority

FBD
INSURANCE

Teagasc

Agriculture and Food Development Authority

BEEF 2022

ACKNOWLEDGEMENTS

Teagasc acknowledges with gratitude the support of FBD Insurance, sponsor of BEEF 2022

FBD INSURANCE

Tuesday, 5th July 2022

Compiled and edited by:
Mark McGee and Paul Crosson
Teagasc, Grange Animal & Grassland Research and Innovation Centre

ISBN: 978-1-84170-678-8

Table of contents

Grassland

Suckling Systems

Dairy-Beef Systems

Growing & Finishing Cattle

Meat Quality

Advisory, Education & Policy

Farming Lifestyle

Health, Safety and Bio-Security

To minimise disease risks and accidents, visitors entering and leaving Grange Research Centre are asked to:

Use Footbaths

Not Handle Cattle

Not Enter Pens or Paddocks containing Cattle

Thank You

Beef 2022

Foreword

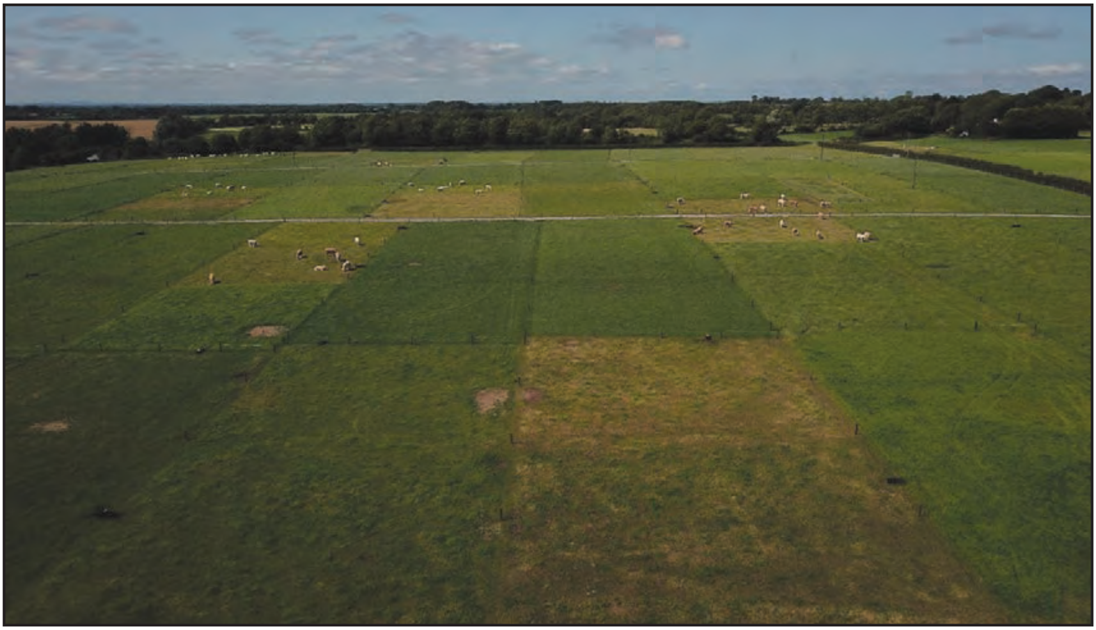
I am delighted to welcome you to BEEF 2022 at Teagasc Grange. Our beef open days normally follow a two-year cycle, but our planned 2020 event was cancelled due to the pandemic. Although we had a very successful Virtual Beef Week in 2020, it was no replacement for our traditional face-to-face events. It is impossible to replicate the engagement and interaction of these more traditional events and for this reason, I am especially delighted to welcome you to Grange today and I look forward to meeting you.

Beef farming is the most widespread of all farm enterprises with almost 100,000 farms having a beef enterprise. Therefore, the sector makes a key contribution to the Irish economy, particularly in rural areas. Beef farmers face many challenges, with farm level profitability and meeting environmental obligations being the two biggest at the moment, but the continued development of the sector is crucial for the viability of rural areas throughout the country.

In keeping with the size and importance of the sector, Teagasc commits significant resources to our beef programme in our research, advisory and education departments. From a research perspective, in addition to our 250-hectare flagship site at Grange, which you have the opportunity to visit today, our research site at Johnstown Castle is investigating multi-species swards for a dairy calf-to-beef enterprise. We continue to develop our beef programme and have recruited two new researchers and five supporting staff to our beef team in the past 12 months. We hope to further build our beef research capacity in the coming months and will have announcements forthcoming in that regard.

Today you will also have an opportunity to meet some of the farmers and the advisory team from our two new demonstration programmes - the **Future Beef Programme** focused on suckler beef and the **DairyBeef 500 Campaign**. These will involve widespread advisory activity for suckler and dairy-beef systems, including a network of demonstration farms spread throughout the country. Each programme will leverage our discussion group model and will aim to promote profit-enhancing technologies relevant to farms throughout the country. There will be an intensive dissemination campaign so I am sure you will hear much more from these programmes in the coming years.

The theme of our event today is 'Supporting Sustainable Beef Farming'. It is worth emphasising that sustainable farming is, first and foremost, economically viable farming. Improving farm viability has been, and continues to be, the overarching objective of our beef programme. The Teagasc National Farm Survey figures for 2021 show large percentage increases in beef farm incomes, albeit from a low base. Incomes on 'Cattle Rearing' farms increased by 29.7% to €10,937, while incomes on 'Cattle Other' farms increased by 5.7% to €16,416. Although



the increases were encouraging and welcome, the overall incomes are still very low. The increases in input costs which were emerging towards the end of 2021 have accelerated in 2022. It remains to be seen if these large input cost increases will be sufficiently covered by the significantly increased beef prices currently being received by farmers. The analysis from our Rural Economy team highlights that farm supports, particularly for suckler farms, are vitally important for family farm income on beef farms. The rapid escalation in both input and beef prices in the past 12 months raises many questions as to what this means for our 'blueprint' system and for farm incomes in Ireland, and these issues will be extensively discussed at the Open Day today.

Of course, sustainability also means continuing to reduce the environmental footprint of our beef farms. With our pasture-based production systems, we have a very strong starting point as regards the environmental sustainability of our beef farms and this stands us in good stead from a marketing and reputational point of view. Our research continues to harness the potential of grazed pasture for our beef farm systems. Today we have signalled the prominence of the environmental aspects of the beef programme by locating our 'Signpost Farms' Environment village, as the first of our technology villages. The Signpost Farms Programme incorporates our enterprise-level programmes such as Future Beef, DairyBeef 500 and Grass10 under its umbrella. This signals our determination that management measures recommended to farmers are firstly those which either increase productivity or reduce production costs on our suckler, dairy-beef and finishing farms. We are confident that there are enormous environmental gains to be achieved by improving efficiency of beef farms. Indeed our first stand today shows that the most efficient farms are the most profitable and produce beef with a low carbon footprint. Our research programme is also seeking to develop the 'next generation' of solutions to further reduce the environmental footprint of beef. In particular, we have invested heavily in research to mitigate methane emissions from beef cattle, which predominantly emanate from rumen digestion. The early results from this research are very promising and you will have an opportunity to see these and meet the researchers involved first-hand today.

I would like to thank our sponsors FBD Insurance for their generous support for this open day. I would also like to thank industry partners who will join us today, highlighting the collaborative nature of the beef sector.

So all in all, there are many important and interesting topics for beef farmers that will be discussed at the Open Day, and I hope that you find the day enjoyable, informative and fulfilling.

Professor Frank O'Mara

Director Teagasc

Beef 2022

Welcome to Grange

Paul Crosson and Pearse Kelly

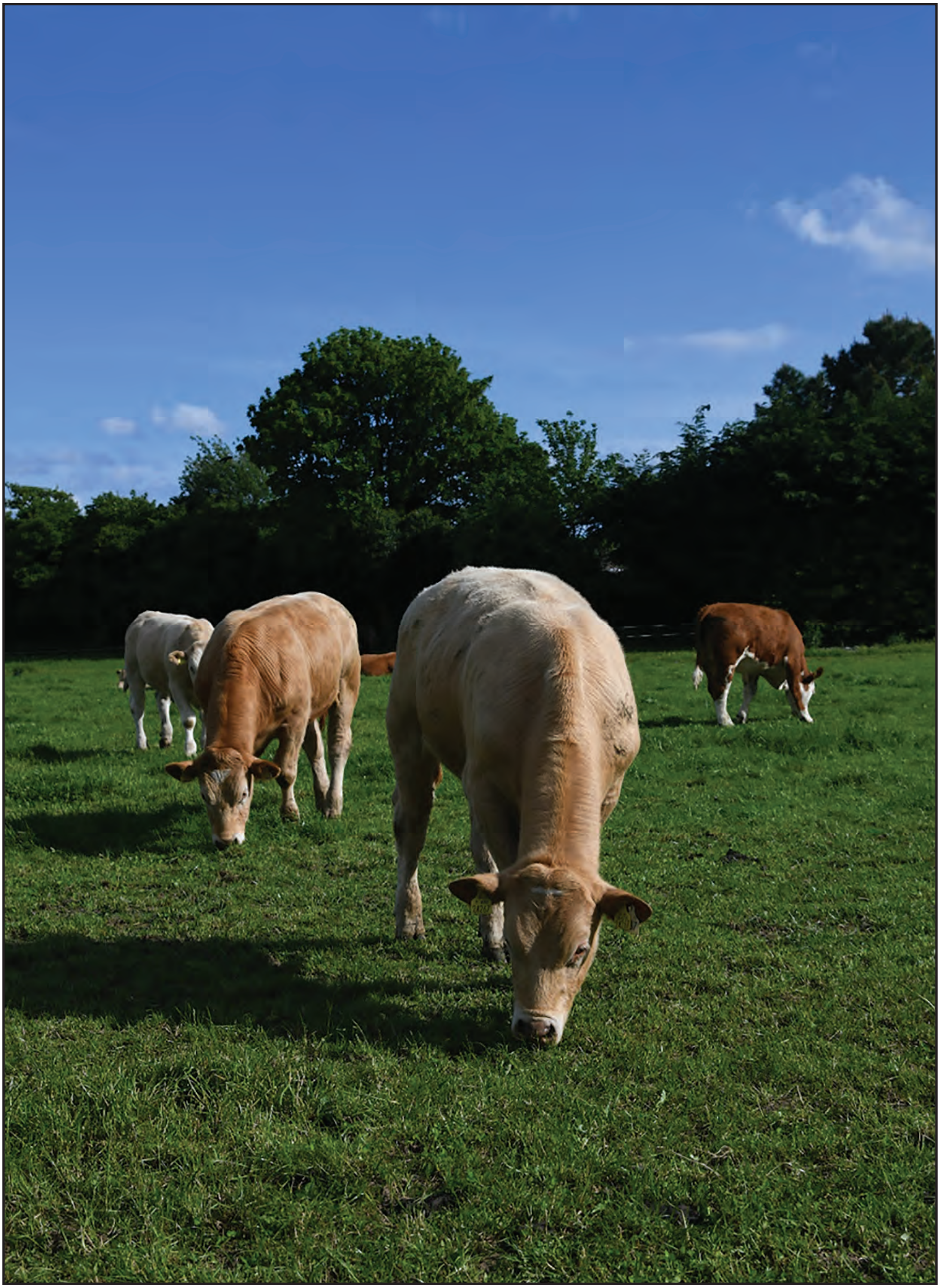
Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

On behalf of the staff at the Teagasc, Animal & Grassland Research and Innovation Centre, Grange and other staff involved with today's event, it is a pleasure to welcome you to BEEF 2022. The theme today is 'Supporting Sustainable Beef Farming" where we will be focusing on the application of technologies that will help beef farmers to increase the profitability and environmental sustainability of their family farm businesses. Technologies in relation to, grazing management, animal nutrition, beef genetics, reproductive management, animal health, farm planning and reducing the environmental footprint of beef production systems will be essential to increase the competitiveness and sustainability of the Irish beef sector, and all of them will feature strongly at BEEF 2022. We will also be addressing the historically high input prices that Irish farmers are currently experiencing and what strategies can be put in place to mitigate their impact on beef farm profitability.

Today's event is comprised of four main 'speaking' stands followed by a series of 'villages' where the key technologies to improve beef farming sustainability will be shown throughout the day. We have a number of live-demonstrations throughout these villages that will be both informative and interactive. You will also have the opportunity to meet with beef farmers from around the country who are Teagasc 'Signpost' demonstration farmers in our 'Future Beef' and 'DairyBeef 500' programmes. These farmers are implementing many of the technologies on show today on their farms. Visitors today will have the opportunity to visit our new pilot scale anaerobic digestor and to hear what research is being planned on this topic. BEEF 2022 will finish with a Forum where a panel of leading experts will address the key challenges that are facing beef farmers and the industry over the coming years and how these can be addressed.

In preparation for this event, particular attention has been paid to health and safety, and biosecurity arrangements. Please use the footbaths provided, pay attention to the signs erected throughout the circuit and follow the direction of our staff. Visitors are asked not to enter paddocks, with cattle in them which are 'double-fenced', or pens with cattle in them for both bio-security and safety reasons. Your help and co-operation with these safety measures is greatly appreciated.

A major Open Day at our National Beef Research Centre in Grange is an opportunity for you, the visitor, to see first-hand the latest research and advice on a wide range of topics that will make beef farming more sustainable, both profitably and environmentally, into the future. Again, on behalf of Teagasc and Grange staff we hope you have an enjoyable and worthwhile visit, and can take some of what you see here today back to your own farm.



Supporting Sustainable Beef Farming

Selecting the most suitable system for your beef farm

Paul Crosson, Mark McGee and Pearse Kelly

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Beef production in Ireland is characterised by having an array of different production systems.
- Given the range in farm systems, a clear three-to-five year plan is critical to improve the economic and environmental sustainability of beef farms.
- The beef system operated, and the 'intensity' at which it is farmed, will depend on a number of factors including labour availability, facilities, land area and type, and economics.
- Analysis of alternative beef systems indicated that the rise in input prices have led to average costs for suckler weanling-to-beef and dairy calf-to-beef systems of €4.50 and €4.05 per kg beef carcass, respectively.
- Of the production systems analysed, net margin per hectare was greatest for systems finishing at the end of the 'second' grazing season.
- Greenhouse gas emissions were lowest for dairy calf-to-beef systems and for systems finishing cattle at younger ages.

Introduction

The Irish beef sector is one of the most important indigenous industries in Ireland with cattle production accounting for 27% of gross output from agriculture and generating beef exports of approximately €2.3 billion. Beef production is a significant enterprise on over 94,000 farms spread throughout Ireland, thereby making a key contribution to the Irish economy, particularly in rural areas.

Beef production in Ireland is characterised by having an array of different production systems. Many farms operate more than one system with others moving between systems depending on the market conditions from one year to the next. In addition to a long list of beef system options there is also a wide range of stocking rates across Irish beef farms. The majority of farms operate at low-to-modest stocking rates (< 130 kg organic N/ha) with a relatively small number requiring a Nitrates Derogation (>170 kg organic N/ha) for their farm.

Given the range in farm systems, and complexity of operating multiple systems, having a clear three-to-five year farm plan is recognised as being the first step that needs to be taken by any beef farmer who is looking to improve the economic and environmental sustainability of their farm. Choosing the most suitable beef system for your farm, including the most appropriate stocking rate, is the foundation on which this farm plan must be built. Once these decisions are made, the remaining steps of the plan, such as grassland management, animal breeding and animal health, are easier to decide.

Which beef system suits a farm or farmer, and the intensity at which it is farmed, will depend on a number of different factors. These include labour availability, facilities, land area and type, and economics. Every farm will be characterised differently when it comes to each of these factors and this will determine the choice of system and target stocking rate.

Labour availability

One of the biggest influences on choice of beef system is how much time you can devote to the farm. If you are beef farming fulltime any of the systems are manageable, but if you have a full-time off-farm job and can only commit a certain amount of hours per week to farming then it does start to influence your choices. How much stock and how many grazing groups can you comfortably 'carry'? If your farm is fragmented, do you have the time to move cattle to and from 'out-blocks' or does it make sense to pick a system and a stocking rate that allows you to leave cattle on land that is away from the farmyard for much longer periods. Time availability is also linked to stress and overall farm productivity. Some people cope well under time pressure whereas others do not, which can lead to corners being cut and essential time-critical tasks on the farm being rushed or neglected. If this is the case, either the beef system needs to change and/or the level of stock needs to be reduced.

Facilities

A well-stocked farm needs to have enough winter housing accommodation, enough slurry/farm yard manure storage and good animal handling facilities that are safe and fit for purpose. Where a farm has these already in place it gives them much greater choice when it comes to their beef system. It also allows them to increase stocking rates without the need for investing more money in the farm. However, where these are not available choices have to be made. How many cattle can be housed over the winter and, if more housing is needed, is it a case of finding the necessary funds or do you 'cut your cloth to suit your measure' and choose a beef system and stocking rate that matches your existing housing? There are production systems that require less housing than others. These include summer grazing, finishing heifers and steers off grass before the second winter, and finishing autumn-born calves at two years of age.

Land

Soil type, soil fertility, drainage capacity, sward type and level of farm fragmentation are all factors that will influence a farm's choice of beef system along with the number of stock it can carry per hectare. Some of these can be improved where there is a willingness to do so but for some of them they are unlikely to change on many farms without a significant investment in time and money. Therefore, most farms have to work with what they have. Ultimately, the quantity of grass a farm can grow in a year dictates the number of cattle that farm should carry if operating a grass-based systems. A well-stocked, calf-to-steer beef system will need to grow in excess of 10 t DM per hectare annually, whereas a medium-stocked farm buying stores in the spring and selling them in the autumn might only need half this amount of grass.

Work-life balance

There is an increasing emphasis in society on 'work-life balance'; in other words, how much time and effort is devoted to 'work' activities in comparison to leisure and family time. Beef farming, and indeed farming in general, is somewhat different than other occupations since most farms are family-farms so there is an overlap in farming and family pursuits. Nevertheless, a balance must be struck between these partially competing objectives.

Similar to most things in the life, the more you put into something the more you get out. Beef farming is no different. Some beef systems have very busy periods in the year compared to others and this may not suit some, for example, calving cows or rearing calves. Many beef systems need 'top-quality' grass silage to be profitable, whereas for others it is a case of making enough silage of average feeding quality, such as for suckler cows. Heavily-stocked farms with a rotational grazing system can benefit hugely from measuring weekly grass covers, whereas set-stocked farms with low stocking rates will get little advantage from using this management tool. Heavily-stocked farms require a greater focus on soil fertility, meeting winter forage requirements, using the latest grassland and breeding technologies, animal health, coping with adverse weather events and tighter financial management. How 'driven' a farmer is to improve their beef farm will often help to determine the best system of beef production they should be in and the number of stock they realistically should be aiming for.

In the following sections, we will examine the economic and greenhouse gas (GHG) emissions implications of a range of production systems, bearing in mind the conditional factors noted above. Specifically, we will assess beef systems producing and finishing suckler-bred weanlings and dairy calf-to-beef production systems.

Suckler beef systems

In general suckler beef production systems can be categorised as cow-calf systems producing weanlings and weanling-to-beef systems. Integrated suckler calf-to-beef systems are less commonplace and for the purposes of this analysis we will assume separate systems for producing weanlings and finished cattle.

The Irish suckler herd is predominantly spring-calving with 75% calving between January and June and 45% calving from February to April. The objective is to align calving date, and the period of greatest nutritional demand from the cow, with the onset of the grazing season. Cows suckle their progeny over a grazing season of six-to-nine months after which calves are weaned and in most cases, sold as weanlings or, if they are retained for a period post-weaning, as 'yearlings'/'stores'. In these systems, replacements are typically purchased as 'maiden' heifers for breeding with 'in-herd' selection of replacements also practiced, although this is less common. There are a wide array of suckler weanling-to-beef systems primarily based on gender (steers vs. bulls) and feeding system (differing in proportional feeding of concentrates). Four typical systems are described in Table 1. Indeed, within each of these systems there are many variations and these are described in more detail on pages 24 and 208.

Given the major price perturbations that have arisen in recent years and particularly in 2022, the financial performance of the four suckler systems outlined in Table 1 were assessed. In the suckler calf-to-weanling system, a spring-calving (February) system was assumed with cows and calves turned out to pasture in mid-March. Weaning weight was 330 kg and 315 kg for male and female calves, respectively. Calves were assumed to be weaned at the end of October and sold in November. Replacements were sourced from within the herd, thereby reducing the availability of heifer weanlings for sale by approximately 20%. For the three suckler weanling-to-beef systems, weanling steers were purchased in November and 'taken through' to slaughter according to the systems outlined in Table 1, i.e. at the end of the second grazing season, during or towards the end of the second winter and during the third grazing season.

Table 1. Overview of four typical suckler beef production systems operated on Irish farms based on spring-born progeny

System	Age at sale (months)	Feed budget[1]	Finishing steer system[2]	Weanling / carcass weight (kg)
Calf-to-weanling	6-9	75/20/5	-	300-340
Weanling-to-beef				
Slaughter time				
'Second' grazing season	18-21	60/20/20	Pasture: GG + C	330-350
'Second' winter	21-25	45/40/15	Indoor: GS + C	380-400
'Third' grazing season	25-29	55/40/5	Pasture: GG	400-420

[1]Feed budget: % grazed grass/ grass silage/ concentrate feeds on a dry matter (DM) basis.
[2]Finishing steer system: Pasture = finished at pasture on grazed grass only (GG) or with concentrate (C) supplementation; Indoor = finished indoors on a grass silage (GS) diet with concentrate supplementation.

A fundamental constraining factor on beef cattle farms is forage availability. To facilitate a 'balanced' comparison of the four production systems outlined in Table 1, inorganic fertilizer nitrogen (N) application rates were the same for all systems with 100 kg/ha applied to grazing swards and 90 kg/ha and 70 kg/ha (plus slurry) applied to first- and second-cut silage swards, respectively. A modest contribution from clover of 50 kg N/ha was assumed in these scenarios; it is recognised, however, that well-established clover swards can contribute up to 150 kg N/ha and this is presently being assessed for suckler weanling-to-beef systems in studies at Teagasc Grange.

Given the variation in feed budget and animal category (i.e. numbers of 0-1, 1-2 and 2+ year old cattle) for each system, stocking rates varied somewhat for each system (Table 2), and systems finishing animals at older slaughter ages had fewer animals sold, because they were 'carrying' animals for a longer time on a fixed land area. This is particularly evident where cattle are sold at 28 months of age. All systems required a derogation from the Nitrates Directive; the 23-month weanling-to-beef system operates at the highest organic N stocking rate. In this case, total feed availability is greater than the other systems owing to higher levels of imported concentrate feed.

Net margin per hectare was greatest for the 21-month weanling-to-beef system (Table 2). This system benefits from high beef output and a high proportion of grazed grass in the total feed budget (compared to the other weanling-to-beef systems), and is also less sensitive to concentrate and fertilizer prices. The next most profitable system was the 23-month weanling-to-beef system; although production costs per kg beef output was highest for this system, the system benefits from a high level of beef output which, at current prices (base of €5.00/kg assumed), leaves this system more profitable than the 28-month system.

Given the extraordinary rise in both input and beef prices, a wide range in sensitivity values is provided. In particular, these systems show very large sensitivity to beef and weanling prices (Tables 2 and 3). For example, an increase in weanling price of 50 cent/kg changes profitability such that, rather than being considerably less profitable than the suckler weanling-to-beef systems, the suckler calf-to-weanling system is the most profitable. Clearly, the impact of sale price has a considerable impact on net margin and the ranking of systems for profitability.

Table 2. Summary of the performance, profitability and greenhouse emissions for four suckler beef systems based on a 40-hectare farm at prevailing prices1

	Calf-to-weanling	Steer weanling-to-beef systems		
***Sale*/slaughter age (months)**	***9***	**21**	**23**	**28**
Organic nitrogen (kg/ha)	183	190	202	175
Forage in the diet (DM basis)	0.95	0.80	0.85	0.95
Concentrate (kg DM/head[2])	215	475	585	250
Number of animal units sold[2]	61	161	143	84
Weaning/carcass weight (kg)	*325*	342	385	410
Beef output[3] (kg/ha)	*752*	1380	1374	861
Gross output value (€/ha)	2015	3197	3571	2393
Gross margin (€/ha)	962	1663	1518	1227
Net margin (€/ha)	309	1096	847	635
Net margin (€/head)	180	272	237	302
Production costs[4] (€/kg)	2.27	4.41	4.64	4.46
Price sensitivity (€/ha)				
Beef sales3 (+/- 50 cent/kg)	+/-249	+/-690	+/-687	+/-431
Weanling price (+/- 50 c/kg)	-	+/-662	+/-586	+/-347
Concentrate (+/- 50 €/t)	+/-22	+/-96	+/-104	+/-26
Protected-urea (+/- 100 €/t)	+/-35	+/-29	+/-36	+/-34
Greenhouse gas emissions (kg CO2e)				
Per kg beef output[3]	11.5	14.3	15.8	18.1
Per hectare	7,300	9,900	11,800	9,100

[1]Price assumptions: concentrate feed €440/t as fed, protected-urea €950/t, silage harvest €375/ha. [2]Number of animal units per farm: sale of 'live' weanlings in the suckler calf-to-weanling system, steers 'finished' in the three suckler weanling-to-beef systems. [3]Beef output: *live weight* for weanling system, carcass weight for weanling-to-beef systems. [4]Production costs: per kg beef live weight for calf-to-weanling system, and per kg beef carcass for weanling-to-beef systems. The latter include cost of purchased weanling. Family farms are assumed, with no charge applied for land and labour.

Table 3. Summary of the profitability (net margin, €/ha) of four suckler beef systems for a range of beef and weanling price scenarios

Beef/weanling price[1]	Calf-to-weanling	Steer weanling-to-beef systems		
***Sale*/slaughter age (months)**	**9**	**21**	**23**	**28**
€4.50/€3.00	309	406	160	205
€5.00/€3.00	*309*	*1096*	*847*	*635*
€5.50/€3.00	309	1786	1534	1066
€5.00/€2.50	60	1758	1434	982
€5.00/€3.50	558	435	261	288

[1]Beef price in €/kg carcass (R3 base), weanling price in €/kg live weight.

A further consideration is the impact of production systems on GHG emissions given the requirement for agriculture to reduce emissions by between 22% and 30% by 2030. The impact of reducing slaughter age is apparent with GHG emissions per kg beef being over 20% lower for systems finishing at 21 compared to 28 months of age (Table 2). In contrast however, of the three weanling-to-beef production systems, GHG emissions per hectare were lowest for the 28-month system.

To assess the effect of reducing stocking rate on beef output and profitability, the four suckler systems which were evaluated under a 'moderately-high' stocking rate of approximately 190 kg organic N/ha were compared at a 'low' stocking rate of 140 kg organic N/ha (Figure 1). The 'low' stocking rate is somewhat higher than the mean stocking rate of 116 kg organic N/ha on suckler beef farms nationally, but comparable to the Teagasc Roadmap 2027 projection for the suckler beef farming sector (https://www.teagasc.ie/media/website/publications/2020/2027-Sectoral-Road-Map---Beef.pdf).
For the low stocking rate system fertilizer N application rates were reduced to 30 kg/ha for grazing swards; fertilizer N application on silage swards was maintained at the same level as the higher stocked systems. The effect of reducing stocking rate was to reduce animal numbers and beef output by approximately 25% and 23%, respectively, and to reduce profitability per hectare by more than 50% compared to the higher stocked systems (Figure 1).

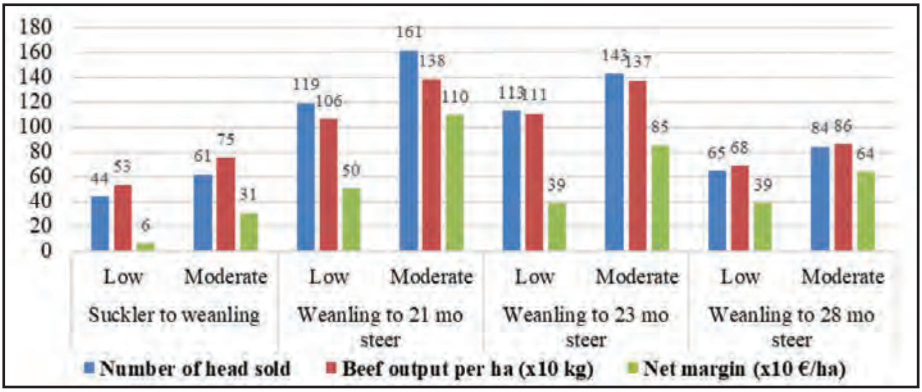


Figure 1. Effect of stocking rate ('low' = 140 kg organic N/ha vs. 'moderate' = 190 kg organic N/ha) on beef output and net margin per hectare for four suckler (a calf-to-weanling and three steer weanling-to-beef) systems, based on a 40-hectare farm.

Suckler bull beef production

Ireland has a reputation for the production of steer beef and this is a key element of the marketing of Irish beef globally. Production systems for finishing male progeny as steers have been described above and elsewhere in this booklet (Pages 24 and 204) and these systems predominate within the beef sector. Nevertheless, there continues to be an interest in finishing male cattle as bulls to capture the natural growth and production efficiency benefits that derive from bulls when compared to steers. The beef processing industry have established guidelines for the production of young bulls and, in general, animals must be under-16-months of age at slaughter to be eligible for bonus payments on the Quality Payment Scheme (QPS; a scheme whereby farmers receive a premium above the quoted price where conformation is greater than R-grade). However, there is still some interest in producing bulls that are somewhat older (circa 18-months of age) in order to avail of a partial second grazing season before housing and finishing in late summer/early autumn.

Finishing bulls at under-16-months of age reduced the proportion of forage in the diet and, at current prices and under the conditions assumed in this analysis, increased production costs and reduced profitability when compared to bulls slaughtered at 18 months of age or steers slaughtered at 21-months of age (Table 4). Offering bulls a period at grass in the 'second' grazing season increased margin per head, and was greater than all systems assessed. It is important to note, however, that these systems do not conform to the current industry specification for payment on the QPS and are potentially discounted at sale. In the case of this system, and bulls in general, a contract for sale is strongly advised. Given the low forage demand for bull systems relative to the steer beef systems presented above, these systems would typically operate alongside another systems so that the farm overall makes optimal use of grazed pasture. The low forage demand for bull systems is due to the early slaughter age and the importation of concentrate feed (approximately 1.1 t DM fed per head for both bull systems), which reduces the constraining factor of land for producing forage. This has implications for facilities and labour, both of which are often limiting factors on beef farms. A further consideration is the 'starting' weight of weanlings for bull beef systems, particularly where the objective is to finish at under-16 months of age. In this analysis, bull weanlings commenced at 330 kg live weight to permit a balanced comparison with the previous weanling-to-steer scenarios; clearly a starting weight of greater than this is desirable, particularly for under-16-month bull systems, to obtain a greater carcass weight. This has implications for purchase price or, in integrated calf-to-beef systems, dam and sire genetics and creep feeding in the pre- and post-weaning periods.

Table 4. Effect of finishing male progeny as bulls compared to steers in suckler weanling-to-beef systems on diet composition, financial performance and GHG emissions intensity

	Bull	**Steer**	
Slaughter age (months)	**Under-16**	**18**	**21**
Forage in the total diet (DM basis)	0.52	0.64	0.82
Carcass weight (kg/head)	360	407	342
Net margin (€ per head)	201	414	272
Production costs (€/kg carcass)	4.59	4.15	4.41
GHG emissions (kg CO2e/kg carcass)	11.3	11.2	14.3

Dairy calf-to-beef systems

The expansion of the dairy cow herd has given rise to a greater availability of dairy-origin calves for beef production. Production systems are broadly similar to those which pertain for suckler progeny with finishing taking place at the end of the second grazing (18 to 21-months of age), during or towards the end of the second winter (21 to 25-months of age), and during the third grazing season (25 to 29-months of age). Indeed, the earlier average calving date for the Irish dairy herd and greater use of early-maturing sires increases the opportunity for finishing before the second winter for dairy calf-to-beef systems.

In the analysis presented here (Table 5), we assume February-born early-maturing (Aberdeen Angus) beef × dairy calves were purchased at two weeks of age and finished as steers at the end of the 'second' grazing season (20-months of age), during the 'second' winter (22- and 24-months of age) and during the 'third' grazing season (26-months of age). Profitability was greatest for early slaughter age systems, with the 20-month slaughter system most profitable overall. This early slaughter system benefited from a higher number of animals carried and relatively low production costs. Similar to the suckler systems, the impact of beef price has a considerable impact on net margin per hectare. The effect of early slaughter age reducing GHG emissions per kg beef carcass was also evident.

Table 5. Summary of the performance, profitability and greenhouse emissions for dairy calf-to-beef steer systems based on a 40-ha farm at prevailing prices[1]

	Slaughter age (months)			
	20	**22**	**24**	**26**
Organic N (kg/ha)	213	200	204	182
Forage in the diet (DM basis)	0.77	0.81	0.79	0.88
Concentrate (kg DM/head)	701	702	878	578
Number of steers finished	136	111	99	78
Carcass/weaning weight (kg)	282	308	332	343
Beef carcass output (kg/ha)	960	851	826	670
Gross output value (€/ha)	4067	3650	3577	2911
Gross margin (€/ha)	1652	1488	1199	1174
Net margin (€/ha)	948	782	479	516
Net margin (€/head)	279	283	193	264
Production costs (€/kg carcass)	3.89	3.96	4.29	4.10
Price sensitivity (€/ha)				
Beef carcass sales (+/- 50 c/kg)	+/-480	+/-426	+/-413	+/-335
Calf price (+/- 50 €/head)	+/-180	+/-147	+/-132	+/-104
Concentrate (+/- 50 €/t)	+/-122	+/-99	+/-111	+/-58
Protected urea (+/- 100 €/t)	+/-26	+/-27	+/-29	+/-30
Greenhouse gas emissions (kg CO2e)				
Per kg beef carcass	10.3	11.9	13.1	14.8
Per hectare	9,900	10,100	10,800	9,900

[1]Price assumptions as per Table 2; calf price €180 per head.

Conclusion

There are a number of factors which determine the production system operated on beef farms in Ireland. In particular, the part-time nature of Irish beef farming and, therefore, availability of labour can be a major constraint. Furthermore, beef farms are predominantly on more 'marginal' land with a greater number on Soil Type 3 (categorized as having more limited uses) when compared to other farm enterprises. A further constraining factor is availability of housing facilities; low farm incomes mitigate against investment and beef farms often operate using housing facilities that are fully depreciated. These factors have a key impact on stocking rates which in turn is an important determinant of profitability. The sharp rise in production costs is evident and, overall, the levels of profitability presented in this analysis is highly contingent on the assumed beef and weanling price.

The environmental performance of beef cattle production is under increasing scrutiny with GHG emissions of particular interest. The analysis presented here showed that the emissions from dairy calf-to-beef systems was lower than suckler systems and that age at slaughter has a large impact on emissions.

Performance targets for resilient beef production

Mark McGee[1], Martina Harrington[2], Nicky Byrne[1] and Paul Crosson[1]

[1]*Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2]*Teagasc, Dublin Road, Enniscorthy, Co. Wexford*

Summary

- A major source of inefficiency in beef cattle production systems is failure to meet performance targets.
- Achieving high animal performance is critical if animals are to be slaughtered younger.
- Where key performance targets are not met, this has large negative ramifications for the profitability and environmental footprint of beef production systems.

Introduction

The source of calves for Irish beef production come from the national herd of 2.4 million cows, of which currently 63% are dairy cows and 37% are suckler cows. Due to the abolition of milk quotas in the European Union, rapid expansion of the Irish dairy herd has meant that proportionately more beef is now derived from dairy-bred compared to suckler-bred animals. The suckler cow herd consists mainly of crossbreds of which, 75% are late-maturing breeds and 25% are early-maturing breeds. Eighty-five percent of suckler calves are the progeny of late-maturing sire breeds of which, 37% of the total are Limousin, 33% are Charolais, 5% are Simmental and 2% are Belgian Blue, with the remaining 15% the progeny of early-maturing sire breeds (10% Angus, 4% Hereford). In the dairy herd, 93% of cows are Holstein-Friesian, and 50% of dairy calves are the progeny of Holstein-Friesian sires (provide replacement heifers), and 36% are the progeny of early-maturing (21% Aberdeen Angus, 15% Hereford) and 7% the progeny of late-maturing (mainly Limousin and Belgian Blue sires) beef breeds. Consequently, in terms of beef cattle production, the predominant 'raw material' from the suckler herd is late-maturing genotypes, and from the dairy herd is Holstein-Friesian and early-maturing beef × Holstein-Friesian genotypes.

Calf births in Ireland are very seasonal with 91% of dairy calves born in the first six months of the year, and 75% in the three peak months, February to April. Calving in the suckler herd is later, with 76% of cows calved in the first-half of the year, and 52% in the peak months of March to May. Therefore, most Irish beef production systems entail a spring-born animal, which has implications for principal slaughter periods.

In 2021, 1.4 million 'prime' cattle (steers, young bulls and heifers) were slaughtered, with males accounting for 59%; within the male cattle slaughtered, steers accounted for 84% and young bulls the remainder. Nationally, mean carcass weight for steers, young bulls and heifers in 2021 was 356 kg, 371 kg and 313 kg, respectively; 22% of steers, 35% of young bulls and 6% of heifers had carcasses heavier than 400 kg. In terms of carcass fatness, 25%, 4% and 47% of steers, young bulls and heifers, respectively, had a carcass fat score of '4-' or greater. This compares with the commercially-acceptable minimum carcass threshold for fat classification of 2+, and implies that a relatively high proportion of steers and heifers are 'overfat', which is a costly production inefficiency. Currently, mean slaughter age nationally for suckler-bred and dairy-bred steer genotypes ranges from 26.3-28.1 months and from 26.6-27.7 months, respectively. Corresponding ranges for heifers are 24.6-26.4 and 24.3-26.0 months of age (see page 228).

Growing concern with climate change has resulted in proposals to further reduce national greenhouse gas (GHG) emissions. The beef sector can contribute to meeting these emission targets by increasing the biological efficiency of production systems, and reducing animal slaughter age.

Importance of grass

Due to the considerably lower comparative cost of grazed grass as a feedstuff (see page 78), suckler and dairy-bred beef production systems in Ireland are predominantly grass-based, and 'designed' to optimize the seasonal supply of pasture. A key objective is to increase the contribution of high-digestibility, grazed grass to the lifetime intake of feed, through as long a grazing season as possible, while simultaneously achieving high individual-animal performance. The foundation underpinning good grass production and utilisation is having adequate soil fertility, unimpeded drainage, targeted application of fertilizer and good grazing infrastructure, coupled with appropriate grazing management practices. However, the seasonality of grass growth and inclement grazing conditions means that an indoor 'winter' period, of varying duration, occurs on practically all Irish farms and the main feed costs on beef farms relate to this period, and especially when feeding finishing cattle. Therefore, providing sufficient grass silage of appropriate digestibility for the indoor winter period – high dry matter digestibility (>72% DMD) grass silage for all growing-finishing beef cattle, and moderate-digestibility grass silage (~67% DMD) for 'dry' suckler cows in good body condition – is a crucial component of grassland management and feed self-sufficiency in beef production systems. Because of their relatively greater cost, concentrate feedstuffs should only be used 'strategically', to rectify deficits in forage nutrient supply at key points in the lifecycle in order to achieve target growth and carcass fatness levels. The level of concentrate supplementation depends on the nutritive value of forage offered (higher digestibility forage requires less concentrate to achieve the same performance), the

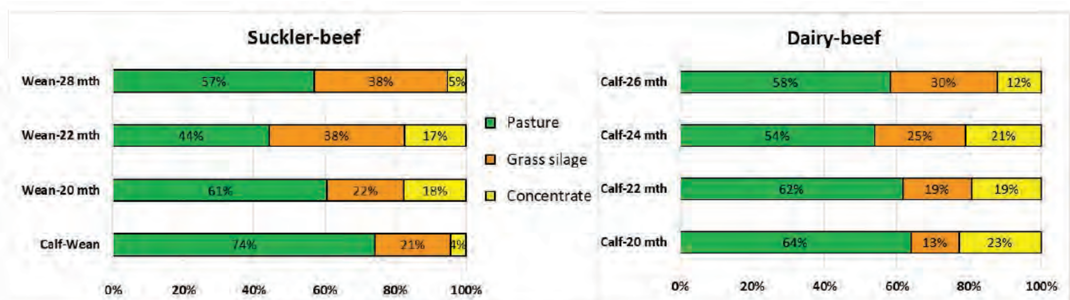


Figure 1. Feed budget composition for spring-born, grass-based, suckler calf-weanling plus weanling-to-beef, and dairy calf-to-beef research systems, with slaughter at different ages (20-month = end of 'first' grazing season; 22- & 24 months = during & end of 'second' winter, respectively; 26- and 28-month = during 'third' grazing season

target growth required (e.g. 'store' or 'finishing' period) and the animal 'type' (e.g. breed, gender, genetic merit). The grass-forage' component of the feed budget for contrasting grass-based suckler- and dairy-beef steer research systems ranges from 82-96% for suckler-beef and 77-88% for dairy-beef systems (Figure 1).

Grass-based beef production system targets

Many types of beef production systems are operated commercially, depending on factors such as the animal origin (suckler- vs. dairy-bred), progeny gender (steers, heifers and bulls (see pages 166, 208, 212 and 216)), on whether it is a 'component' - selling/buying live cattle at different ages (e.g. 'weanling', 'yearling' or 'store' cattle) or a partially (e.g. weanling-to-beef, store-to-beef) or fully (e.g. calf-to-beef) 'integrated' system, and ultimately the slaughter age/target market. For the purposes of clarity, animal performance targets for integrated suckler and dairy calf-to-beef systems are depicted in Figure 2; the same principles apply to other 'component' systems.

1. Suckler cow productivity targets

The lifetime productivity of suckler cows begins with the onset of puberty and thereafter is determined by critical events comprising age at conception, age at first calving, duration of the postpartum interval for each consecutive calving, and conception and pregnancy rate, which is ultimately manifested as calving interval and number of calves weaned over her lifetime. Reproductive targets for a suckler cow herd include an average age at first calving of 24-months, calf mortality of less than 5%, a calving rate of greater than 0.95, an empty rate of less than 5%, a calving-to-calving interval of 365 days, compact calving, with 80% calving in 6 weeks (Figure 2) and a 'long' productive life. A target age at first-calving of 24-months is important as it provides the foundation for maximum potential lifetime productivity – 'unproductive' older replacement heifers are inefficient. Attaining a calving-to-calving interval of 365 days, through operating a compact calving season, and good animal husbandry in terms of meeting cow nutritional requirements and body condition score levels after-calving to ensure resumption of oestrous, is essential. As the calf is the primary output of a suckler cow, the number of calves born is fundamental to productivity; thus, attaining a calving rate as close to one as possible (i.e. each cow in the herd produces a calf every year) is essential. Central to seasonal spring-calving suckler systems is the alignment of calving date with onset of the grazing season in spring, which means that the relatively higher nutritional requirements of lactating spring-calving cows can be met with lower-cost, high-nutritive value grazed grass. This 'date' will differ from region-to-region and is a function of prevailing grass growth commencement date plus soil type, climate and thus grazing 'conditions'. Additionally, the suckler cow must produce sufficient colostrum and milk and ultimately rear a healthy, vibrant and heavy weanling that achieves lifetime growth targets with desirable carcass characteristics.

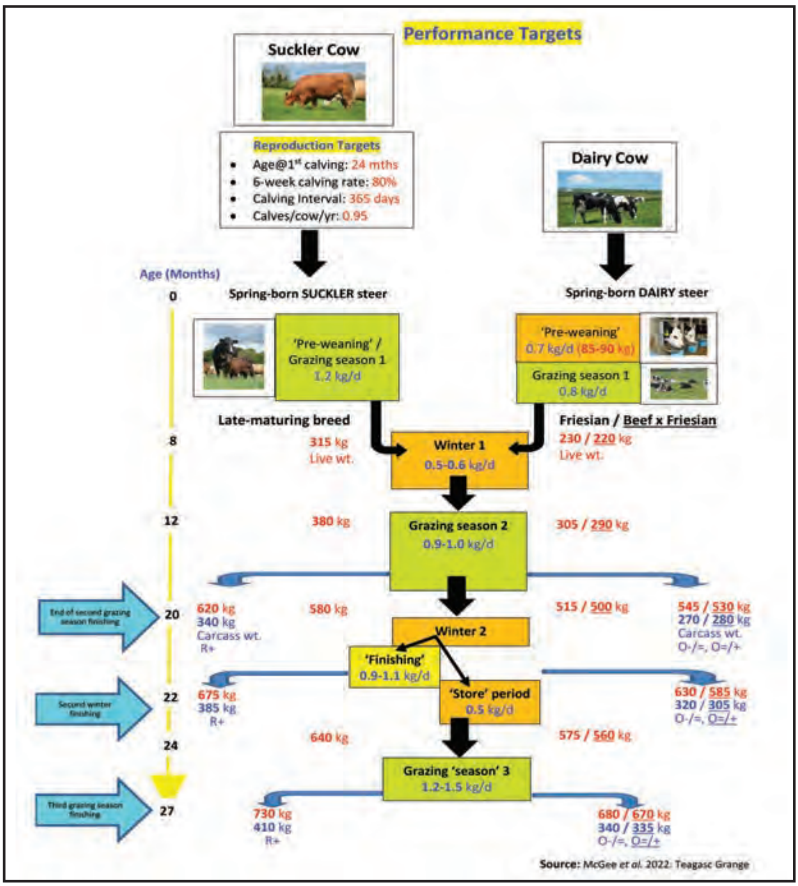
2. Growth targets for spring-born suckler- and dairy-bred calves

- *Birth - end of the 'first' grazing season*

Grass-based suckler systems entail spring-calving cows (~March) rearing their own calves until weaning at the end of the grazing season at about 8 months of age, following which the 'weanlings' are housed; concentrate supplementation (~1 kg/day) is usually provided shortly before weaning to support the weaning process. In grass-based dairy-beef steer production systems, spring-born calves are artificially-reared on milk replacer and concentrates over an indoor rearing period of approximately 8 weeks, turned out to pasture in summer (~May) at 85-90 kg, and housed at the end of the grazing season (~October/November); concentrate supplementation (~1.0 kg/day) is usually provided at the start and end of the grazing season. Animal growth rate is a significant driver of beef farm profitability and is largely a function of feed 'quality' and quantity, animal genetics and herd health.

Adequate calf passive immunity, derived through timely ingestion of sufficient quantities of quality colostrum, optimised early-life nutritional management coupled with appropriate parasite and animal health strategies during this time period (and subsequently), are critical to ensure that suckler and dairy-bred calves can meet their production potential. Target pre-weaning live weight gains of dairy calves are 0.7 kg /day, and subsequently at pasture 0.8 kg/day (Figure 2). Target live weight gains of spring-born single-suckling un-supplemented calves on well-managed rotationally grazed systems typically exceeds 1.2 kg daily over the grazing season, although this is heavily influenced by cow milk yield.

Figure 2. Animal performance targets for spring-born grass-based suckler and dairy steer calf-to-beef production systems



At the end of the 'first' grazing season, spring-born dairy weanlings are about 90-100 kg lighter than their suckler-bred counterparts (Figure 2). Despite the fact that these contrasting breed types differ markedly in their intake relative to weight (dairy-bred consume more than suckler-bred), feed efficiency (dairy-bred poorer than suckler-bred) and carcass traits (dairy-bred have inferior kill-out proportion, and carcass weight and conformation score compared to suckler-bred), animal management and live weight gain targets from housing at the 'first' winter until slaughter are broadly similar for both suckler-bred and dairy-bred production systems.

- *'First' winter growth targets*

During the 'first' winter indoor ('store') feeding period, animals consume a 'restricted-energy' diet based on grass silage ad libitum and supplementary concentrates (e.g. 1.0 kg fresh weight/day). A target live weight gain of 0.5-0.6 kg/day through the first winter is acceptable for steers, heifers (and bulls) destined to return to pasture in spring (Figure 2). This feeding regime is designed to minimise winter feed costs and subsequently exploit compensatory growth on cheaper-produced pasture, which further avails of the economic efficiency of grazed grass over conserved forages and concentrates (See p 196).

- *Second' grazing season growth targets*

During the 'second' grazing season (~March-October/November) a target live weight gain of ~0.9-1.0 kg/day should be attainable without meal supplementation (Figure 2). Appropriate grazing management practices include, turning cattle out to grass as early as possible in spring and ensuring an adequate supply and intake of good 'quality' leafy grass, by avoiding excessively high pre-grazing herbage masses and excessively low post-grazing sward heights (See p 204).

Finishing spring-born steers at about two years-of-age involves an 'expensive' final indoor winter feeding period. As grazed grass is considerably cheaper than grass silage or concentrates, early finishing of cattle from pasture in autumn before housing (~20-months of age), reduces total costs per animal. Because a commercially-acceptable carcass fat score (minimum target of 2+) is currently a primary market requirement, the propensity of cattle to deposit subcutaneous fat is important to ensure they have an adequate carcass fat cover. One strategy is to provide concentrate supplementation (e.g. 3-4 kg/day) to animals during the finishing phase at pasture (See p 196).

- *'Second' winter and 'third' (short) grazing season growth targets*

Alternatively, at the end of the 'second' grazing season steers are re-housed and offered high-digestibility grass silage supplemented with concentrates. Animals destined for finishing at ~22 to 24 months of age receive a moderate allowance of concentrate (e.g. 4-5 kg daily, depending on silage DMD) with a target live weight gain of 1.0 kg /day (Figure 2). In contrast, steers destined to be turned out to pasture for part of (3-4 months) a 'third' grazing season and finished at pasture at 27-months of age receive a much lower (e.g. 1 kg/day), if any, concentrate allowance. Similar to the 'first' winter, their target live weight gain is also only 0.5 kg/day in order to further exploit compensatory growth during the subsequent short grazing period (Figure 2).

Importance of performance targets

Where key performance targets described earlier (i.e. both animal- and production system-related) are not met, this has large negative ramifications for the profitability and environmental footprint of beef production systems. For example, the impact of age at first-calving and calves/cow/year in spring-calving suckler systems, and calf mortality, grazing season length, daily live weight gain, and age at slaughter in both suckler and dairy-beef systems, on profitability and GHG emissions is summarised in Figures 3 and 4.

For both the suckler and dairy-beef production systems reducing biological efficiency mostly resulted in reductions in profitability on a per animal basis, and concurrently increases in GHG emissions 'intensity' (per kg 'product' produced), albeit the magnitude of the effects differed across the systems. This inverse relationship implies that reducing GHG emissions to meet national climate targets is generally associated with greater profitability of grass-based beef production systems.

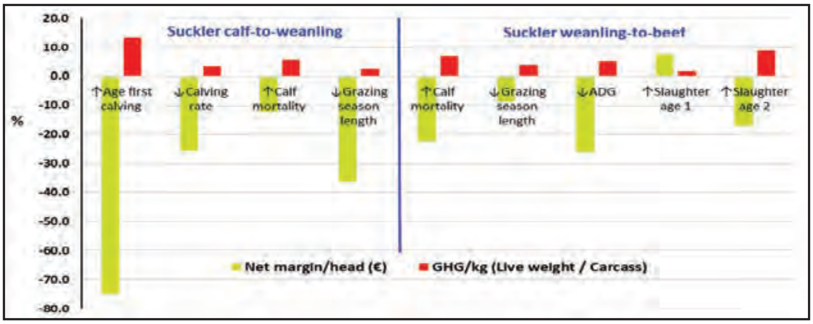


Figure 3. Effect of increasing age at first-calving (24 vs. 36 months), reducing calves/cow/year (96% vs. 0.91%), increasing mortality (4.1% vs. 8.6%), reducing grazing season length (one month) in a spring-calving suckler calf-to-weanling system, and increasing mortality (0.9% vs. 4.4%), reducing grazing season length by one month, reducing daily live weight gain (ADG, -8%) and increasing slaughter age by one (animals remain at pasture), or two (animals require housing) months, in a suckler weanling-to-beef system, on the percentage change in net margin/head and GHG emissions (per kg live weight (LW) for the calf-to-weanling, and per kg carcass for the weanling-to-beef, system))

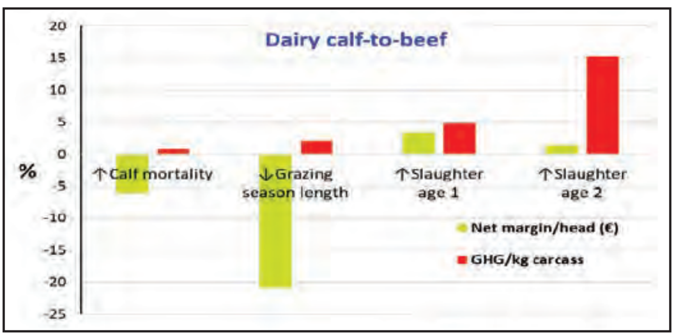


Figure 4. Effect of increasing mortality (5.9% vs. 10.0%), reducing grazing season length by one month and increasing slaughter age by one (animals remain at pasture) or two (animals require housing) months, on the percentage change in net margin/head and GHG emissions in a dairy calf-to-beef system

In the production system examples provided, increasing slaughter age by one month (i.e. from ~20 to 21 months) resulted in animals having an additional month at pasture, and by two months (from 20 to 22) resulted in animals having to be housed for a second winter, with associated increases in GHG emissions per kg product. Because these cattle were older at slaughter, total GHG emissions per animal (t/head) increased too, by 7 and 23% in the suckler weanling-to-beef system, and 9% and 26% in the dairy calf-to-beef system, for the additional one and two months of age, respectively. This highlights the potential role of reducing slaughter age as a GHG mitigation strategy for beef producers.

Achieving performance targets on beef farms

Nicky Byrne[1], Mark McGee[1], Alan Twomey[2] and Catherine Egan[3]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork*
[3] *Teagasc, Mellows Animal & Grassland Research and Innovation Centre, Athenry, Co. Galway*

Summary

- Refine beef production systems and ensure performance targets are met effectively using available resources to enhance financial and environmental performance.
- Using high-merit beef genetics plays an important role in developing progeny of higher profit potential.
- Respiratory disease is the most common cause of mortality in beef cattle.
- Clover incorporation has the potential improve grassland productivity and quality, while reducing dependence of chemical fertiliser.

Introduction

The ability of an animal to meet production targets (see page 24) is a function of genetic merit, health, nutrition and management. The configuration of these factors is partially dependant on the chosen production system. Clearly defined production systems are important if targets are to be met efficiently. The optimum production system for your farm is one which makes the most efficient use of limited resources, for instance land, labour and buildings/ facilities, and primary inputs such as fertiliser and feed. In terms of animal performance targets, breed/genetics creates the potential, but it is management that primarily allows that potential to be achieved. With clear goals and target markets it becomes apparent which animal breed 'type' and management strategy is optimum for your farm. There is an ever-increasing need to improve the economic and environmental sustainability of beef farms, especially considering the rising cost of inputs, especially fertiliser and feed-related prices, coupled with greater environmental constraints, particularly concerning greenhouse gas (GHG) emissions and nitrogen (N) losses.

Identifying more profitable cattle using the commercial beef value (CBV)

Although there is general breed ranking for most beef production traits, there is major variation within breeds, which can be exploited through breeding. Genetic indexes are an important tool that have allowed Irish cattle breeders to make more informed breeding decisions and improve farm efficiency. Up until now such selection indexes have focused on the 'breeding' herd and their specific needs rather than those of cattle 'rearers' i.e. buying animals to produce for slaughter. The commercial beef value (CBV) is a genetic index, expressed in euros, for 'non-breeding' beef cattle, focused on identifying animals with superior carcass traits and feed efficiency. The CBV is tailored towards farmers purchasing growing-finishing cattle, and the traits of greatest economic importance for these systems with high heritability are included.

All commercial male and un-calved females bred from the suckler and dairy herd, which have a recorded sire will have a CBV. Based on animal type (suckler, dairy × beef and dairy × dairy), cattle will be allocated a 'star' rating depending on their CBV value relative to the population of their respective animal type, from one- to five-star, with one-star representing the bottom 20% and five-star representing the top 20%. Table 1 outlines the threshold CBV values for each star rating across each animal group. The CBV is available on your ICBF HerdPlus account, from where you can view your eligible animals profile and generate a report, and will be available on mart boards. Farmers should request this information when purchasing cattle.

Table 1. Threshold commercial beef values (CBV) per star rating and animal type

Star rating	Suckler	Beef × dairy	Dairy × dairy
***** 5-star	>€302	>€124	>€44
**** 4-star	>€265	>€79	>€30
*** 3-star	>€228	>€61	>€18
** 2-star	>€178	>€44	>€1
* 1-star	<€178	<€44	<€1

Based on analysis from the Grange dairy-beef research herd over the last three years, five-star CBV beef × dairy steers produced a 22 kg heavier carcass at a younger slaughter age (four days) compared to one-star animals, when reared on an 'intensive' grass-based production system. The CBV will play a role in the selection of suitable calves/ weanlings for dairy-beef and weanling-to-beef systems, as they are generally traded at a young age and marketed off their potential, which is often hard to predict using traditional selection tools.

To improve the marketability of progeny from the dairy and suckler herd by maximising their CBV, farmers should use high-merit sires from the Terminal Index and Dairy Beef Index (DBI), paying particular attention to carcass and feed intake sub-indices within each. As genetics are both permanent and cumulative farmers aiming to maximise the CBV of their calf crop should ensure balance with other non-carcass traits of importance to the breeding herd, as the selection for slaughter traits can be antagonistic to these traits. In choosing suitable sires the Terminal and DBI indexes achieve this balance of calving, carcass and efficiency traits, in a configuration such as that outlined in Figure 1.

Figure 1. Relative emphasis of different categories of traits in the Terminal Index (left) Dairy Beef Index (DBI) (middle) and Commercial Beef Value (CBV) (right).

Breeding a 'balanced' cow

The Replacement Index estimates the suitability of an animal's daughters, to produce a high beef merit 'replacement' for the suckler herd as efficiently as possible. There are 17 traits included in the Replacement Index, split between 'cow' traits (71%) and 'calf' traits (29%), in order to identify low maintenance suckler cows that are fertile and have a good calving and milking ability, yet can breed progeny with superior carcass and feed efficiency traits. Analysis of data from farms participating in the BEEP-S scheme found as the Replacement Index of cows increased, cow live weight reduced, yet calf weaning weight increased. **Nationally five-star suckler cows are 24 kg lighter, but wean calves 8 kg heavier than one-star cows on the Replacement Index, improving 'weaning efficiency' by 3%.** Fertility traits are the most important for profitable suckling systems, but are under the least genetic control, meaning the roles of breeding management, nutrition and health largely determine the level of reproductive efficiency on farms.

In suckler cow production systems mean calving date is targeted for early-spring to coincide with the start of the grass growing/grazing season and facilitate early-turnout to pasture. Where mature spring-calving suckler cows are in good body condition score (BCS) (3.0+, Scale 0-5) at the start of the winter their feed energy intake can be restricted so that some of the body fat reserves are utilised to reduce winter feed requirements. This feed energy restriction can result in a feed saving of up to 25%, equivalent to 1.0 to 1.5 tonnes fresh weight of grass silage. However, if cows are not in good BCS at the start of the winter, they cannot be restricted and must be fed to requirements. This particularly applies to first-calvers and old/thin cows.

Beef cow fertility, and more specifically the interval between successive calvings, plays a key role in compact spring-calving herds. The BCS of a cow at calving is critical in determining when cows commence oestrous cycles after calving. Good conception rates of 60-70% are achievable to either AI or natural service.

Calving rate plays an important role in maximising output per cow and her contribution to farm output. The goal on suckler farms is to produce a live calf every year, of good 'quality' and achieving good weight for age. The target is to achieve 0.95 calves per cow per year. However, in 2021 nationally the figure was 0.86 calves per cow per year. For a 100-cow suckler herd a calving rate of 0.86 means nine calves fewer being weaned versus the target, representing a reduction in farm sales at similar levels of production costs. This reduction in calving rate can be as a result of infertility, disease, poor nutrition, retaining empty cows and high mortality rates.

Maintaining a healthy herd

Herd health plays an important role in performance on beef cattle farms and is crucial to fertility, productivity and profitability. A proactive approach is essential. Diseases such as bovine viral diarrhoea (BVD) and leptospirosis in herds can have a devastating effect on fertility by increasing the calving interval, calving pattern and cost to the farmer. Get veterinary advice at the first sign of a problem. A herd health plan that includes bio-security, vaccinations and the culling of 'carrier' animals, drawn up in consultation with your vet, is the best way to manage disease problems. Managing a disease outbreak in a herd is significantly more costly and labour intensive than implementing a preventative herd health plan. It is evident that, where there are underlying health issues on a farm, animal performance suffers, output is down and costs increase. Many farms have changed from an approach of reacting to health issues to a proactive approach involving preventative vaccinations to avoid health issues occurring in the first place. Housing is a key area for disease outbreaks on-farm. Good ventilation with clean air moving through the shed to remove gasses, odours, dust and micro-organisms is required. It should also remove the moisture and heat generated by the animals. High calf morbidity and mortality associated with bovine respiratory disease (BRD) results in significant economic loss for farmers. The All-Island Animal Disease Surveillance 2020 indicated that respiratory disease accounted for 33% and gastro-intestinal tract (GIT) infections accounted for 14% of deaths in 0-5 month old calves. Corresponding figures in 5-12 month old weanlings were 40% and 18%. Early diagnosis of disease is essential to ensure good overall animal growth performance and health and to reduce treatment costs.

Grassland - achieving more from less

The ability of beef farms to grow and utilise grass, our cheapest feed resource, is fundamental to the economic, environmental and social sustainability of most beef production systems. Even allowing for differences in local climate and soil types, large variation in annual grass production exists between beef farms, and thus highlights an opportunity to increase grassland efficiency through management. PastureBase Ireland, our national grassland data base, shows that the top-twenty beef farms in 2021 grew 13.9 t dry matter (DM)/ha compared to 7.7 t DM/ha for the bottom-twenty farms, applying 174 kg and 92 kg inorganic fertilizer N/ha, respectively. The top-twenty farms have an increased number of paddocks, good soil fertility and frequently measure grass. Interestingly, these farms are located throughout the country, on a range of soil types and are achieving more grazings per paddock (6.3 versus 4.7 grazings for the bottom-twenty farms) at a pre-grazing herbage mass of 1750 kg DM/ha. Based on the level of herbage produced, the top-twenty farms used a moderate level of chemical N; however, even these farms have opportunity to improve farm gate N balance, which is increasingly important considering rising fertiliser and feed costs and environmental constraints.

Improving soil fertility

In terms of soil fertility, the three key considerations are pH (lime), phosphorous (P) and potassium (K). In 2020 15% of soil samples taken from Irish drystock farms were optimum for these three elements. Consequently grass production and growth response to N fertilizer is constrained on the remaining 85% of farms. Given the rising cost of chemical fertilizers, intensively-managed grassland beef farms should be soil tested regularly to identify any nutrient deficits and facilitate making more targeted applications of chemical fertilizer, slurry/dung and lime. Correcting soil fertility increases the availability of N in soils and improves the persistence of productive herbage species, such as perennial ryegrass and clover. Soil pH affects the availability and uptake of major and trace elements to plants. To maximise grass production, and N, P and K availability the ideal pH is 6.3 for most soils. Liming increases soil pH, and research has found by applying 5 t/ha of lime, to a soil with a low pH of 5.2 resulted in additional 1.0 t DM/ha/annum being grown. There is a low-to-medium demand for P and K on grazing paddocks on beef farms as the majority of P and K removed under grazing is recycled back by grazing animals. In contrast, silage paddocks have much greater offtakes. Organic manures are the cheapest form of fertilizer and should be strategically used to maintain and build P and K levels to index 3. Typically, 1000 gallons of cattle slurry contains 5 and 30 units of P and K, respectively, similar to 1 bag of 0-7-30. The correction of grassland soils from a P index 1 to 3 results in the production of an additional 1.5 t DM/ha/annum from swards.

Managing the grass plant

To achieve a long grazing season, good grazing infrastructure (paddocks, roadways, water, etc.) is necessary to maximise grass growth, utilisation and to help maintain sward quality whilst reducing labour. On many drystock farms the number of paddocks is inadequate resulting in an excessively long residency times. Extended residency times will lead to cattle opting to graze regrowth, contributing to reduced DM production, reduced opportunity for white clover and ultimately poor animal performance due to restricted intake by prolonging the duration for which excessively low herbage mass is offered. The grass plant can only support three actively growing leaves, and if a fourth emerges the oldest leaf will begin to die reducing sward 'quality'. During the mid-season it takes seven days for a grass leaf to appear. To strike a balance between quantity and quality the optimum time to graze is when the plant has 2.5 to 3 actively growing leaves. The number of days it takes to reach the three-leaf growth stage should determine your farms rotation length - this is typically 21 days during the mid-season (3 leaves × 7 days per leaf). Grazing infrastructure facilitates early-spring grazing on beef farms, which can support higher animal performance, helping meet live weight targets as spring grass compared to grass silage is of higher highly digestibility, protein, DM content and energy, with each kg DM having 1.03 Unité Fourragère Viande (UFV; net energy for meat production). In spring, the aim is to maximise the number of animals grazing pasture, while at the same time budgeting to ensure sufficient grass until the start of the second grazing rotation in early-April. This is generally done by turning 'priority' groups of cattle out to pasture first, such as weanlings or cattle intended for slaughter in early summer. The main challenge in mid-season is to maintain sward quality as grass goes through the reproductive growth stage. The target is a rotation length of 18 to 21 days and to maintain pre-grazing 'covers' of 1300 to 1600 kg DM/ha. When grass growth exceeds demand paddocks need to be removed, as high-quality baled silage. Planning for spring grass begins the previous autumn as the majority of grass available for early-grazing has been grown over the autumn/winter months. Over winter the nutritive value of grass usually 'improves', meaning higher levels of animal performance are possible in spring than autumn, so there are many advantages of preserving the supply of autumn grass for use the following spring. To do this farms have to start 'building' farm cover by reducing demand and slowing down the grazing rotation from about mid-August, extending it by 10 days/month until about mid-October when rotation length reaches 45 days. This means that higher pre-grazing covers of 2000 to 2300 kg DM/ha will need to be grazed.

The role of clover

White clover is included in perennial ryegrass mixtures to improve sward nutritive value for animal production and reduce N fertilizer use due to the ability of clover to 'fix' atmospheric N, equivalent to between 50 and 150 kg N/ha/annum. Managing grassland with less chemical N fertilizer input, through greater reliance on biological N fixation by clover can reduce costs (less chemical N fertiliser), reduce GHG emissions, and increase herbage quality. The inclusion of white clover in grazing swards improves herbage quality and promotes higher DM intake, which can lead to increased live weight gain of beef cattle. The contribution of clover to improved sward quality occurs when it exceeds 25% of the sward on a DM basis, which generally occurs from June onwards, and helps combat the decline in grass quality at that time of the year. To promote a high clover percentage, swards should be grazed at covers from 1300 to 1600 kg DM/ha, tightly to a residual height of 4 cm to encourage light to the base of the sward and receive a reduced level of N fertilizer over the summer months. It is important to close clover paddocks late in the year at low covers to encourage light to the base of the sward so as to promote the survival and development of stolons over the winter and increase clover's competitiveness with grass over the following grazing season.

Red clover swards have the ability to fix higher levels of N (150-200 kg N/ha annually) when compared to white clover. The growing point of red clover is more exposed in the sward than that of white clover making it more vulnerable to physical damage from animals and machinery. This means that red clover is less suitable for frequent grazing and is usually established as a 'silage crop'. Red clover swards generally persist for two to four years under a multi-cut system, although well-managed swards can persist somewhat longer. Research at Teagasc Grange found that swards of red clover sown in a mixture with perennial ryegrass and receiving no chemical N fertilizer persisted for six years and, on average, across those years produced a similar annual yield to perennial ryegrass swards receiving 412 kg N/ha when managed under a four-cut silage system.

Balancing winter feed costs and animal performance

Typically, grass silage provides 25-30% of the annual feed requirements of beef cattle. Silage is a relatively expensive feed to produce. Optimising its yield and 'quality' is an important consideration in relation to animal performance and reducing the requirement for purchased concentrates. Beef systems generally consist of multiple animal groups (e.g. suckler cows, weanlings and finishers) which have different nutrient requirements.

Dry suckler cows in good body condition can be adequately fed on moderate quality silage (67% DM digestibility, DMD), whereas higher DMD silages are targeted to growing/finishing cattle and lactating cows. Due to compensatory growth at pasture during the following grazing season, weanling cattle only need to grow at a moderate rate over the first winter, 0.5-0.6 kg live weight/day. Where silage DMD is high (e.g. 75% DMD) this growth rate can be achieved with less than 1.0 kg concentrate/day, whereas when silage DMD is low (e.g. 65%), 1.5-2.0 kg/day of concentrate supplement is required. Similarly, finishing cattle offered silage with a DMD of 70% require 5.5-6.5 kg concentrate daily to gain 1.0 kg live weight /day; to sustain this growth rate, every 1% unit drop in silage DMD requires an additional 0.33 kg/day of concentrate. It is important to conduct a silage quality analysis to provide the preservation efficiency and nutritional plus feeding value, in order to devise appropriate feeding regimes. Commercially, the feed value of silage is predominantly analysed using Near Infrared Spectroscopy (NIRS), which provides rapid results. The reliability of these results is dependent on calibration. Testing systems used should be accredited, with laboratories/operators performing checks against silages with a known laboratory 'wet chemistry' result.

Drafting for slaughter

The selection of cattle for slaughter (drafting) is primarily dependent on their ability to meet market specifications for carcass fat score, which is between 2+ and 4=. Nationally, a relatively high percentage of animals are being slaughtered at excessively high fat scores, representing additional feed days, and associated economic and environmental costs. Studies from Grange have shown no impact on meat eating quality from cattle slaughtered at a 'low' carcass fat score from a pasture-based diet compared to animals with a higher carcass fat score produced on a high-concentrate indoor finishing system. As finishing periods increase in duration, the conversion of feed into carcass reduces, to a point where feed costs exceed returns from carcass gain. It is essential that live weight gain and the level of fatness of finishing cattle are monitored regularly, allowing timely drafting for slaughter. Body condition (fat) scoring, by 'handling' each animal and paying particular attention to the level of fat deposited at the tail head, rump, loin, ribs and between folds of skin, is essential. The 'fleshing ability' of animals will determine the frequency of drafting; this is generally completed every 10 days across research herds in Teagasc Grange.

The implications and options for increased costs on beef farms in 2022

Alan Dillon[1] and Aidan Murray[2]

[1] *Teagasc, Advisory Offices, Gortboy, Kilmallock, Co. Limerick*
[2] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*

Summary

- There will be significant increases in costs on beef farms in 2022; in two worked examples, cost increases of almost 40% are estimated.
- In these examples, increased output prices are unlikely to offset the increase in costs at farm level.
- The first step to managing 2022 is the completion of a financial budget that evaluates the financial performance of the farm during 2022.
- All options should be considered with the major focus on making greater use of grazed grass for the remainder of the year, and finishing animals at pasture prior to rehousing for a second winter.

Introduction

The year 2022 has brought about unprecedented input cost increases, the likes of which Irish farmers have not seen before. Inputs began to rise dramatically in late 2021 with chemical fertilizer prices increasing by €300-€500 per tonne by Christmas followed by further price increases in spring to the point where the majority of fertilizers were costing in excess of €1,000 per tonne. Although the cost of concentrate feed, milk replacer, diesel and polythene also increased over this period, they did so at a much slower rate. Consequently, the impact of these price rises was not initially felt by Irish farmers finishing cattle, rearing calves etc. during the early months of 2022.

Beef prices have also risen considerably; prices rose by over €1/kg carcass between January and May 2022, which has given those farmers finishing cattle over the late spring and summer period a much bigger margin than expected. Assuming an average carcass weight of 350 kg, each animal slaughtered would be earning an additional €350 in May and June compared to January 2022, and nearly €600 per head extra compared to spring 2020.

The main issue facing Irish beef farmers operating various production systems will be beef prices next autumn and spring, and to what extent production cost increases can be covered by beef price rises; ultimately, that is what will determine profit margins for cattle finished in spring 2023. On top of that, what can farmers do now to mitigate the impact of rising costs?

A number of worked examples are outlined in this paper which highlight how various beef systems will fare out in the current environment of record input costs. Our focus is on overall production costs and actions farmers can take to mitigate price rises.

Budgets

Commercial farm performance data and information for 2021 was used for the budget baselines and starting points. For comparison purposes a number of assumptions were made in relation to input levels and price increases on feed, fertilizer, contractor charges and all other associated areas of expenditure within a typical beef farming system. For the purpose of this paper, it is assumed that in 2022 farmers will purchase the same or similar amount of inputs/services as in 2021 but at much higher prices as is currently the case. Calf purchase prices in 2022 for dairy-beef systems were broadly similar to 2021. Fixed costs were assumed to increase marginally overall, with diesel being the biggest increase across beef farms as the increases in electricity costs have a small effect due to relatively low usage.

Budget assumptions

- Meal: €260/tonne in 2021, and €400/tonne for 2022.
- Contractor charges: increase by 25%.
- Fertilizer prices: 2.5 times higher on average.
- Other variable and fixed costs: minor increases.
- Input level: Assumes the same volume of inputs are used on farm.

Dairy calf-to-beef systems

For the purposes of analysis, costs from the Teagasc Green Acres dairy calf-to-beef demonstration farms 2021 Profit Monitor data have been used as the baseline for comparison purposes for the dairy calf-to-beef systems. The 12 farms are located nationwide and encompass a wide range of scale, land type, stocking intensity and calf-to-beef systems, which encompass 24- to 30-month spring-born steer and heifer systems, 19-month bull systems and autumn-born steer systems. Average farm size is 52 hectares (ha) with an average stocking rate of 2.3 livestock units (LU)/ha and live weight output of 608 kg/LU. Within this group there is a range of farm sizes from 24 ha to 92 ha and profitability ranged from €51/ha to €1,342/ha net profit excluding direct payments. From Table 1 it can be seen that the production costs increased substantially, by 37%, in 2022 when compared to 2021.

Table 1. Production cost comparisons for dairy calf-to-beef systems (€/kg live weight, using Green Acres demonstration farm data)

	2021	**2022 (est[1])**
Calf price	0.25	0.25
Purchased feed[2]	0.62	0.95
Fertilizer	0.16	0.40
Veterinary	0.09	0.10
Contractor	0.13	0.16
Other variable costs	0.11	0.12
Fixed costs	0.50	0.55
Total production costs[3] (€/kg live weight)	1.85	2.53
Total production costs[3] (€/kg carcass weight)	3.62	4.95

[1]Estimated based on 2021 quantities for sales and inputs at 2022 prices. [2]Includes milk replacer. [3]Assuming a carcass yield of 0.51 kg carcass/kg live weight.

The biggest cost increases are for fertilizer (+150%), purchased feed (+53%) and contractor charges (+25%). Given the wide range in production systems operated by the Green Acres farmers, the impact of increased costs will differ markedly from farm-to-farm. The spring steer 24-month finishing system and bull beef systems are quite exposed to large cost rises in meal and fertilizer. In contrast, farms where a large proportion of cattle are slaughtered off grass, or where indoor feeding periods are short, are likely to have lower increases in production costs. The programme farmers have been examining ways to reduce inputs. Examples include improving soil pH to increase the efficiency of fertilizer, making high quality silage (>75% dry matter digestibility, DMD) to reduce concentrate feed requirements and, in the longer term, incorporation of both white and red clover to reduce reliance on inorganic fertilizer nitrogen inputs.

Suckler calf-to-weanling systems

Output tends to be more limiting for suckler calf-to-weanling farms with many farmers in this system operating at a low stocking rate (<1.5 LU/ha). Although fertilizer application rates are relatively low, suckler calf-to-weanling systems remain exposed as price increases for weanling sales are limited by the low levels of live weight sold and cow maintenance costs. Profitability has typically been low in this system so any major increase in input costs will require a very large increase in weanling prices to cover additional costs. A typical suckler-to-weanling system, based on a well-managed suckler calf-to-weanling system completing the Teagasc eProfit Monitor, is described in Table 2. Average farm size was 24 ha, with 28 suckler cows and the stocking rate was 1.9 LU/ha. For this farm, the increase in fertilizer prices (+150%) will have the biggest effect on variable cost increases this year if the same quantity is purchased. Concentrate feeding has less impact for most suckler calf-to-weanling enterprises as the quantities purchased are generally small; nevertheless, there is an estimated 53% increase in concentrate costs. Contractor cost increases (+25%) will have a bigger effect on profitability than concentrates in a weanling system as most of these farms will typically have low levels of owned machinery and rely on contractors to carry out most of the intensive field work such as silage harvesting, slurry spreading, reseeding and hedge cutting. Overall, cost increases of 38% are estimated for this system. Weanling prices up to June 2022 have risen by around 15% versus 2021; based on Table 2 this rise may not be enough to maintain profitability in 2022.

Table 2. Production cost comparisons for a suckler calf-to-weanling system (€/kg live weight) using data from a high-performing farm recording data on the Teagasc eProfit Monitor

	2021	**2022 (est[1])**
Purchased feed	€0.08	€0.13
Fertilizer	€0.34	€0.84
Veterinary/breeding	€0.19	€0.21
Contractor	€0.38	€0.47
Other variable costs	€0.24	€0.27
Fixed costs	€0.74	€0.78
Total production costs (€/kg live weight)	€1.96	€2.70
Total production costs[2] (€/kg carcass weight)	€3.56	€4.92

[1]Estimated based on 2021 quantity of sales and inputs at 2022 prices. [2]Assuming a carcass yield of 0.55 kg carcass/kg live weight.

Winter finishing budgets

Teagasc produce winter finishing budgets each year to provide an indication of costs and margins attainable in these systems (Table 3). The price of 'store' cattle in 2022 is approximately 40-50 c/kg live weight greater than 2021. Variable and fixed costs have increased by 50% and 42%, respectively. Overall, based on the assumptions in this analysis, total production costs have increased to €6.12/kg carcass weight. Clearly, it would be prudent to have a contract with processors to de-risk winter finishing systems.

Table 3. Production cost comparisons for Teagasc Winter Finishing budgets

	2021	**2022**
Purchase weight (kg)	530	530
Purchase price (€/kg live weight)	2.55	3.04
Cost of store (€/head)	1352	1611
Total variable costs (€/head)	389	584
Total fixed costs (€/head)	96	136
Total costs (€/head)	1,837	2,297
Carcass weight (kg)	375	375
Total production costs (€/kg carcass weight)	4.90	6.12

Managing through 2022

As we are now over mid-way through 2022, possibilities to 'remove' costs from beef production systems are reducing. However, it must be recognised that there are options that can be taken on board – doing nothing is not an option. The first and most important step for any farmer is to get an understanding of the impact of the cost changes on the farming operation, and from there necessary decisions can be taken to reduce the exposure to the increased costs. The overall budgeting process should ensure that all options are evaluated for the farm as a whole and may signal that longer term diversification will be needed. As can be seen from the budgets shown in Tables 1, 2 and 3, production costs have increased considerably in 2022. The next section of the paper will detail some of the options possible for farmers but should not be viewed as the only alternatives; rather the objective is to prompt discussion and consideration of options.

(a) Cost focus

As outlined in the budgets there is a dramatic increase in the costs of production, with the sale price increase not counteracting the increase in costs. In the dairy calf-to-beef budget, costs have increased by 37% with feed and fertilizer accounting for most of the increases. Similarly, in the suckler calf-to-weanling system, costs have increased by 38% with feed and fertilizer again being the main driver of cost increases. The increases are dramatic and require a clear focus on cost control. In the analysis we assumed the same level of inputs however, in practice, the impact of these price increases will have been to reduce inputs and in particular fertilizer use on beef farms. Ideally, this would be facilitated by soil testing and particularly addressing soil pH levels where required. Concurrently, soil test results can be used to facilitate more targeted application of inorganic fertilizers with the objective being to reduce fertilizer application levels. Application of fertilizers can be further reduced by grass budgeting and matching application rates to grass and grass silage availability and demand.

Using cheaper forms of fertilizer (switching from CAN to protected-urea to meet nitrogen fertilizer requirements) can also lead to significant savings. Key to ensuring costs are reduced in 2022 on beef farms is increasing grazing 'pressure' to increase grass quality and utilisation, while at the same time increasing performance from high-quality grass, thus reducing purchased feed requirements. Long-term, the strategy should be built around ensuring soil fertility is optimised, as well as through the incorporation of clover into the swards.

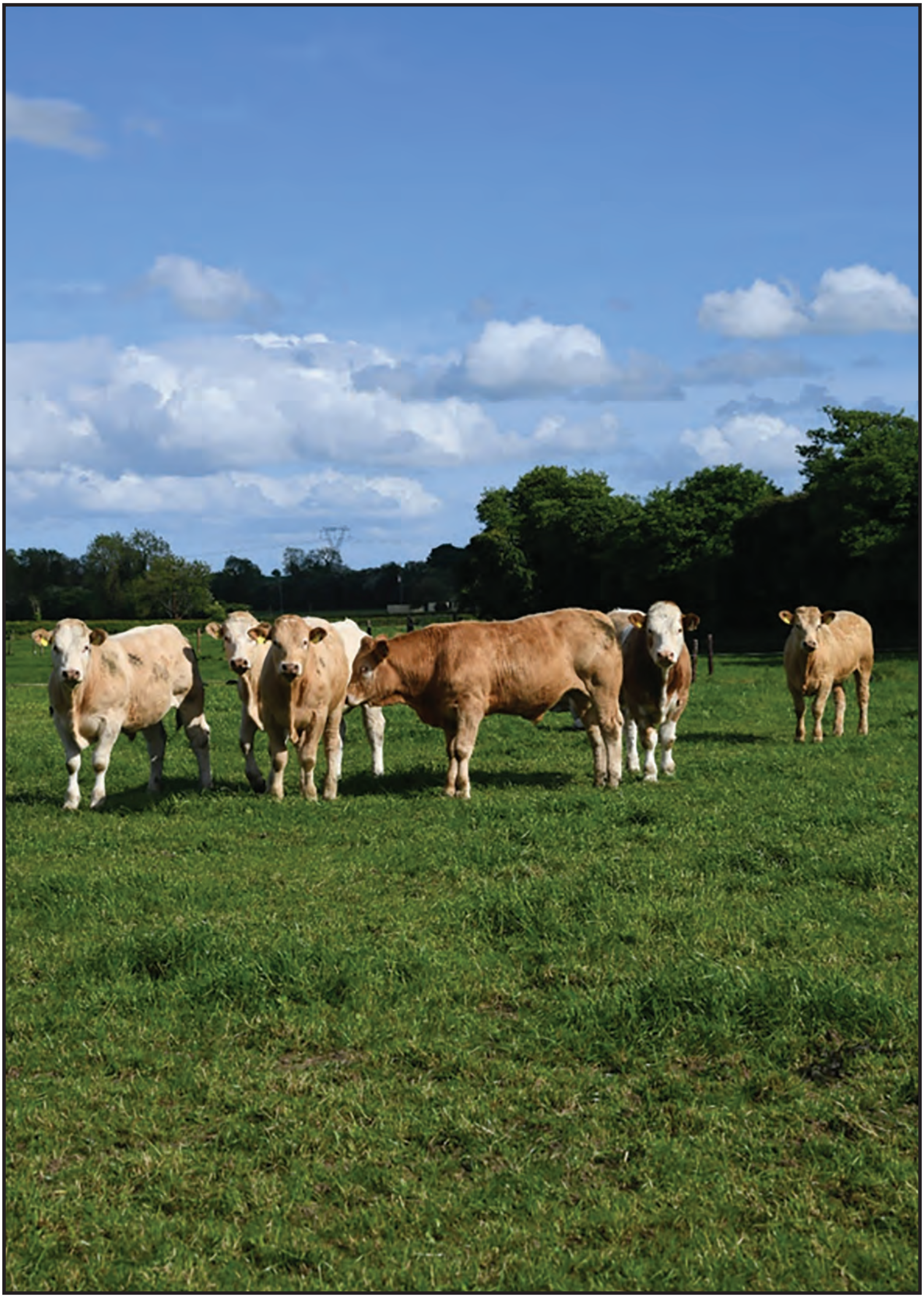
By consulting with agri-input merchants and processors you may get a better picture of where costs and beef prices are likely to go. Along with your adviser complete a partial budget before making any decisions. It will help you examine costs against potential outputs.

(b) Earlier sale of finishing cattle

Weanling sales are commencing and this is providing some indication for suckler calf-to-weanling systems of prices that can then be factored into budgets. The scenario around finishing spring-born cattle at 24 months of age is less clear. In order to reduce the demand for winter feed and reduce the level of exposure to price volatility and increased feed costs, the opportunity to select a proportion of the animals due to be finished at 24 months of age for earlier slaughter (e.g. at 19-20 months) should be explored. The criteria used to identify suitable cattle for earlier 'finishing' should be live weight and 'condition' (fatness) of the animals. Farmers need to assess if 'forward' stores, particularly heifers, are beginning to build fat 'cover'. Farmers can make a decision to feed these cattle that are 'building up' fat deposits with extra concentrate for a short finishing period, either at grass or in the shed, and slaughter at a younger age. Live weight needs to be assessed also before farmers decide on feeding cattle to finish. Farmers are advised to weigh all forward stores now. The advantage of finishing these animals before the 'second' winter includes reduced requirements for silage and expensive concentrate, as well as having a clearer picture of factory prices. On a heifer or steer system, finishing off grass as opposed to out of the shed will reduce feed costs by €1.20 - €1.50/head per day. It could be expected that carcass weight will reduce as a result of this earlier finish; however, the objective is to reduce costs to a greater extent than any reduction in carcass value.

(c) Selling poor-performing high-value animals

Current cull cow carcass prices are at unprecedented levels. In 2022, an option is to identify high-value but low-performing suckler cows to be removed from the herd. For example, there is little justification for retaining non-pregnant cows post-weaning. Furthermore, cows with functionality issues (e.g. udder problems, lameness), docility problems or weaning light calves should be identified for culling. A further consideration for many farmers will be the genetic merit of their herd and in particular older cows; cows that have lower genetic merit are likely to carry inferior genes for suckling systems and this can also be a factor included in culling decisions. These animals could potentially be replaced with heifers of higher genetic merit that will calf at two years of age. The advantage here is that there is a reduction in feed demand as younger/smaller animals will require less feed and the animals that they are replacing currently have a very high economic sale value.



Technology Village

ENVIRONMENT

The Signpost Programme: meeting our greenhouse gas emissions targets to 2030+ on beef farms

Siobhán Kavanagh[1], Tom O'Dwyer[2] and Seamus Kearney[2]

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

Summary

- The main technologies that farmers are being asked to adopt to reduce greenhouse gas (GHG) emissions are those that reduce costs and/or improve profitability while also reducing emissions.
- These technologies include:
- Improving breeding performance through increasing replacement index, reducing age at first calving and increasing calving rate.
- Reducing age at slaughter.
- Implementing a herd health plan.
- Increasing days at grass.
- Using protected urea to replace CAN and straight urea.
- Reducing chemical nitrogen use through improved soil fertility and in particular liming, optimising the use of organic manures and incorporating clover into grassland swards.

The Signpost Programme

The Signpost Programme, led by Teagasc, is a collaboration of farmers, industry, state organisations, farm organisations and media all working together to support and enable farmers to farm more sustainably. The main focus of the programme is to reduce greenhouse gas (GHG) emissions but also to improve water quality and enhance biodiversity on Irish farms. The Signpost Programme is taking a holistic view of sustainability, encompassing economic, social and environmental sustainability.

There are 3 main pillars to the Signpost programme

1. The 117 Signpost demonstration farmers are central to the programme and will point the way forward for all farmers. These farms are made up of a number of conventional and organic beef, dairy, sheep and tillage farms, as well as, pig farms and agricultural colleges. These farmers will be the 'early-adopters' of the technologies to reduce GHG emissions and provide the necessary support and enable farmer to farmer learning at a local level.
2. The Signpost Advisory campaign is the second element of the Signpost programme. The Signpost Advisory campaign is supported by Teagasc Advisory and Education staff as

well as industry and private advisers. The programme is being delivered via a network of discussion groups, events, one-to-one consultations as well as media – traditional and digital. Farmers have the opportunity to track the progress of their own local Signpost Farm and be supported to make a change to how they farm to reduce gaseous emissions. The education of the next-generation of farmers as well as training of all farmers is a key priority of this programme over the next couple of years.

3. Teagasc has established the National Agricultural Soil Carbon Observatory to provide the knowledge required on soil carbon sequestration. The Signpost farms will be an integral part of this Observatory. Deep soil samples are being taken on the Signpost farms to establish baseline soil carbon levels, with the sampling process repeated in a number of years' time to monitor any changes. In addition, flux data from long-term eddy covariance towers will provide detailed information on carbon exchange at an ecosystem level; these towers will be located on a subset of the Signpost farms. Biodiversity will be an important element of Farm Sustainability Planning, with key actions to be undertaken on each farm outlined in the Plan. It is also envisaged that a LiDAR survey will be undertaken on each Signpost farm at the start and end of the Programme so that carbon sequestration in hedgerows can be quantified.

If you wish to become engaged with the Signpost Programme check out **www.teagasc.ie/signpost** and signup for the monthly Signpost e-newsletter.

Current Technologies to reduce emissions

There are a suite of technologies currently available to beef farmers to reduce our greenhouse gas emissions. The key technologies available to beef farmers include:

1. Improved animal breeding performance

Improving Replacement Index

Improving the Replacement Index of breeding females results in better fertility, improved efficiency and consequently reducing GHG emissions from non-productive animals.
Research work has demonstrated that 5-star animals improved profitability by €55 / animal, compared to 1-star animals. Additionally, 5-star animals were 10% more carbon-efficient than 1-star animals.

Younger age at first calving

Suckler herds in Ireland have an average age at first-calving for replacement heifers of 30.5 months. The top 10 % of herds achieve an average figure of 26 months. Compared to a heifer calving at 24 months, older heifers at first-calving have greater total lifetime emissions. The higher emissions come from enteric fermentation, feed energy and manure management, storage and spreading of slurry. There is considerable scope for improvement, nationally.
The economic impact of lowering age at first-calving by one month is estimated at €10 per cow. The impact of age at first-calving is to increase GHG emissions by 0.8% for each month that first-calving is greater than 24 months of age.

Higher calving rate

The national average calving rate for suckler cows is 0.83 calves per cow per year. If a cow does not produce a calf every 12 months, the carbon footprint of that animal increases

because there is less beef produced to 'dilute' the emissions produced, which remain largely the same per cow whether or not a calf is produced.
Improving the calving rate by 5% will increase the profitability of by €49 / cow or €1,960 for the herd of 40 cows. Improving calving rate by 5% will reducing reduce GHG emissions by 3%.

2. Reduced age at slaughter

Finishing animals older at slaughter results in higher lifetime emissions from greater quantities of methane produced, additional emissions from slurry stored and spread and dung and urine excreted during grazing.
The economic impact of increased weight gain is estimated at €0.21 per kg beef produced for an increase of 100g /head / day in lifetime performance. The impact of increased weight gain on GHG emissions is estimated at 2% per 100 g increase in lifetime average daily gain for beef cattle systems.

3. Health

The implementation of a comprehensive health plan will improve the efficiency of the farming system and reduce GHG emissions by improving breeding performance, as well as reducing age at slaughter.

4. Grassland

Increasing the grazing season length lowers GHG emissions. Grazed grass has higher digestibility than grass silage resulting in improved productivity and less energy lost as methane. Also, the ensuing shorter housing period means less slurry stored and less slurry to be applied, resulting in less emissions
It is estimated that for every 10-day increase in days at grass, profit increased by €25 / cow or €1,000 in a 40 cow herd. The corresponding reduction in GHG emissions is 1.7%.

5. Protected urea

Nitrous oxide (N_2O) is a GHG which has almost 300 times more global warming potential than carbon dioxide (CO_2). It is lost to the atmosphere from the breakdown of organic and chemical fertiliser. The spreading of chemical fertilisers including calcium ammonium nitrate (CAN) emit high levels of N_2O. Protected urea is designed to slow the rate at which urea is converted to ammonium, reducing N_2O emissions.
Protected urea is 25-30% cheaper than CAN and grows similar grass yields. Protected urea has 71% lower nitrous oxide emissions than CAN.

6. Reducing chemical nitrogen (N) use

In addition to switching to lower emitting forms of fertilizer, reducing total quantities of chemical N reduces N_2O emissions.
A reduction in N fertiliser of 10 kg per ha will reduce farm GHG emissions by 1% and improve income by €10 / Ha.

How to reduce farm inorganic fertilizer application rate?

- Improving soil fertility and in particular liming
  Soil sampling and the implementation of a nutrient management plan are key to reducing chemical N fertilizer use. Spreading lime to increase soil pH has the potential to release up to 80 kg N from the soil and yield a return of €6-10 for every €1 spent on lime.

- Optimising the use of slurry

  Slurry is a valuable source of fertilizer particularly if it is applied at the right time of the year (spring), using the right equipment (low emissions slurry spreading (LESS) equipment). Spring application captures an extra 3 units N / 1,000 gals of slurry and using LESS contributes an additional 3 units N / 1,000 gals of slurry. Spring application also reduces the storage period and the associated emissions.

  A 20% shift to spring application can reduce farm GHGs by 1.3% while a shift to trailing shoe can lead to a reduction of 0.9% in GHG emissions.

- Incorporating clover

  Incorporating clover into grassland reduces the demand for chemical nitrogen. Therefore, if there is less chemical N fertilizer spread, there is less N_2O being emitted into the air.

  Clover has been shown to 'fix' the equivalent of 100 kg inorganic N/ha from the atmosphere. On suckler farms, profitability increased by 14% for the grass/clover system when compared to a 'conventional' pasture system.

SIGNPOST

Farmers for Climate Action

Strategies to reduce methane emissions from Irish beef production

Paul Smith[1], David Kenny[1], Emily Roskam[1], Marie O'Rourke[1], Alan Kelly[2], Maria Hayes[3], Stuart Kirwan[1] and Sinéad Waters[1]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *University College Dublin, School of Agriculture and Food Science, Belfield, Dublin 4*
[3] *Teagasc Food Research Centre, Teagasc Ashtown, Dublin*

Summary

- Methane is produced during the digestion of feed in the forestomach of ruminant livestock.
- Intensively-finished beef cattle offered a high-concentrate on average produce approximately 230 g of methane per day, equivalent to 22 g of methane for every kg of dry matter consumed.
- A suite of anti-methanogenic additives have been identified using an in vitro rumen simulation technique system. The most promising additives are now being assessed in sheep and beef cattle for their in vivo anti-methanogenic potential and effects on animal production.
- Low residual methane emissions (RME) beef cattle produce 30% less methane but maintain the same level of feed efficiency and carcass output as high RME animals.
- Achieving methane emissions reduction targets for ruminants will require a combination of strategies focused on suppressing methane output.

Introduction

Plant matter consumed by ruminant livestock is digested by members of a microbial ecosystem residing in the rumen (forestomach). However, one group of rumen microbes, known as methanogens, produces methane, a wasteful end product of ruminal feed digestion, which accounts for nearly 60% of Irish agricultural related greenhouse gas (GHG). Methane is a GHG that is 28 times more potent to the environment than carbon dioxide. Voluntary feed intake is the largest contributor to the quantity of methane emitted by an animal. Simply put, as an animal's level of feed intake increases, more feed is fermented in the rumen, which both benefits the supply of energy and protein to the animal, but also elevates the supply of substrates to methanogens (mainly hydrogen and carbon dioxide), leading to an increased synthesis of methane in the rumen. Indeed, a recently-completed Teagasc project, *RumenPredict*, established that for an indoor finishing ration, beef cattle produce, on average, 230 g of methane per day equivalent to 22 g of methane for every kg of dry matter intake.

The immediate implementation of steps laid out in the Teagasc Marginal Abatement Cost Curve (MACC), such as improved grassland management and technical efficiency, has the potential to deliver more than a 10% reduction in total on farm GHG emissions. However, additional methane mitigation strategies are urgently required for the sector. Reducing slaughter age, improved grassland management, dietary supplementation with methane supressing compounds and the breeding of low methane emitting animals are some of the methane mitigation strategies currently being investigated by Teagasc. The most promising mitigation strategies, combined with those already identified with the Teagasc MACC, will be delivered on-farm via the Teagasc Signpost Programme.

Mitigation strategies currently under investigation

1. Reducing age of slaughter

Research at Teagasc Grange is investigating strategies aimed at shortening the time it takes for animals to reach target slaughter weight and carcass fatness. Improvements to the average daily liv weight gain of an animal, can not only be economically beneficial to the producer, but also reduces the quantity of methane emitted over the lifetime of an animal. Indeed, decreasing the age at slaughter from 27 to 24 months, has the potential to deliver a "methane savings" of in excess of 19 kg of methane per animal, over their lifetime. Improved grassland management, the genetic selection of more efficient growing animals and possibly the inclusion of clover and alternative species within the grazing sward, all have the potential to reduce the average slaughter age of Irish beef cattle, and are discussed in more detail in the following sections.

2. Pasture management

Low feed costs are the hallmark of pastoral-based ruminant production systems. However, striking a balance between the quantity and quality of grass produced within the sward can be a challenge. As grass matures, the concentration of fibre increases within the plant which can reduce the digestibility of the grazing sward. A reduction in sward digestibility leads to a notable increase in enteric methane emissions by promoting the abundance of ruminal microbes associated with methane production. Therefore, both good grazing management and the incorporation of more digestible forages within the grazing system have the potential to promote greater average daily gain in cattle, therefore reducing days to slaughter and consequently the quantity of methane emitted over the lifetime of an animal. Incorporating white clover into perennial ryegrass (PRG) dominated swards or including it in multi-species swards, decreases the chemical nitrogen requirements of the sward thereby reducing costs and nitrous oxide emissions. Some studies have demonstrated the methane reduction potential of both white clover and multispecies mixtures primarily as a result of higher sward digestibility. Furthermore, clover, plantain and chicory contain plant compounds which potentially have negative impacts on the activity of ruminal microbes involved in the production of methane. Research at Teagasc Grange is currently investigating the implication of including white clover in PRG-dominated swards and in multi-species swards on the methanogenic output of beef cattle over the grazing season and as well as evaluating ensiled PRG/clover and multi-species sward mixtures over the indoor winter period. Laboratory-based experiments will examine the effect of multispecies compared with PRG dominant swards on methane emissions using the artificial rumen simulation technique (RUSITEC) system, and this will be followed by a large study with beef cattle.

3. Dietary supplementation

The addition of fats and other lipids, containing high proportions of polyunsaturated fatty acids (PUFAs) i.e. soya oil and linseed oil to the diet have been proven to reduce the production of methane in numerous studies.

Seaweeds have been a traditional part of animal nutrition for centuries. More recently, the tropical red seaweed, *Asparagopsis taxiformis* has attracted worldwide attention following published reports of reductions in methane emissions of up to 80% when small quantities of this seaweed were added to cattle and sheep diets. While the Irish climate is unsuited for the commercial production of *Asparagopsis taxiformis* researchers at Teagasc Grange are investigating the methane reducing capabilities of indigenous brown and green seaweeds. Over 30 seaweeds have being screened using the RUSITEC system, which simulates the rumen digestive process. The efficiency of a small number of seaweeds with apparent anti-methanogenic properties are currently being assessed in beef and sheep trials.
The synthetic compound 3-nitrooxypropanol (3-NOP) or Bovaer® (developed by DSM) has been widely researched in dairy and beef cattle with methane reductions of >30% observed. When consumed, Bovaer® is broken down into compounds that are already naturally present in the rumen, with its effect on methanogenesis immediate once ingested. It acts by inhibiting an enzyme which is required for the final step in methanogenesis and therefore stops the methane production process. However, the continued suppression of methane synthesis requires a constant supply of the compound in the rumen, with ruminal wash out of Bovaer® known to return emissions to near pre-supplementation levels. This feed additive has been tested internationally under high-input intensive production systems with fewer research studies on livestock fed high-forage-based diets. In February 2022, the feed additive was approved for commercial use in the European dairy industry and was recently shown to reduce methane emissions by approximately 30% in beef cattle offered a grass silage-based diet at Teagasc Grange. Following the results of our study and others, the product will hopefully soon be licenced in Europe for inclusion in beef cattle diets.
Synthetic compounds such as oxidising methane inhibitors developed by industry partners are also being evaluated at Grange. To date, these additives have been assessed using the RUSITEC system, yielding promising results. The most promising formulations of these inhibitors are currently being fed to sheep and beef cattle to assess their anti-methanogenic potential and effects on animal productivity. A major global challenge is the application of feed additives during grazing. We are working closely with industry partners to develop slow-release formulations of their additive for pasture based systems.

4. Breeding

The genetic selection of low methane emitting animals has long been advocated as mitigation strategy for the ruminant livestock industry. Indeed, recent data from Teagasc Grange and ICBF has highlighted a 30% difference in daily methane emissions between beef cattle of similar breed, age and diet. Therefore, there is significant potential to harness the genetic variation for methane emissions that exists within the national herd, to bring about permanent and cumulative reductions in the methane output of future generations of livestock, via implementation of a low methane emitting breeding programme. Indeed, the breeding of more feed efficient and faster growing animals has great potential to decrease the lifetime emissions of beef animals. Until recently, the development of a national low methane emissions breeding programme had been limited due the lack of technology available to measure emissions from large cohorts of animals within a commercial setting. However, with the advent of the GreenFeed Emissions Monitoring System (Fig. 1), it is now practically feasible to estimate methanogenic output of individual animals, both at pasture and indoor feeding conditions. Equally, the strong correlation between feed intake and daily methane emissions had traditionally limited the breeding of low methane emitting animals for fear of negatively impacting feed intake, which is a key driver of animal productivity, particularly in forage-based production systems. Nonetheless, the recent collaboration led by Teagasc in partnership with ICBF and UCD has identified the residual methane emissions (RME) index as the optimal metric for disentangling the relationship of daily methane emissions with feed intake.

Figure 1. The first GreenFeed Emissions Monitoring System used to estimate enteric methane emissions at the ICBF Progeny Performance Test Centre in Tully (Co. Kildare).

Residual methane emissions can be described as the difference between methane emissions predicted for an animal based on its body size and feed intake and that which it actually produces. At the ICBF National Progeny Performance Test Centre in Tully (Co. Kildare), individual RME values were calculated for 282 crossbred beef cattle (steers and heifers) undergoing a 90-day finishing period with detailed measurements of methane output, feed intake, growth rate and carcass output collected. Animals were ranked as high (undesirable) and low (desirable) in terms of RME. Low RME animals (efficient) produced, on average, 30% less methane, despite having the same feed intake, feed efficiency, growth and carcass output as their high (inefficient) ranking RME contemporaries. Results highlight the potential to breed more environmentally sustainable animals, while at the same time not having a negative impact on the animals' performance, and indeed profitability. Further work is currently ongoing to study the underlying biology of the trait in an effort to potentially incorporate RME into the national breeding indices for Irish beef cattle.

Conclusion

Supressing the quantity of methane emitted by an animal and improving both the growth rate and feed efficiency of livestock, will be the most effective path towards achieving the agricultural sectors target of a 10% reduction in enteric methane emissions by 2030. While the reduction targets are challenging, research currently under way in Teagasc Grange, in collaboration with industry partners, aims to develop a suite of dietary and animal breeding methane mitigation strategies as well as production system modifications for better technical efficiency for the sector. The cost-effectiveness and overall impact of each methane mitigation action will be evaluated through the Teagasc MACC with the delivery of the most economical and promising mitigation strategies to the industry facilitated by the Teagasc Signpost programme.

Gaseous nitrogen losses in agricultural sources and mitigation

Dominika Krol, Gary Lanigan, Rosie O'Neill, Ali Sultan Khan, Maxwell Owusu-Twum and Karl Richards

Teagasc, Environment, Soils and Land Use Department, Johnstown Castle, Co. Wexford

Summary

- Nitrogen lost into the atmosphere causes environmental pollution and represents loss of valuable on-farm nutrients.
- Ways to reduce these losses are:
  - Spread slurry using low emission spreading methods.
  - Switch to low-emission fertilizers such as protected urea.
  - Correct soil fertility and include clover in grassland swards.
  - Increase nitrogen-use efficiency and reduce fertilization accordingly.
  - Breed for more efficient animals.
  - Reduce the crude protein content of the animal diet to avoid excess nitrogen loss.

Introduction

Agricultural emissions to air are divided into two main categories - greenhouse gases and air pollutants (Figure 1). Greenhouse gases have a negative impact on climate change and agriculture contributes 36% of our national emissions. The gases are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). In agriculture, the first two are the most important. Methane represents around two-thirds of all emissions and nitrous oxide the remaining third. When it comes to emission sources, nearly 60% come from animals and 30% from soils that were fertilised by manures or synthetic fertilizer or animals grazing pasture. The remaining 10% comes mainly from management of animal manures like housing during indoor feeding periods and slurry storage. The Climate Action and Low Carbon Amendment Act 2021 seeks to reduce Irish greenhouse gas (GHG) emissions by 51% by 2030 with agriculture set a reduction target of between 22% and 30%. Achieving these targets pose significant challenges for agriculture across the island of Ireland, especially in the context of sustained economic and GHG emissions growth since 2011.

The other type of emissions are air pollutants like ammonia. Ammonia is a gaseous form of N which can significantly reduce the N available for grass growth when lost from N fertilizer and slurry. Ammonia negatively impacts on human and animal health, while also damaging ecosystems. Ireland has committed to reducing ammonia emissions, however, we have been exceeding our EU targets in recent years. In Ireland, agriculture is responsible for 99% of all ammonia emissions so any national reduction will have to come from agriculture, primarily from how we manage our N fertilizer and slurry. Ammonia comes mainly from management of animal manures (housing, slurry storage and land spreading) but also from grazing animals, and finally from spreading of synthetic fertilizer.

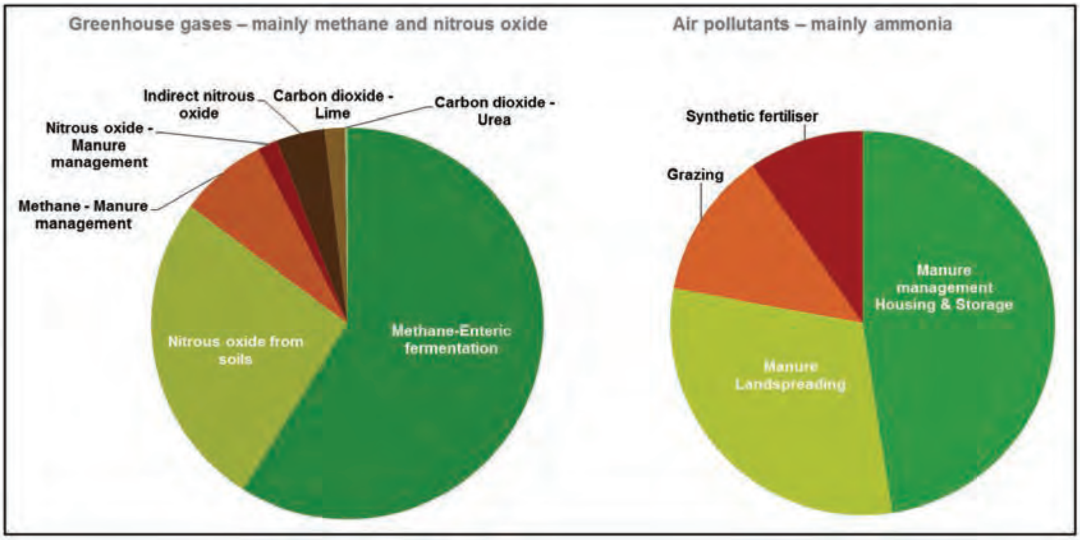


Figure 1. Gaseous emissions from agricultural sources.

Solutions to emissions - suite of GHG and ammonia mitigation measures

Teagasc assessed a number of options to reduce nitrous oxide and ammonia emissions on Irish farms using Marginal Abatement Cost Curves (MACCs; Figures 2 and 3). The MACCs compare options based on cost to implement at farm level and their effectiveness at reducing emissions. MACCs indicate that there are many measures to reduce emissions while improving on-farm efficiency and profitability.

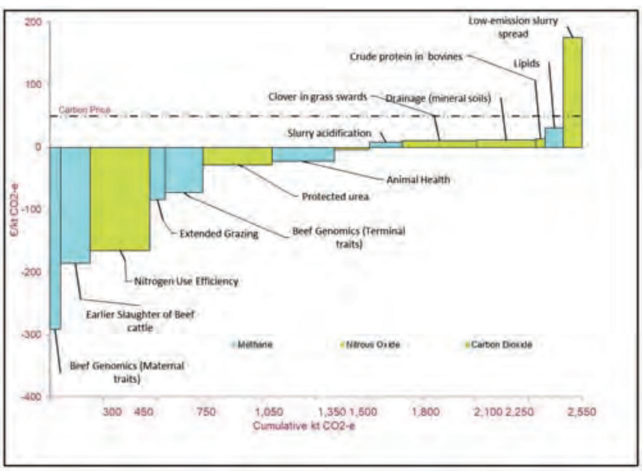


Figure 2. Cost and abatement potential of greenhouse gas mitigation from Irish agriculture. From https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf

Table 1 simplifies the MACCs presenting a suite of 'win-win' solutions that can easily be implemented and deliver good results for GHG and ammonia mitigation. Improvements in beef genomics, including improving maternal traits (such as higher fertility) or terminal traits (such as improved live weight gain) as well as improved animal health can reduce the carbon footprint of beef whilst also enhancing profitability. Other measures such as extended grazing, and reducing the age of slaughter by one month can provide benefits mainly through reducing animal methane emissions. Other presented measures focus on N use efficiency and resultant N losses. Optimization of soil fertility and inclusion of clover in grass sward, including as a component of multi-species swards, allow for lower N fertilisation rates without a yield penalty. Similarly, choosing fertilizer sources such as protected urea substantially reduce N losses to the air while sustaining quantity and quality of yields.

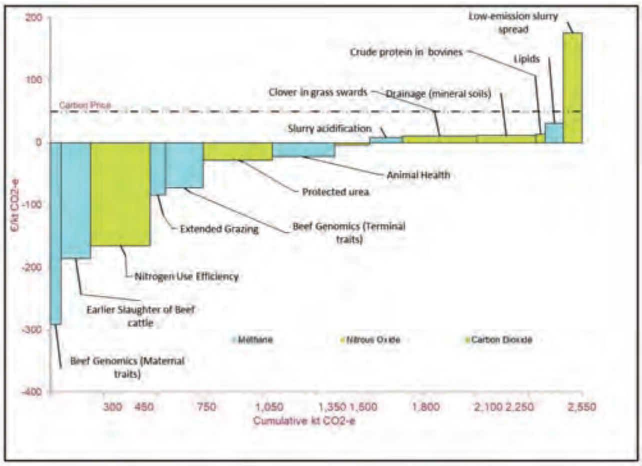


Figure 3. Cost and abatement potential of ammonia mitigation from Irish agriculture. From https://www.teagasc.ie/media/website/publications/2020/NH3-Ammonia-MACC.pdf

Remaining measures focus on manure management, either through extending animal grazing season and thus reducing quantity of animal manure being stored and land spread, or through mitigating emissions during storage and land spreading by using slurry additives or low emission spreading technologies. The mitigation of N losses during storage and land spreading results in a higher retention of N, which can then support plant growth. Reducing the crude protein of animal rations reduces farm input costs, while also reducing ammonia emissions. Protected urea and low emission slurry spreading (LESS) are the two most effective options to reduce ammonia emissions and can deliver up to 80% of the reduction required to meet our EU ammonia targets.

Table 1. Various measures mitigating greenhouse gas and ammonia emissions

Mitigation measure	Greenhouse gases	Ammonia
Dairy EBI	✓	
Animal health	✓	
Nitrogen use efficiency	✓	✓
Clover in sward	✓	✓
Protected urea	✓	✓
Soil fertility	✓	✓
Extended grazing	✓	✓
Low emission slurry spreading	✓	✓
Slurry additives	✓	✓

Recent research into reducing gaseous N losses and improving farm sustainability

Work carried out in Teagasc, Johnstown Castle shows that a long-term low soil phosphorus level results in high N_2O emissions from N fertilizer application. When applied to grassland low in soil phosphorus, N is not incorporated into plant biomass and is lost to the environment. This highlights the importance of discerning exactly what is limiting the system as in this case any applied N is a waste because it cannot be recovered in herbage yield and results in both financial losses and environmental damage. Such N loss occurs regardless of the form of N-fertilizer and the application rate (potassium nitrate, ammonium sulphate, ammonium nitrate, urea and high or low application rates.)

Recently published research from Teagasc Johnstown Castle shows that N_2O emissions from fertilizer applied to soils, which are at the upper end of the recommended agronomic range, are reduced by 39%. Therefore, farmers who improve soil pH for agronomic benefits, can also reduce N_2O emissions. This represents a 'win-win' for the farmer and the environment.

Current research into reducing gaseous N losses and improving farm sustainability

Teagasc Johnstown Castle is carrying out a number of research projects seeking to improve our knowledge of processes and quantification of gaseous N losses, as well as investigating new and novel ways of mitigating emissions.

- *Abating Ammonia in Agriculture:* This project seeks to investigate novel strategies for abating ammonia emissions to add to a suite of options available to Irish agriculture. The research will produce reliable emission factors associated with slurry spreading techniques and amended slurries during storage and after land spreading to improve national accounting of mitigation. The socio-economic barriers hindering the adoption of ammonia abatement measures will also be investigated during the project.
- *Environmental and economic sustainability of biogas / biomethane production in Ireland through anaerobic digestion of slurry and various grass feedstocks:* Research at Teagasc Johnstown Castle is looking into greenhouse gas and ammonia emissions associated with using digestate as fertilizer for grasslands, while also exploring the agronomic performance of those grasslands.
- *Land-Use, Agriculture and Bioenergy Measures for the Abatement of Climate Change and inclusion in Marginal Abatement Cost Curve*: This project seeks to build on the previous MACC and quantify mitigation associated with a range of new measures that reduce N_2O emissions, enhance carbon sinks via land-use and displace fossil fuel emissions via closed farm nutrient loops using enhanced production of bio-based products. This research will refine emission factors nationally so that the mitigation measures can be incorporated into national inventories and enable farmers to receive credit for emissions reduction. It will also evaluate the economic and mitigation consequences of incorporation of abatement measures into production systems and help develop farmer decision support tools. The project will focus on knowledge transfer and the delivery of timely messaging and demonstration to farmers using the Signpost farms programme. The project will generate new projections of GHG emissions out towards 2050 and a new MACC analysis will be generated incorporating the new measures evaluated in this project and other current and future projects to identify the pathways for agricultural to become climate neutral by 2050.

Agricultural sustainability support and advisory programme (ASSAP)

Noel Meehan[1], Méabh O'Hagan[2] and Fiona Doolan[3]

[1]*Teagasc, Deerpark, Ballinasloe, Co. Galway.*
[2]*Teagasc, Slane Road, Drogheda, Co. Louth.*
[3]*Teagasc, Friary Road, Naas, Co. Kildare.*

Summary

- Ireland has been set a target by the E.U. Water Framework Directive (WFD) of achieving at least 'Good Status' for all waters.
- The River Basin Management Plan for Ireland sets out Ireland's plan to achieve this target.
- The ASSAP service is available to farmers in 190 Priority Areas for Action (PAAs) and is a key part of helping achieve WFD targets.
- The ASSAP is a free and confidential advisory service available to all farmers in a PAA.

Introduction

Under the Water Framework Directive (WFD), Ireland is required to prepare river basin management plans to address national water quality issues every six years. Ireland's second cycle river basin management plan was published in April 2018. Its key innovation was a change in philosophy to move away from dependence on the regulatory-based 'one-size-fits-all' approach, towards being more collaborative, and identifying and implementing 'the right measure in the right place', whilst supporting local communities to get involved in protecting their water resources.

As part of this new thinking, the Agricultural Sustainability, Support and Advisory Programme (ASSAP) was established in a collaborative process between the state and the dairy processing co-operatives, to provide an evidence based approach to agri-pressure identification. This programme, working with the Local Authorities Water Programme (LAWPRO), offers farmer-focused advice in 190 priority areas for action (PAAs) and is a critical, integral and parallel part of this collaborative process.

The support received from the Department of Agriculture, Food and the Marine (DAFM), the Department of Housing, Local Government and Heritage (DHLGH) and the dairy industry (Aurivo, Arrabawn, Carbery, Dairygold, Glanbia, Kerry, Lakeland, North Cork, and Tipperary) has facilitated this new approach. Funding from DAFM and DHLGH enabled Teagasc to fund 20 Sustainability Advisors and the Dairy Processing Co-ops have provided funding for 13 advisors as part of the Dairy Sustainability Initiative (DSI) – now known as Dairy Sustainability Ireland.

The ASSAP programme enables local landowners to engage positively in seeking solutions to local problems with the support of a confidential sustainability advisory service focused on water quality improvement. 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.

The aim of ASSAP is to provide a free and confidential advisory service for farmers located in the 190 priority areas for action (PAAs) identified in the national river basin management plan 2018-2021 and to provide farmers with advice focused on the prevention of contaminant losses to waters with a view to attaining water framework directive water quality targets.

Work flow process

Each of the 190 priority areas for action (PAAs) selected for the ASSAP were chosen as they were deemed to be catchments for 'at risk' waterbodies. This means that the waterbodies are at risk of not meeting the Water Framework Directive (WFD) objectives of good or high status. These PAA's were selected as part of Ireland's River Basin Management Plan (RBMP) 2018-2021 and comprise of 726 waterbodies with multiple pressures.

The identification of the PAA's and the establishment of LAWPRO and ASSAP provided the opportunity to implement a local catchment assessment (LCA) process which harnesses existing information and farmer/community engagement in assessing the pressures impacting on a waterbody. The successful implementation of the process to date is based on the strong collaborative effort between LAWPRO, ASSAP and the farming community and this has evolved over time.

The steps of the process are outlined in the graphic below:

Figure 1. Graphic outlining the work flow process for a PAA

Explanation of terms:

Desk study, community and farmer meetings

The LAWPRO catchment scientist undertakes a comprehensive desk study of the PAA which will help to identify the pressures impacting the PAA, the issues and pathways of concern for nutrient, sediment, pesticide and pathogen losses. LAWPRO and ASSAP organise community and farmer meetings to provide initial information on the programme and likely pressures impacting water quality in the PAA.

LCA Fieldwork

The LAWPRO catchment scientist confirms the aspects of agricultural practice impacting the waterbody, i.e. the pressure in so far as is possible. The significant issues are confirmed, (nitrogen (N), phosphorus (P), sediment, etc.), identification of the significant pathway and confirm the reference point in the PAA stream.

Draft referral

The LAWPRO catchment scientist prepares the draft referral for the spatially defined PAA stream reference point. Confirmation of the pressures, issues and pathways, location of reference point, area impacting and an estimate of the number of farms to be visited is provided the ASSAP advisors.

Farm visits

Following receipt of the draft referral, the ASSAP advisors visit the farms in the area identified, based on the PAA stream reference point, to carry out farm assessments. The advisors identify the agricultural practices that are related to the significant issues, (N, P, sediment, etc.) highlighted in the draft referral and recommend mitigation actions to alleviate impacts in consultation with the farmer.

ASSAP feedback & discussion

Upon completion of the farm assessments, the ASSAP provides an anonymised report outlining the issues identified on the farms visited and the mitigation actions recommended and agreed by the farmers. This helps to clarify the accuracy of the draft referral, with amendments added if necessary.

WFD App Referrals

Based on the information gathered and feedback and discussion process the LAWPRO catchment scientist creates a WFD App referral. Please note that the WFD App is a web-based water quality management tool developed by the EPA.

Further feedback and final reporting

A final anonymised report is prepared following a period of follow up visits by advisors and implementation of measures by farmers and consultation with LAWPRO catchment scientists. This is uploaded to the WFD App.

The ASSAP farm visit:

As stated, the advisors will contact farmers based on a referral from LAWPRO. The advisor will offer a free farm visit to assess the farm for any potential issues that are having an effect on the water quality in the PAA stream. In general, an advisor will assess the farmyard, nutrient management practices and general farm land management practices including the use of pesticides etc.

To date, there has been very positive engagement from farmers to the programme with 96% of farmers contacted availing of the service. The majority of the pressures (73%) identified in the PAA's are from the diffuse loss of P, sediment and N. The average number of issues identified across farms is six and the most frequently identified issues are concerned with P and sediment loss to waters by surface runoff, the timing, rates and locations of the application of chemical fertilisers, livestock access to watercourses and streams and the adherence to riparian buffer zones on farms. Figures 2 and 3 provide examples of typical nutrient loss pathways.

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 the farm. The practical advice will be designed to put 'the right measure in the right place' and

Figure 2. Heavy rainfall leads to overland flow of water with potential loss of phosphorus and soil particles.

prevent nutrients and other contaminants from entering water. A written summary of the advice and actions will be provided and a timeframe for completion agreed between them. A series of follow-up farm visits will be required to establish the level of implementation of the measures recommended.

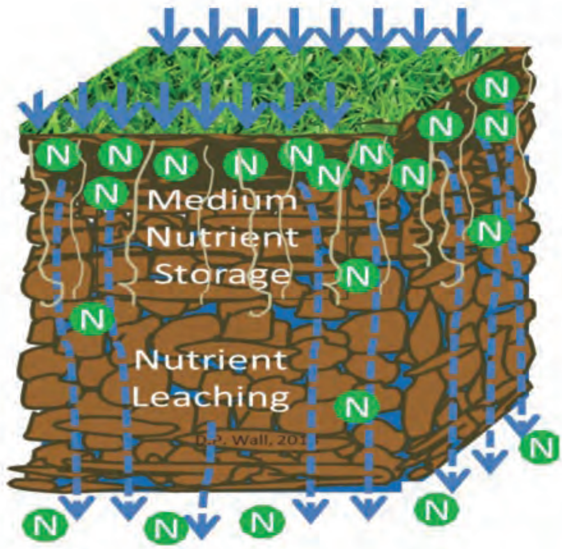


Figure 3. Nitrogen not used up for plant growth is available to be leached to groundwater/streams during heavy rainfall.

Conclusion

The ASSAP programme is collaborative and the funding and support received from DAFM, DHLGH 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.

The scale of the environmental challenges facing agriculture requires action from all industry stakeholders along with government support to reach the standards required. While farmers in the ASSAP have shown willingness to respond to the challenges they require further advisory and financial supports to be in a position to respond adequately to the increasing asks on the sector.

Teagasc Biodiversity Management Practices Self-Assessment Tool: Linear Habitats

Catherine Keena[1] and Jim Kinsella[2]

[1] *Teagasc, Kildalton, Piltown, Co Kilkenny*
[2]*University College Dublin, School of Agriculture and Food Science, Belfield, Dublin 4*

Summary

- The Teagasc Biodiversity Management Practices Self-Assessment Tool: Linear Habitats shows how well the linear habitats on a farm are managed to deliver biodiversity side by side with productive agriculture. The four elements are:
  - Hedges
  - Farming platform structure
  - Field margins
  - Watercourses

Introduction

Biodiversity management practices undertaken by farmers are a key element of farm sustainability. There is a need to include biodiversity management in the assessment of farm sustainability. This paper draws on existing evidence and literature to inform the development of an innovative, affordable, repeatable and rapid assessment tool that measures biodiversity management practice on farms and gives clear messages on Best Practice Biodiversity Management. The tool combines four elements of intensively managed livestock farms, which are of high relevance to biodiversity management, namely: hedges, farm landscape structure, field margins and watercourses (Figure 1).

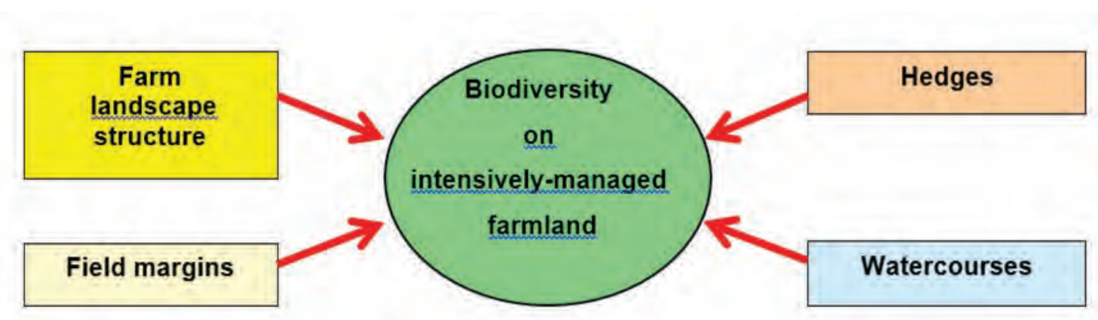


Figure 1. Diagrammatic representation of the characteristics of farms that combine to reflect biodiversity on intensively managed Irish farmlands

In order to effect biodiversity practice change on farms, engagement with farmers is key. A study on biodiversity knowledge exchange with Irish farmers using face-to-face questionnaire-based interviews on-farm concluded that while farmers were positive towards biodiversity, it was not a priority. There was a lack of understanding of biodiversity, requiring effective training. Farm advisors were identified as the key source of environmental information, and along with other farmers and family members, were key influencers of farming decisions.

Hedges

Hedgerow structure is important for biodiversity. There are two distinct hedge types in Ireland. Both types are good, but each requires very different management. A lack of understanding of each hedge type leads to inappropriate management and damage to hedges. Ideally, each farm should have both types of hedges present to maximise biodiversity benefits.

1. Escaped (never-topped) hedge or treeline: Do NOT top. Side trim only
2. Topped hedges: Top to maintain as a hedge – a little above the previous years cut. Aim to grow up to at least 1.5 m and retain a new thorn tree in every hedge

Figure 2. Do not top an 'Escaped hedge' and do not let a 'Topped hedge' escape.

The bigger and bulkier a hedge is the better. A hedge height over 1.5 m provides suitable nest sites for birds with adequate cover above and below their nests. Birds do not nest at the base of hedges where foxes can reach them. Neither do they nest at the top of a hedge, exposed to birds such as magpies or birds of prey.

Flowering hedges provide flowers for bees and fruit and seeds for birds and small mammals. Escaped hedges flower freely with the biodiversity value in their canopy. Topped hedges with a dense base provide great cover at ground level for mammals as well as nest sites. With the recommended regular hedge cutting necessary for maintenance (little and often is recommended), there are few flowers or food on the body of Topped hedges. Retaining occasional thorn trees provide flowers and food. Existing Topped hedges with no mature thorn trees can be greatly improved by selecting individual or clumps of thorns from within the hedge and allow to develop into mature trees. The practice of retaining an occasional new thorn tree every year provides a diversity of tree heights. Songbirds use smaller developing trees which are a metre or so above the body of a hedge as 'songposts'.

Farmed landscape structure

Agricultural landscapes can be viewed as a mosaic of habitats, many linear in nature, within agricultural land. Average field size has the strongest overall effect on biodiversity on intensively managed farmland. The positive effect of decreasing average field size is not due to an increase in cover of natural and semi-natural areas in landscapes with smaller fields. Rather for a given amount of natural or semi-natural cover, farmlands with smaller fields have higher biodiversity. Linear habitats are networks or corridors for nature through the countryside. Their greater edge: area increases habitat diversity. Under the Environment Impact Assessment (Agriculture) Regulations, permission must be sought from the Department of Agriculture Food and the Marine where hedge removal will result in a field over 5 ha. Farmed landscape with average field size less than 5 ha provides networks for nature and corridors of movement for birds, bats, bees and butterflies to move through the countryside.

Field margins

Field margins are a rough grass habitat, which is absent from a lot of intensively-managed farmland in Ireland. Uncultivated and unsprayed field margins allows the rough grass margin to continue undisturbed, protecting the soil biodiversity. Their presence allows grasses and wildflowers to flower and seed, providing habitat for associated invertebrates, birds and small mammals. Birds such as linnet feed on grass seed. There is a high biodiversity value in native plants growing wild naturally. Wildflowers growing wild in unimproved field margins undisturbed and unfertilised for millennia are not to be confused or equated with sowing unregulated packets of flower seed following cultivation and the pre-existing plants (or 'weeds') sprayed-off to make the area look 'pretty' for a short time until the process is repeated. In this latter case, the word wildflowers has been hijacked! We need to maintain our native species of flora and fauna, which have been here for thousands of years and are in tune with each other with regards timing of flowering and other growth stages. Some are inconspicuous – in other words, they may not be 'showy' or attractive to humans. Actions to protect our declining biodiversity must be evidence-based and directed by science, rather than individual preferences. It cannot be about actions that make the landscape attractive to humans, those that are easiest, or about focusing on one species at the expense of others.

Watercourses

All watercourses are important for biodiversity, including small watercourses and drains which are important in their own right, and also important for their influence on larger watercourses. Fenced watercourse banks prevent siltation from eroded banks allow natural bankside vegetation to flourish. Watercourse margins provide further protection for watercourses and allows space for native wildflowers and grasses to grow, providing habitat for associated fauna. Prevention of livestock drinking access to watercourses prevents siltation of watercourses, and protects the habitat for instream biodiversity

Conclusion

Linear habitats comprising hedges, field margins and watercourses are valuable habitats for biodiversity within the farming platform, alongside land managed for agricultural production. Best practice biodiversity management practices on these linear habitats are important. Complete the Teagasc Biodiversity Management Practices Self-Assessment Tool: Linear Habitats for your farm to see how you score (see the next page).

Teagasc

Biodiversity Management Practices Self- Assessment Tool: Linear Habitats

Tick if Yes

Hedge Management

1. Is the height of all your internal hedges at least 1.5m above ground level (or above hedge bank if present)?
2. Is there a flowering thorn tree* in every hedge?

Layout of Farming Platform

3. Is your average field size** less than 5 ha?

Field Margin Management

4. Do you always retain at least 1.5m uncultivated margins when cultivating?
5. Do you avoid spraying within your field margins (except for spot spraying noxious weeds)?

Watercourse Management

6. Are all watercourse banks on your farm fenced?
7. Is there a fenced margin over 1.5m on all watercourses?
8. Do you prevent livestock drinking access to all watercourses?

What is your score? (*TOTAL number of Ticks*)

Target Score = 8

***Flowering thorn tree**
- Escaped hedges (untopped / treelines) naturally contain flowering thorn trees
- Topped hedges may contain individual flowering thorn saplings or trees **IF** retained

****Average field size:**
- Owned land .... ha/No of fields (surrounded by permanent biodiverse boundaries) .... = ... ha
- Biodiverse boundaries include hedges, watercourses, vegetated margins, etc – Not wire fences

*** **Noxious weeds:** Ragwort, dock, thistle, wild oat, male wild hop and common barberry

Food-feed competition and greenhouse gas emissions for beef cattle production systems

Paul Crosson[1], Peter Doyle[1], Mark McGee[1] and Mark Kearney[1,2]

[1]Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath
[2]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4

Summary

- Compared to forage-produced beef, grain-fed beef has distinct advantages including lower greenhouse gas (GHG) emissions intensities.
- However, the quantity of human-edible concentrates utilised in beef systems is being questioned, in part due to the inefficient use of human-edible feed to produce beef.
- Thus, beef production systems must optimize the conversion of non-human edible feedstuff into human food, while generating low levels of GHG emissions.
- Studies at Teagasc Grange have demonstrated the complex interaction of minimising GHG emissions and maximising the efficiency of human-edible protein production.
- Production systems that maximise forage in the diet (grazed grass and grass silage) have higher food/feed ratios; however, GHG emissions are also greater.
- Replacing cereal grains with 'by-products' in animal diets also increases food/feed ratios with a corresponding reduction in GHG emissions.

Introduction

Beef cattle have the capacity to make use of forages and by-product feedstuffs that cannot be consumed by humans, and can therefore contribute to human food security, particularly where human-edible feeds are minimized in cattle diets. However, it has been estimated that one-third of the annual global cereal grain harvest is used for livestock feed rather than as human food. From an environmental sustainability viewpoint, a distinct advantage of grain-fed beef is that greenhouse gas (GHG) emissions intensities tend to be lower when compared to forage-produced beef. While this is an important consideration, consumer expectations also include the net contribution of livestock production to food security and so beef production systems must optimize the conversion of non-human edible feedstuff into human food, while generating low levels of GHG emissions.

A number of studies at Teagasc Grange have evaluated the food-feed ratio of contrasting beef cattle production systems. In these studies, the protein content in 1 kg of bovine meat was based on measured crude protein (CP) in the meat. Similarly, the share of human edible protein (HEP) for each of the ingredients in the concentrate was calculated. The ratio of

HEP produced (i.e. meat) to HEP fed (i.e. concentrate) was quantified. An efficiency greater than one meant that the system produced more HEP than that consumed. Conversely, an efficiency between zero and one meant that the system produced less HEP, than that consumed.

Suckler weanling-to-beef systems

In a study with suckler weanlings, fifty-four spring-born, late-maturing bulls were purchased in October at eight months of age and assigned to one of three production systems; (1) grass silage *ad libitum* plus 1.2 kg concentrate dry matter (DM) per head daily for a 148 days indoor winter period, followed by pasture only for 123 days, re-housed (August) and offered concentrates *ad libitum* plus a minimum of 1 kg grass silage DM per head daily until slaughter at 21-months of age (December) (GRAIN); (2) grass silage and concentrates offered over the first 148 days indoor winter period, followed by pasture only for 196 days, re-housed (November) and offered grass silage *ad libitum* plus 3.5 kg concentrate DM per head daily until slaughter at 24-months of age (March) (SIL+GRAIN)); and (3) offered grass silage only (plus minerals and vitamins) for a 148 days indoor winter period, followed by pasture only for 196 days, re-housed (November) and offered grass silage only (plus minerals and vitamins) for 140 days, and turned out to pasture (March) until slaughter at 28-months of age (June) (FOR). The aim was to slaughter the animals at a mean target carcass weight of 390 kg.

From the start of the first winter to slaughter, the proportion of grazed pasture + grass silage DM in the total diet was 0.61, 0.84 and 1.0 for GRAIN, SIL+GRAIN and FOR, respectively (Table 1). The associated land used for herbage production was lower for GRAIN than SIL+GRAIN and FOR, respectively (assuming fixed animal numbers). This resulted in greater stocking rate and carcass weight gain/ha for GRAIN, than SIL+GRAIN and FOR, respectively. However, due to their higher concentrate intake, GRAIN and SIL+GRAIN were net consumers of food protein/ha, whereas FOR was a net producer of food protein/ha. Emissions of GHG were lower for GRAIN on a carcass weight gain basis but greater on a land area basis than SIL+GRAIN and FOR. The GHG emissions were marginally greater (4%) for SIL+GRAIN than FOR when expressed on a carcass weight gain basis.

The constituent ingredients in concentrate feed rations also has implications for food/feed ratios with the use of 'by-products', e.g. from the brewing, distilling and food industries, in animal rations instead of cereal grains, potentially substantially reducing human food competition. This was quantified using data from a suckler weanling-to-beef study at Grange which involved spring-born steers slaughtered at 19-months of age at the end of their second grazing season having been supplemented with 3.2 kg concentrate DM for the final 95 days on pasture. At pasture a cereal-based (i.e. 86% barley, 7% soyabean meal; Ration 1) concentrate supplement was provided and this was subsequently compared in a desktop study with a concentrate supplement whereby by-products replaced 42% of the barley and all of the soyabean meal (i.e. 50% barley and almost 50% by-products, citrus pulp and dried corn distillers grains; Ration 2), and a concentrate supplement entirely composed of by-products (i.e. citrus pulp, beet pulp, dried corn distillers grains, maize gluten feed and soya hulls; Ration 3). The concentrates were balanced for energy and protein (+ minerals/vitamins) such that no difference in animal performance was assumed. This analysis showed that all systems were net producers of HEP and that Ration 2 and 3 increased the food/feed protein ratio by 1.6 and 4.3 times, respectively, and reduced GHG emissions by 3% and 4%, respectively.

Table 1. Feed consumed, food/feed competition and greenhouse gas emissions of suckler weanling-to-beef production systems (GRAIN = finished on *ad libitum* concentrates at 21-months of age; SIL+GRAIN = finished on grass silage plus 3.5 kg concentrate DM at 24-months of age; and FOR = finished at pasture (forage-only) at 28-months of age).

	GRAIN	SIL+GRAIN	FOR
Feed consumed (t DM/head)			
Grazed pasture	1.01	1.77	2.51
Grass silage	0.85	1.46	1.87
Concentrate	1.18	0.6	0
Food/feed competition			
Human edible meat (kg/ha)	788	424	331
Net protein output (kg/ha)	-452	-85	78
Food/feed protein	0.29	0.53	-
Greenhouse gas emissions (kg CO_2e)			
Per kg carcass weight	16.0	19.8	19.0
Per ha	18,700	12,500	9,300

Dairy calf-to-beef systems

In another study, the effect of alternative dairy-beef production systems differing in respect to age at slaughter and finishing diet were modelled. Production systems incorporated the spring-born steer progeny of early-maturing (EM) sires bred to Holstein–Friesian dams slaughtered at 20-, 24- or 28-months of age. It was assumed that calves arrived on the farm at 10 days of age in March and were treated similarly during the calf rearing stage, the first grazing season and the first indoor winter feeding period. During the second grazing season, steers destined to be slaughtered at 20-months of age received concentrate supplementation for the final three months at pasture before slaughter. Steers destined to be slaughtered at 24- and 28-months of age remained at pasture until October at which stage they were housed indoors. The 24-month finished steers were fed a diet of grass silage and concentrate until slaughter, while the 28-month steers were housed, fed grass silage and returned to pasture at the end of March until slaughtered. The inorganic nitrogen applied to the grazing area for all systems was kept constant for all systems at a rate of 110 kg/ha. The animal performance data was based on studies conducted at Teagasc Grange.

Numbers of animals finished differed substantially with 45% more animals finished for systems finishing at 20-months of age compared to 28-months of age. Live weight and carcass output per ha were also much greater for 20-month slaughter systems compared to 28-month finishing systems. Emissions of GHG per ha were highest for 24-month systems compared to 20- and 28-month old finishing systems (Table 2). The GHG emissions per kg of carcass weight were highest for 28-month systems, followed by 24-month and lowest for 20-month finishing systems. Finishing animals at 20-months of age had the highest net protein output, followed by 24-month system with 28-month finishing systems having the lowest protein output. Human edible protein efficiency was only greater than one for 28-month production systems.

Table 2. Feed consumed, food/feed competition and greenhouse gas emissions of early-maturing dairy calf-to-beef production systems (20M = finished at 20-months of age at the end of second grazing season; 24M = finished at 24-months of age at the end of the second winter; and 28M = finished at 28-months of age during the third grazing season.

	20M	24M	28M
Feed consumed (t DM/head)			
Grazed pasture	2.32	2.72	3.88
Grass silage	0.54	1.20	1.48
Concentrate	0.63	0.83	0.50
Food/feed competition			
Human edible meat (kg/ha)	450	412	326
Net protein output (kg/ha)	109	100	79
Food/feed protein	0.85	0.77	1.40
Greenhouse gas emissions (kg CO_2e)			
Per kg carcass weight	12.1	15.0	17.5
Per ha	8,090	9,150	8,450

Conclusion

Studies at Grange have shown that finishing beef cattle at younger ages, on high nutritive value grazed pasture and receiving concentrate supplementation results in lower GHG emissions per kilogram of carcass basis and also produce higher quantities of beef carcass, human edible meat and HEP. However, from the perspective of protein efficiency (i.e. quantity of human protein produced as a ratio of HEP included in the cattle's diet), slaughtering in the third grazing season with minimal concentrate input over the lifetime is preferred.

A further consideration is that gross protein does not take into account protein 'quality'. For example, digestible indigestible amino acid scores (DIAAS) in the animal product for human consumption is 2.4 times greater than that of proteins in the human-edible plant protein inputs, due to the amino acid composition and its associated bioavailability in beef to meet human amino acid requirements. Accounting for this would improve the food/feed debate in favour of ruminant systems.

A further aspect of food security is the optimal use of 'tillable' land. Due to feed conversion inefficiencies of livestock converting animal feed into human food, the re-allocation of tillable land from animal feed production to direct human food production would considerably increase global food availability. Again, however, the broader 'sustainability' implications must be considered. In this regard, the potential loss of soil carbon from changing land uses is an important consideration. Given the capacity of ruminants to utilize resources (forage and by-products) that cannot be consumed by humans, beef production can make a significant contribution to human food security, particularly when practiced on non-tillable land areas.

The Teagasc Grange anaerobic digestion plant

Paul Crosson[1], Ciara Beausang[1], Sofia Tisocco[1,2] and JJ Lenehan[1]

[1]*Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2]*College of Science and Engineering, National University of Ireland, Galway*

Summary

- The European Commission recently launched the REPowerEU plan which aims to diversify gas supplies, speed up the deployment of renewable gases and replace gas in heating and power generation.
- Biogas and biomethane are renewable energy sources which can be used in any of the three energy vectors, electricity, transport and heat.
- In Ireland, the anaerobic digestion (AD) sector is relatively underdeveloped despite a lot of studies indicating its potential due to the abundance of grassland and cattle slurry, which can used to provide feedstock for AD.
- Teagasc Grange is the site for a pilot-scale AD plant which is currently under construction and due to be commissioned in 2022.
- Research at Teagasc Grange is exploring the environmental and economic sustainability of biomethane from a range of grass silages derived from swards differing in species composition and in the rates of nitrogen fertiliser received.
- This research highlights that the fertiliser inputs and sward type used in silage production are key determinants in the sustainability of biogas production.

Introduction

Geopolitical events in first quarter of 2022 illustrated the challenges European energy policy faces in terms of affordability, reliability of supply, and environmental sustainability, and these events led to the announcement by the European Commission of the REPowerEU plan. The plan seeks to diversify gas supplies, speed-up the deployment of renewable gases and replace natural gas, which is a fossil fuel, in heating and power generation. The European Union (EU) currently imports 90% of its gas consumption, (European Commission, 2022) demonstrating the need to accelerate the clean energy transition in Europe.

Anaerobic digestion (AD) is a multi-step process whereby organic waste and residues are converted into biogas by a group of microorganisms in an anaerobic environment. While biogas could be used as any of the three energy vectors, in Ireland it would be most useful if used for renewable heat or transport. Biogas refers to the gas prior to upgrading, which contains approximately 55% methane (CH_4), while biomethane refers to the upgraded gas, containing approximately 97% CH_4. Anaerobic digestion plants can be fed a wide range of organic feedstocks. There are many suitable feedstocks for biogas production from the agricultural sector, including crops such as maize specifically cultivated for biogas production, animal slurry and manures, as well as waste and by-products from agro-industries.

The biogas industry in Ireland is relatively underdeveloped despite a lot of studies indicating its potential. As of 2019 there were 12 agricultural biogas plants in Ireland, with a further 6 under construction. The potential for a biogas industry derives largely from the abundance of grassland, which can used to grow feedstock for AD, and the significant number of livestock and hence slurry that can be co-digested with grass and grass silage in the AD process. The ultimate goal is to not only increase renewable energy resources but also to promote sustainable development in rural areas, reduce energy costs for farmers and provide the opportunity to increase farm incomes.

Teagasc Grange Biogas Plant

Teagasc Grange is the site of a biogas plant which is currently under construction and due to be commissioned in 2022. The two main components of the plant are:

- Digester vessel: The digester is a 1,625m^3 capacity concrete pre-cast panel (pre-stressed and post-tensioned) tank – 18.63 m internal diameter and 6 m high. The tank wall is fitted with external insulation protected by steel cladding. A dual membrane biogas collection system is fitted on top of the tank. The outer visible dome is made of PVC coated reinforced polyester fabric, whereas the inner gas-proof membrane is made of LDPE. Two submersible propeller agitators are used for mixing the digester contents and are mounted on vertical guiderails. The equipment can be accessed through hatches fitted in stainless steel cantilevered pedestals fixed to the top of the tank's concrete wall panels without the need to de-commission the digester or remove the gas collection system.
- Digestate vessel: The digestate vessel is of similar structure and capacity to the digester vessel with the exception that there is no insulation or cover. The construction allows that a cover can be added at a future date. The digestate tank is mixed by a fixed propeller agitator in the tank wall.

Gas cleaning removes non-desirable gases. Initially sulphur is removed by air addition to the digester vessel headspace. The gas is de-humidified by passing it through a chiller to bring the temperature below its dew point. An activated carbon filter is used for the further removal of sulphur/hydrogen sulphide and carbon dioxide will be subsequently removed to produce bio-methane (98% methane).

Liquid and solid feed stocks are pre-mixed, macerated and homogenised before being fed into the digester vessel. Nominal feedstock mix per day is 10 tonnes (t) of grass silage at 25% dry matter (DM) and 10 t of slurry at 8% DM. The quantities of each will depend on silage 'quality' primarily in respect of dry matter digestibility. A pumped feedstock recirculating loop is used for heating the material through an external heat exchanger. The digester can operate at mesophilic (35-40°C) or thermophilic (55-60°C) conditions.

When fully-operational, expected nominal gas production will be 70 m^3/hour. The bio-methane produced will be pressurised for transport by road tanker to the national gas grid at the injection point in Nurney, Co. Kildare. Alternatively, the bio-methane can be used for natural gas powered trucks with refuelling on site. In addition, the option of using a natural gas tractor on the research farm at Grange will be explored.

Environmental sustainability

The environmental sustainability of biogas and biomethane derived from grass silage is an important consideration. The Renewable Energy Directive (RED) is the legal framework for the development of renewable energy across all sectors of the EU economy. Energy crops,

i.e. crops that are grown solely for energy production, have been shown to fare poorly in sustainability assessments as they often compete with animal feed or human food and induce land use change. The RED also requires that renewable heat and transport fuel have emissions savings of 80% and 65%, respectively, versus their fossil fuel comparators.
Research was conducted at Teagasc Grange to determine the environmental sustainability, in respect of greenhouse gas (GHG) emissions, of bio-methane gas production. The comparative performance of a range of grass silages derived from swards differing in species composition and the rates of nitrogen fertiliser received was assessed with the aim being to identify the sward type with the lowest quantity of GHG emissions per unit of energy produced. The five sward types, yields obtained and the GHG emissions produced in the production of biomethane from each sward are described in Table 1.

Table 1. Sward types, species included, rates of inorganic nitrogen applied and annual dry matter (DM) yield

Species of forage	Nitrogen (kg/ ha)	Annual DM yield (kg/ ha)	GHG emissions (g CO2eq/ MJ)
Perennial ryegrass	120	9,517	39.0
Perennial ryegrass	240	11,443	49.1
Perennial ryegrass and red clover	0	10,771	23.1
Multi-species sward (Timothy, perennial ryegrass, red clover, ribwort plantain, chicory)	0	11,679	23.7
Multi-species sward (Timothy, perennial ryegrass, red clover, ribwort plantain, chicory)	120	12,171	38.4

The lowest GHG emissions per unit of energy generated (g CO_2e/MJ) was from the perennial ryegrass/red clover sward. Regardless of sward type, the stage in the AD process which contributed most to overall emissions was 'fugitive' methane losses from biogas production, which accounted for 35% of total emissions. This methane is lost to the environment due to 'leakage' in the AD process and is, therefore, not available for energy production. This was followed by agro-chemical inputs (20%) and field nitrous oxide (N_2O) emissions (15%). Transport, biogas generation and upgrading accounted for the remaining 30% of emissions. When considering the ability of grass silage to meet the minimum emissions savings under the RED, this research highlights that the fertilizer inputs and sward type used in silage production are key determinants in the sustainability of biogas production. Silage should be produced with minimal inorganic nitrogen to meet the necessary emissions savings. This can be achieved through the incorporation of legumes, such as red clover, or through the use of multi-species swards.

Economic viability of anaerobic digestion

While there is much interest in biogas as a mitigation technology in Ireland, another issue that remains to be addressed is the financial returns. There is limited research on the economics of grass silage and cattle slurry co-digestion for grid injection. Current research at Teagasc Grange is seeking to determine the breakeven price for biogas based on the annual costs and incomes for a biogas plant. The AD system in this study is based on the biogas located at Teagasc, Grange, Dunsany, Co. Meath.

Optimization of anaerobic digestion

Research at Grange is exploring alternative combinations of feedstock in AD with the overall aim being to optimize biogas production. Co-digestion of manure with grass silage provides many advantages in optimizing the AD process. The main ones are an increase in the biogas yield and process stability, increasing the biogas plant's economic viability. Mathematical modelling of the AD process is a powerful tool allowing changes in operating conditions to be simulated and determining which variables are most influencing the biogas and methane yields. For instance, the mix ratio between the feedstocks (grass silage: cattle slurry ratio), the hydraulic retention time (HRT) and the reactor temperature are some of the variables that affect biogas production.

Acknowledgements

Funding from MaREI, the Science Foundation Ireland (SFI) Research Centre for Energy, Climate and Marine received by Dr. Ciara Beausang is gratefully acknowledged.

BovINE - Addressing the sustainability challenges facing all beef farmers

Richard Lynch[1], Maeve Henchion[1] and Kevin Kinsella[2]

[1]*Teagasc, Ashtown Food Research Centre, Dublin 15*
[2]*Agspace Ltd, Kilcormac, Co. Offaly*

Summary

- Beef farmers want to be more sustainable but how can they achieve this?
- BovINE (Beef Innovation Network Europe) was established to identify the needs of farmers in nine EU member states and to respond to those needs.
- BovINE draws on the reservoir of knowledge which exists at farm level under four key themes: socio-economic resilience, animal health & welfare, production efficiency & meat quality, and environmental sustainability.
- Using these themes, BovINE identifies solutions in existing 'good practices' and research findings that have not yet been widely adopted at farm level.
- The feasibility of each solution in practice is assessed through demonstrations on multiple beef farms across Europe.
- All results are easily accessible on the BovINE Knowledge Hub.

Introduction

A European project, known as BovINE (Beef Innovation Network Europe) aims to identify the 'grassroot' needs of the 255,000 farmers that constitute the EU bovine sector and to collectively develop practical solutions by creating an innovation network between the multiple stakeholders involved in the European beef sector. Partners from Belgium, Estonia, France, Germany, Ireland, Italy, Poland, Portugal and Spain are involved in the project, with each partner developing their own national knowledge exchange networks by enlisting beef farmers, farming organisations, advisors, researchers and other stakeholders. These networks are connected across Europe by Teagasc who are the overall project coordinator, with the Irish network being facilitated by the Irish Farmers Association. All nine countries have appointed a network manager to coordinate the multiple stakeholders, to identify both the challenges beef farmers are facing and any potential on-farm solutions that address the needs of other European beef farmers. BovINE has also created a number of working groups which focus specifically on one of four pillars of sustainability; socio-economic resilience, animal health & welfare, production efficiency & meat quality and environmental sustainability. Each working group brings together a range of experts within the European research community to unearth research innovations not yet tested on commercial beef farms.

Challenges and solutions found to date

Each year BovINE identifies priority challenges surrounding the economic, social and environmental sustainability of beef farms across Europe. Farmers and stakeholders in each of the nine countries are consulted through a round of national meetings to record the current challenges they face on a daily basis in making their farms more sustainable. The needs and challenges identified from the meetings form the basis of a 'needs register', related to each of the four thematic areas in BovINE, with two priority topics identified each year (see below).

Socio- economic resilience

- Long-term business planning approaches.
- Tools and strategies to manage for price volatility and cash flow.
- Initiatives to improve beef image and to break with the current trend of consumption decline.
- Economically efficient housing systems for beef cattle.
- Methods to ensure a fairer distribution of the final price along the supply/food chain.
- The use of alternative feedstuffs to reduce the high costs of raw material for feeding.

Animal health & welfare

- The health and welfare of new born calves on suckler farms.
- Lameness of finishing bulls.
- Simple labour-saving tools to measure & communicate high animal welfare standards on beef farms.
- Management, housing & environmental factors which affect animal welfare in rearing & finishing units.
- On farm health check of young stock prior to sale/purchase.
- Training in animal welfare and stress-free haulage systems during weighing and transport of beef cattle for operators/farmers.

Production efficiency & meat quality

- Animal monitoring tools on beef cattle farms.
- The use of available data to improve carcass and meat quality.
- Animal feeding and stress on meat quality.
- Optimizing the number of calves per cow per year in suckler beef herds.
- Tools to evaluate carcass and meat quality prior to and in the slaughterhouse.
- On-farm strategies to increase marbling/ tenderness/colour in beef meat.

Environmental Sustainability

- Reduction of greenhouse gas emissions intensity on beef farms.
- Improvement in water quality and reduction in water use.
- Environmental sustainability reward schemes for beef farmers.
- Carbon sequestration techniques on beef farms.
- Tools for calculating and improving environmental sustainability on beef cattle farms.
- Methods to enhance biodiversity on beef cattle farms without the need for large investment.

Finding practice-ready solutions

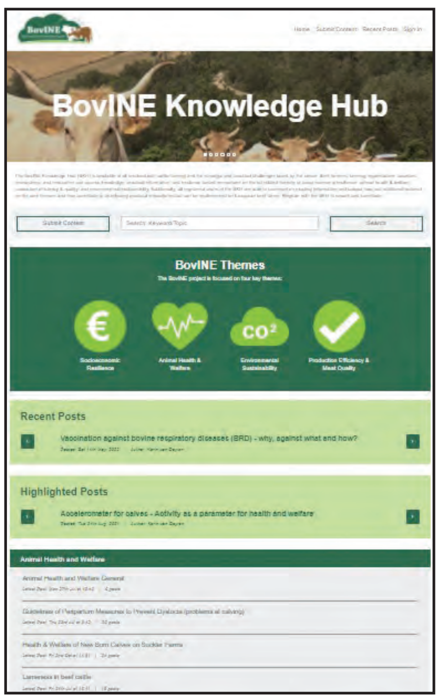
A systematic process is applied to identifying solutions to address the challenges and needs collected, using a two-step approach. Firstly, working groups undertake a review of solutions developed by research but not yet applied at farm level on a widespread basis. These solutions are sourced from both published academic literature and grey literature. Secondly, regional networks identify solutions from on-farm innovations (good practices) that have already been implemented by members of their regional network.

In total, each of the nine regions collect eight 'good practices' each year (one per challenge) resulting in 72 on-farm solutions for sharing throughout the BovINE network. Ten research innovations are also collected per year, (five per challenge) resulting in a total of 40 solutions for sharing.

To further test the feasibility of the solutions found, each country selects a number of research innovations to test in a real farm environment. Results of these are then fed back to members of the BovINE network through reports, video diaries, etc. Some previous demonstrations which have been undertaken have focused on novel techniques for reviving new-born unresponsive calves, feed additives to reduce enteric methane emissions, automated weighing systems and the use of infrared cameras to detect lameness in beef cattle. Cost-benefit analysis of selected research innovations is also undertaken annually.

Central space for sharing solutions

At the core of the BovINE project is a specially developed online digital knowledge repository known as the BovINE Knowledge Hub/ where all the innovations, technologies, useful good practices and reports on demonstrations are stored and shared amongst the European beef farming community. The knowledge hub is free to all with an interest in beef farming and is open to those who not only wish to search for useful solutions but also for anyone who wishes to share their useful tips and practices with others.



BovINE webinars

Additionally, the project is currently running a series of webinars where experts from across Europe discuss some of the novel technologies and innovations the project has unearthed. Some of our previous webinars have focussed on virtual fencing of beef cattle, strategies to reduce methane emissions on beef farms, feed efficiency in beef cattle and tools to measure animal health and welfare on beef farms. All recordings of past and future webinars are hosted on the projects YouTube channel (BovINE videos). Interested parties can also register for these webinars by signing up to the projects mailing list available here.

How to get involved

If you are a beef farmer, advisor, veterinarian or any other stakeholder in the Irish or broader European beef supply chain you can get involved by becoming

a member of the BovINE network. Participants will have access to the most up-to-date farming practices and initiatives, enabling them to identify potential areas for improvement within their own enterprise or organisation.
To become a member of the Irish BovINE network please contact kevin@agspace.ie or alternatively you can find more information on BovINE by visiting the project's website www.bovine_eu.net or by connecting with us on our social media channels using the handle @bovine_eu.

BovINE
BEEF INNOVATION NETWORK EUROPE

Upcoming events

The Irish BovINE network will host its final conference in September/October 2022. The event will feature keynote speakers in the area of sustainable beef production systems and all the latest findings from BovINE. If you wish to attend the event please contact our Irish Network Manager: kevin@agspace.ie

The project will also host a pan –European end of project conference in November 2022 in Spain. The aim of the event will be to foster the exchange of knowledge between stakeholders in the European beef sector and as such, attendees will be sought from the beef farming communities of all nine countries in BovINE. To register your interest in attending the event please contact the BovINE Project Manager: richard.lynch@teagasc.ie

BovINE was funded by the European Union's Horizon 2020 rural renaissance programme; Project No: 862590 under call H2020-RUR-2019-1.

Technology Village

GRASSLAND

The cost of producing home-grown feeds on Irish farms

Peter Doyle[1], Tomás Tubritt[2], Nicky Byrne[1], Michael O'Donovan[2] and Paul Crosson[1]

[1] *Teagasc, Grange, Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *Teagasc, Moorepark, Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork*

Summary

- Analysis of five commonly grown feeds on Irish beef farms has shown that the rise in input prices has led to an increase in feed costs between 22% and 33% in 2022 when compared to 2021.
- Growing and efficiently utilising high-quality home-produced feed, rather than purchasing concentrates, which are also increasing in cost, remains the most cost-effective option for feeding livestock.
- Grazed grass is the lowest cost high-quality feed source available, with clover inclusion in swards providing further opportunities to reduce costs.
- With rising supplementary feed costs, it is vital that farms produce sufficient winter feed of appropriate quality.
- Targeting high grass utilisation on grassland farms needs to be a key objective.

Introduction

Unprecedented increases in prices of fertilizer, fuel and feed on global and Irish markets in 2022 has large consequences for the cost of beef production on Irish farms. The purpose of this article is to outline the cost of producing home-grown feeds on Irish farms in 2022 and see how this compares with the cost of purchased concentrate feeds, as well as to quantify the increase in feed costs between 2021 and 2022.

Feed cost analysis

The "Teagasc Grange Feed Model" was used to determine the cost of producing five of the most commonly grown feed crops in Ireland in March 2022 versus September 2021. Assumed dry matter (DM) yields, DM concentration, energy content (Unitè Fourragère Lait (UFL)), DM digestibility and inorganic nitrogen (N) fertilizer (kg N/ha) applied for each feedstuff is outlined in Table 1. Based on market prices in March 2022, straight N fertilizers were valued at €2.70/kg N and rolled barley was valued at €390/tonne fresh weight for the purpose of the analysis. Contracting costs were estimated based on the increases observed in fuel prices and other input prices (ad blue, plastic, etc.). Compared to recent years, on average contracting costs rose by 56% in March 2022 (e.g. pit silage = €430/ha (€174/acre), mowing = €80/ha (€32/acre), tedding €30/ha (€12/acre), wrapping = €7.00/bale including plastic). It is acknowledged that these prices will change throughout 2022 due to market volatility.

Table 1. Assumed dry matter (DM) yields (tonne, t DM/ha), DM percentage, energy content (Unitè Fourragère lait (UFL)), DM digestibility and inorganic N fertilizer (kg/ha) applied for each feedstuff

	Grazed grass	Grass+ white clover	First + second cut pit silage[1]	First + second cut bale silage[1]	Fodder beet	Purchased rolled barley @ €390/t
DM yield (t/ha)	13	13	6 + 4	6 + 4	15	-
DM (%)	17.4	17.4	21.7	32.4	19.0	
UFL/kg DM	1.03	1.02	0.82	0.82	1.12	1.16
DM digestibility (%)	82	81	73	73	86	-
Inorganic N fertilizer kg/ha[2]	225	100	87 + 69	87 + 69	114	-

[1] First- and second-cut silage were assumed to be cut on 29 May and 17 July, respectively.

[2] Remainder of nitrogen requirement was fulfilled via slurry (organic N) application.

The results of the estimated feed costs in spring 2022 and September 2021 are outlined in Table 2. Unless stated otherwise, prices described in the following text include land charges; however, prices excluding land charges are also presented in Table 2. Costs are also presented per hectare, per tonne (t) DM grown, and a relativity to grazed perennial ryegrass swards on a unit energy basis (which excludes land costs of home-produced feeds). Supplementary feeding costs, particularly those associated with indoor feeding such as mineral and protein supplementation (which is particularly important for fodder beet) are not accounted for in the analysis.

It is well-established that grazed grass is the cheapest feed in Ireland and, primarily for this reason, it underpins our ruminant production systems. Perennial ryegrass swards have the potential to produce high yields of a highly-digestible forage over a long growing season. Typically this growth has been supported by N application in the form of chemical N such as urea or calcium ammonium nitrate (CAN) or organic N in slurry and manure. At current prices, a grazed grass sward yielding 13 tonnes of DM/hectare and receiving 250 kg N/hectare (225 kg urea N + 25 kg organic N) is estimated to cost €121/t DM. This represents a 29% increase on 2021, mostly driven by the increases in N fertilizer prices. Therefore under these circumstances, assuming that a yearling steer consumes 7.5 kg DM/ha/day of grazed grass, it costs €0.91 and €0.48 per day to feed a steer grazed grass, including and excluding land costs, respectively.

Legume crops such as white clover have the ability to 'fix' N from the atmosphere, thereby replacing to a large extent the requirement for imported N fertilizer sources. In this analysis, we assume that clover fixes 125 kg atmospheric N/ha and therefore, N application is reduced to 125 kg N/ha for a 13 t DM grazed grass sward, reducing estimated total feed costs to €97/t DM. This shows that successfully incorporating clover onto farms can be a strategy for maintaining herbage production, with reduced fertiliser inputs.

The cost of producing grass silage (pit) in this analysis is €204/t DM and €239/t DM for first- and second-cut, respectively. On average across both cuts, harvested in late-May and mid-July, grass silage is estimated to cost €218/t DM (circa €47/t fresh weight), an increase of 27% when compared to 2021. Similarly, baled silage increased by 33% compared to 2021.

The 2022 price increases are 'driven' by the same factors as pit silage production as well as the increased plastic and transport costs associated with baled silage production. A breakdown of the costs of producing baled silage in 2021 (€25/bale exc. land) and 2022 (€36/bale exc. land) are outlined in Table 3.
Feeds such as fodder beet form an important part of the indoor feeding diet on many farms, particularly for finishers. The cost/t DM of fodder beet (including washing and chopping) in 2022 are similar to grass silage at €227/t DM (ca. €43/t fresh weight), representing an increase of 22% when compared to 2021.

Table 2. Estimated costs (€) to produce feed in 2022 at current market prices (March 2022)

	Grazed grass	Grass+ white clover	First + second cut pit silage[1]	First + second cut bale silage[1]	Fodder beet	Purchased rolled barley @ €390/t
March-2022						
Total costs/ha (incl. land costs) (€)[2]	1569	1259	2179	2322	3403	.
Total costs/ha (excl. land costs) (€)	828	518	1660	1803	2662	.
Total costs/t DM grown (incl. land costs) (€)[2]	121	97	218	232	227	470
Total costs/t DM grown (excl. land costs) (€)	64	40	166	180	177	470
Relative cost to grazed grass per energy utilised (UFL)[3]	1.0	0.6	3.4	3.4	2.5	5.0
September-2021						
Total costs/ha (incl. land costs)[2]	1223	990	1708	1744	2792	.
Total costs/ha (excl. land costs)	482	249	1207	1244	2051	.
Total costs/t D grown (incl. land costs)[2]	94	76	171	174	186	329
Total costs/t DM grown (excl. land costs)	37	19	121	124	137	329
Relative cost to grazed grass per energy utilised (UFL)[3]	1.0	0.5	4.2	4.0	3.4	6.3

DM= Dry Matter; t = tonne
[1] Fodder beet costs does not include the cost of additional protein supplementation required.
[2] Land charge is €741/ha (€300/acre)
[3] Excluding land charge associated with home-produced feeds

While the cost of home-produced feed has increased substantially, the rising cost of purchased concentrate feeds is also noteworthy. For example, rolled barley has increased in price to €390/t fresh weight in spring 2022 and may be liable to further increases. When expressed on a DM basis and taking into account feed-out costs to be comparable to the forage crops evaluated, the total feed costs of concentrate rations is estimated to be €470/t DM. This emphasizes the importance of (1) producing sufficient quantities of home-produce feeds, especially forages and (2) ensuring that the quality of feed produced is suitable for the animal type to be fed. If these two objectives are not achieved, then supplementary concentrate feeding will be necessary at a higher cost that the home-produced alternative. In this regard, detailed fodder budgeting (grazing season and indoor winter feeding) is even more important now.

Table 3: Estimated costs (€) to produce baled silage in 2021 and 2022

	2021		2022	
	First cut	**Second cut**	**First cut**	**Second cut**
Fertilizer (incl. spreading)[1]	€5.79	€6.90	€10.19	€12.11
Harvesting costs (incl. plastic)	€13.27	€14.80	€20.17	€22.00
Other (feeding, herbicides etc.)	€3.11	€1.14	€3.19	€1.16
Fixed Costs	€1.57	€1.89	€1.71	€2.04
Total Costs Excl. Land Charge	€24	€25	€35	€37
Incl. Land Charge (€200/acre)	€31	€33	€42	€45
Incl. Land Charge (€300/acre)	€34	€36	€45	€48

Conclusion

The cost of all feeds have increased substantially. Home-produced feeds, and grazed grass in particular, remain our cheapest feed resource, with grass-clover pastures being particularly cost-effective. Following grazed grass, the costs of grass silage and fodder beet are relatively similar when expressed on a per tonne basis. Fodder beet has somewhat lower production costs compared to grass silage when expressed on a per unit energy utilised basis (although these crops have a greater demand for protein and mineral supplementation, which were not included in this analysis, when compared to grass crops). Purchased concentrates such as rolled barley remains an expensive feed resource, costing about five times the price of grazed grass (excluding land charge) on a per tonne DM basis.

Prices quoted in this article are those prevailing at the time of the analysis (final week of March 2022) and are subject to high levels of volatility.

Making more efficient use of Nitrogen on your farm: LESS and Protected Urea

William Burchill[1], Patrick Forrestal[2], Brian McCarthy[3], Fiona Brennan[2] and Áine Murray[3]

[1] *Teagasc Moorepark, Advisory Building, Fermoy, Co. Cork*
[2] *Teagasc, Soils, Environment and Land Use Department, Johnstown Castle, Co. Wexford*
[3] *Teagasc Moorepark, Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork*

Summary

- Low emissions slurry spreaders (LESS) can deliver three extra units of nitrogen (N) per 1,000 gallons of slurry compared to splash-plate spreaders.
- Low emissions slurry spreading reduces grass contamination and allows more targeted application of slurry to paddocks.
- Testing slurry for its dry matter, N, phosphorus and potassium concentration allows for better slurry management.
- Protected urea grows the same amount of grass as calcium ammonium nitrate (CAN) while being very cost-competitive and reducing emissions.
- Protected urea has no negative effect on soil microbes and leaves no residues in grass or milk.

Introduction

The production and utilisation of grass is a key driver of farm profitability. Irish grasslands respond strongly to nitrogen (N) application so it is important to make the best use of available N on farms. The two main sources of N on farms are purchased chemical N fertilizer and the N contained within slurry. The type of N fertilizer and the slurry application technique used on farm is very important in terms of making the best use N on farms.

Benefits of low emissions slurry spreaders (LESS)

Low emissions slurry spreader (LESS) machines such as the 'trailing shoe' and 'dribble bar' retain more of the on-farm N to grow grass, thus reducing the amount of fertilizer N which has to be purchased. Using the trailing shoe or dribble bar has been shown to improve the efficiency of N within slurry by 3 units of N per 1,000 gallons compared to using splash-plate. For example, typically slurry spread in spring with a splash-plate delivers 6 units of N per 1,000 gallons of slurry spread, whereas using a trailing shoe or dribble bar will increase this to 9 units of N per 1,000 gallons. This improvement in N efficiency is due to lower losses of ammonia-N from the slurry when LESS machines are used. Another advantage of LESS machines is having flexibility with the level of grass covers present when applying slurry (up to a cover of 1,000 kg DM/ha), which means that fields can be targeted for spreading at the times when the soil is most trafficable and the slurry nutrients targeted where and when they are needed i.e. slurry targeted to silage ground and fields in index 1 and 2 for phosphorus (P) or potassium (K). Recent studies carried out by Teagasc has shown that cows prefer to graze pastures fertilized by either trailing shoe or dribble bar compared to splash-plate due to lower contamination of grass as can be seen in Figure 1. This allows for a shorter interval between slurry spreading and grazing which is important in intensive grazing systems. Low emission slurry spreading machines are an expensive capital cost for farms. Depending on herd size and available labour, the use of a contactor with one of these machines maybe a more viable options for farms to get the benefits of these machines.

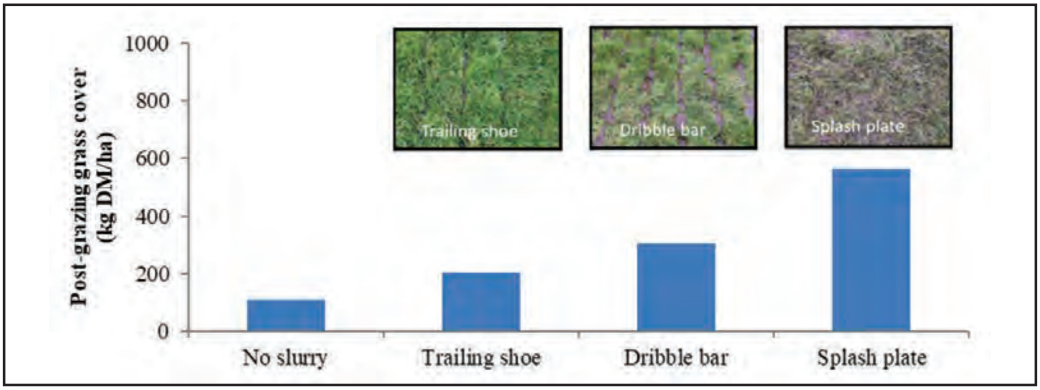


Figure 1. Post-grazing grass covers on field plots spread with slurry using different slurry application methods. Grass cover was 1,100 kg DM/ha at time of spreading and grazing occurred three weeks after slurry spreading. Insert-pictures show level of grass contamination at time of slurry spreading.

Slurry testing

Slurry can be tested for its dry matter, N, P and K content relatively easily and cheaply by a number of laboratories across the country. In the winter of 2020/21 up to 128 slurry samples from dairy farms within Teagasc/Dairygold Joint Programme discussion groups were tested for dry matter, N, P and K content. The slurry contained 10.7 units N/1,000 gallons (applied using LESS in spring time), 5.3 units P/1,000 gallons and 27 units K/1,000 gallons on average and varied slightly compared to the standard Teagasc values (Table 1). Based on these results slurry will provide the following amount of N depending on application technique and rate;

- 2,000 gallons/acre using a trailing shoe/dribble bar in spring = 21 units N/acre
- 2,500 gallons/acre using a trailing shoe/dribble bar in spring = 27 units N/acre
- 3,500 gallons/acre using a trailing shoe/dribble bar in spring = 37 units N/acre
- 2,500 gallons/acre using a splash plate in spring = 20 units N/acre
- 3,500 gallons/acre using a splash plate in spring = 28 units N/acre

The standard N application recommendation in spring is to apply 23 units N/acre in late-January/early-February if ground and growth conditions are suitable. Based on this recommendation and the results of the slurry tests we can see that using a trailing shoe/ dribble bar at a rate of 2,000-2,500 gals/acre will be the most efficient method to meet these N requirements using slurry. Heavier applications of slurry using a trailing shoe/dribble bar will supply more N than is required at this time of the year. Instead the slurry should be spread out over a larger area and used to replace the standard ½ bag urea or 23 units N/acre to reduce your fertiliser N cost in spring.

The slurry N, P and K contents varied depending on the type of tank the slurry was taken from (Table 1). Open tanks, open towers and lagoons had lower slurry dry matter (more watery) and lower N, P and K contents compared to the slurry from covered tanks. This should be considered when applying slurry for first-cut silage in particular which requires 15 units P/acre and 100 units K/acre. For example, slurry from a covered tank applied at 3,000 gal/acre will supply 90 units K/acre, whereas slurry from a lagoon will only supply around 51 units K/acre.

Table 1. Slurry dry matter (DM, %) and nitrogen (N), phosphorus (P) and potassium (K) contents (units/1000 gallons slurry) test results from Teagasc/Dairygold Joint Programme farms in 2021 compared with 'standard' Teagasc values.

	DM %	Units per 1000 gallons of slurry				No. of samples
		N		P	K	
		LESS (spring)	Splash-plate (spring)			
Standard Teagasc values 2012	6.3	8.7	6.5	4.5	31.9	-
Average for Teagasc/ Dairygold supplier farms	6.7	10.7	8.0	5.3	27	128
Covered tanks	7.3	11.9	8.9	5.9	29	53
Open towers	6.5	9.0	6.8	5.0	25	9
Open tanks	5.5	7.8	5.9	4.1	23	15

Benefits of using 'Protected urea'

For years, urea fertiliser was generally spread in the 'spring' and calcium ammonium nitrate (CAN) was spread during the 'summer' as they were the best chemical N fertiliser products to use during those times of the year. Protected urea is a relatively new fertiliser N product that is very cost-competitive compared to CAN, and compared to standard urea when the N-loss savings are considered.

What is Protected urea fertiliser and when can it be applied?

Protected urea uses the same granule as 'normal' urea - the only difference is that a 'protection', in the form of a urease inhibitor, has been added to the granule. These inhibitors reduce ammonia-N gas emissions from the urea which means that more of the fertilizer N is retained for grass growth, which is also better for the environment. Typically when normal urea is spread a small amount of rain is required within 2-3 days to 'wash it in', whereas with Protected urea this 2-3 day window is increased. Protected urea is suitable for spreading throughout the whole grazing season. At present Protected urea can come as straight N or in a compound with potash and/or sulphur (S) (e.g. 40% N + 6% S, 38% N + 7.5% S, and 29-0-14+3% S) either can be used for silage and grazing.

Grass growth: Protected urea vs. CAN under silage and grazing conditions

Studies measuring grass yield on cut-plots similar to silage cuts were conducted at three locations (Cork, Wexford and Down) across the country for two growing seasons from

2013 to 2016. The trials found that protected urea produced the same amount of grass as urea and CAN at each location Figure. 2.
Protected urea has also been extensively compared to CAN and 'normal' urea under grazing conditions at Clonakilty and Fermoy in Co. Cork, Ballyhaise Co. Cavan and Athenry, Co. Galway, which represent different soils types and local climatic conditions.
Protected urea consistently grew the same amount of grass as CAN during different times (rotations) of the year and under varying weather conditions from dry periods to wet periods of weather on the four sites over the three years of the study (Figure 3).

Figure 2. Grass yield from plots receiving either Calcium ammonium nitrate (CAN), Urea or Protected urea at three locations across Ireland. Source: Harty et al. (2017**)**

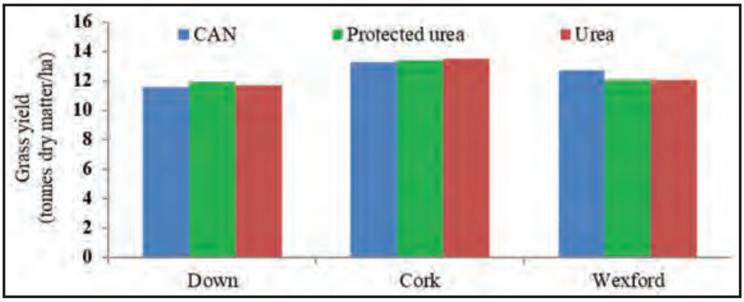
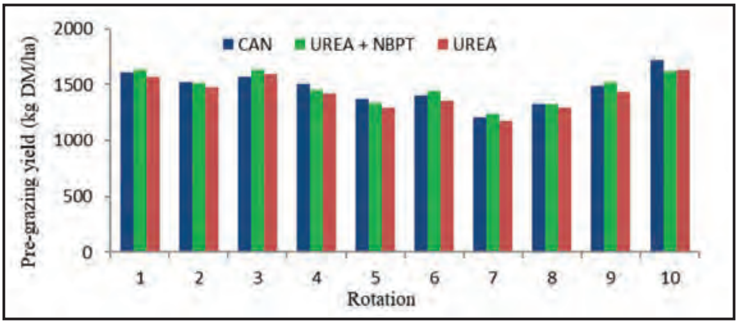


Figure 3. Seasonal responses in pre-grazing herbage yield to nitrogen fertilizer type (CAN), Protected urea (urea + NBPT) and urea across 10 site-years (data are the means of 150 kg N/ha per year and 250 kg N/ha per year).



Protected urea is better for the environment and has no negative effect on soil microbes and leaves no residues in grass or milk

Protected urea has been identified as one of the biggest cost-effective options to reduce both greenhouse gas (GHG) and ammonia emissions from agriculture both of which we have stringent targets to meet under national and EU agreements. Teagasc research has found protected urea to have 71% lower GHG emissions than CAN and 79% lower ammonia emissions than normal urea. The lower losses of fertilizer N from protected urea is resulting in greater N use efficiency which is very important given the current cost of fertilizer N. Additionally, in-season testing of grass samples from long-term plots at Teagasc Johnstown Castle did not detect any residues of the urease inhibitor on grass. Furthermore, there was no residue found in the milk of cows that grazed grass fertilised with protected urea over the course of a year. Teagasc has also recently conducted research examining soils from long-term plots which found that the inhibitor used within protected urea had no impact on the diversity or quantity of soil micro-organism in grassland soils compared to where CAN fertiliser was used.

Principles of reseeding and using the Pasture profit index

Tomás Tubritt[1], Peter Doyle[2], Michael O'Donovan[1], Deirdre Hennessy[1] and Philip Creighton[3]

[1] *Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork.*
[2] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath.*
[3] *Teagasc, Athenry Animal and Grassland Research and Innovation Centre, Co. Galway.*

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.
- Management after reseeding is important to ensure good establishment.
- The Pasture Profit Index (PPI) identifies the best perennial ryegrass varieties available.
- Key traits in the PPI are spring, summer and autumn dry matter (DM) production, grass quality, silage DM yield, persistence and grazing utilisation.
- Grazing utilisation is a new trait with variety performance expressed using the 'Star rating system'

Introduction

Regular reseeding of pasture allows farmers to grow increased yields of higher quality grass. Despite this, reseeding levels in Ireland are low with less than 2% of our national grassland area reseeded annually. As grass is our dominant feed during the main grazing season, and the primary source of winter forage in the form of grass silage, the low level of reseeding must be addressed to maximise herbage production on farms. Swards with low perennial ryegrass content can 'cost' farmers up to €300/ha per year due to reduced herbage production and reduced nitrogen (N) use efficiency. On average, across recent years, reseeding costs approximately €800/ha; however, the increased profitability resulting from the new sward will on average recoup the cost in just two years, making reseeding one of the most cost-effective on-farm investments.
During reseeding, choosing the correct grass variety remains important. The Pasture Profit Index (PPI) is used when selecting grass varieties at reseeding. The PPI outlines, in economic terms, the agronomic differences between varieties for traits that influence the profitability of ruminant production systems.

Timing of reseeding

Timing of reseeding depends to a large extent on weather conditions, and grass supply. Generally, total grass production from a spring/early summer reseed is as much as, if not more than, old permanent pasture in the establishment year. Establishing white clover in spring/early summer is more reliable than autumn due to the stability of soil temperatures. Conditions for post-emergence weed control are also more favourable following spring/early summer reseeding. While autumn reseeding may make sense from a feed budget perspective, soil conditions deteriorate as autumn progresses reducing opportunities to graze, 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.

Key principles to follow when reseeding

- Soil sample for phosphorus (P), potassium (K) and pH.
- Spray off the old pasture with a minimum of 5 l/ha of glyphosate; allow a minimum of 7–10 days after spraying before cultivating.
- Prepare a fine, firm seedbed. There is little difference between cultivation and sowing methods once completed correctly.
- Use grass and white clover varieties from the Teagasc Pasture Profit Index or either of the Irish (Republic or Northern) Recommended Lists.
- Sow at a rate of 28–30 kg/ha of grass plus 3.5–5.0 kg medium leaved clover.
- Include no more than three or four perennial ryegrass cultivars per seed mix.
- Avoid sowing white clover seed too deep; sowing depth — approximately 10 mm.
- Roll well to ensure good contact between the seed and the soil.
- Apply a suitable post-emergence spray when weeds are at seedling stage.

Management of reseeds

Weed control is an essential part of the reseeding process. Weeds in new reseeds are best controlled when grass is at the 2–3 leaf stage. Docks and chickweed are two of the most critical weeds to control in new reseeds; it is important to control these at the seedling stage by applying the herbicide before the first grazing. When clover is included in the swards, it is important to use a clover safe herbicide. All pesticide users should comply with the regulations as outlined in the Sustainable Use Directive (SUD). Care must be taken when grazing newly reseeded swards. The sward should be grazed as soon as the new grass plants roots are strong enough to withstand grazing (root stays anchored in the ground when pulled). Early grazing is important to allow light to the base of the plant to encourage tillering and white clover establishment. Light grazing by animals such as calves, weanlings or sheep is preferred as ground conditions may still be somewhat fragile depending on the seedbed preparation method used. The first grazing of a new reseed can be completed at a pre-grazing yield of 600–1,000 kg DM/ha. Frequent grazing of the reseeds at lower pre-grazing yields (<1,100 kg DM/ha) during the first year post-establishment has a beneficial effect on the sward. The aim is to produce a uniform, well-tillered, dense sward. If possible reseeded swards should not be closed for silage in their first year of production as the shading effect of heavy covers of grass will inhibit tillering of the grass plant and white clover establishment resulting in an open sward which is liable to weed ingress.

Using the PPI

Farmers should select varieties using the PPI to ensure best return on investment when reseeding. The 2022 PPI list is displayed in Table 1. Variety performance data is collected and assessed by the Department of Agriculture, Food and the Marine Recommended List trials, which take place at five sites. Varieties are ranked based on their overall PPI value which is calculated by adding a variety's performance in each of the sub-indices or traits that make up the PPI. These sub-indices (and their relative emphasis within the PPI) are Spring (19%), Summer (6%) and Autumn (8%) dry matter (DM) production, mid-season quality (measured as DM digestibility; 25%), silage DM yield (13%) and persistency (29%). The relative emphasis of a trait within the PPI is based on its economic value and the level of variation between varieties for that trait. Aberclyde is the top ranked variety for 2022 with a PPI value of €253. This value indicates that by sowing Aberclyde on your farm, net profit will increase by €253/ha per year relative to the national average sward performance in Ireland. New to the PPI is the addition of the 'Grazing Utilisation' sub-index expressed using the 'Star rating system'. This trait uses grazing data from the Teagasc Moorepark variety grazing studies. The index provides an indication of how suited a variety is to intensive grazing. Varieties with five stars are highly suited as this indicates that grazing performance of a variety was better than expected, thereby showing high grazing efficiency (lower residual grazing height). Varieties with a low star rating performed poorly under grazing and therefore should not be selected when reseeding for swards intended for intensive rotational grazing. Tetraploid varieties (e.g. Xenon, Aspect, Astonenergy, Abergain) are generally more 'efficient' for grazing than diploid varieties.

Selecting varieties based on the sub-indices allows for system specific seed mixtures to be designed. When choosing varieties for intensively grazed paddocks on the grazing platform, those performing strongly in the grazing utilisation, quality and spring/autumn DM sub-indices should be selected. Variety selection for paddocks destined for regular intensive silage harvesting would benefit from prioritising the silage and spring yield traits. Paddocks located on the grazing platform but destined to be closed for silage should aim to combine high silage and utilisation traits. Research investigating variety mixtures found that the trait performance of a mixture could be accurately predicted as the average of the component varieties for all traits.

Conclusion

Reseeding in spring and early summer is preferable to autumn reseeding. There is little difference between reseeding methods once a firm seedbed is established and good seed-soil contact is achieved. Many management factors affect the success of reseeded swards. Good management after sowing is just as important as decisions around timing and methods of reseeding. The PPI identifies the best varieties for Irish farms. A variety's strengths and weaknesses should be noted to make informed decisions when choosing varieties for reseeding.

Table 1. Pasture Profit Index for 2022

Variety	Ploidy	Heading Date	PPI values €/ha/year							
			Total	Sub-indices						
			PPI	Spring	Summer	Autumn	Quality	Silage	Persistence	Grazing Utilisation
Aberclyde	T	25-May	253	51	66	46	44	46	0	****
Barwave	T	22-May	244	93	61	59	-20	50	0	–
Abergain	T	4-Jun	241	34	61	50	47	49	0	****
Gracehill	T	4-Jun	241	46	60	58	10	67	0	**
Abermagic	D	28-May	215	31	64	78	18	24	0	***
Nashota	T	3-Jun	214	53	57	39	28	38	0	–
Aberwolf	D	30-May	209	54	54	48	11	43	0	**
Moira	D	26-May	209	108	39	57	-32	36	0	***
Glenfield	T	3-Jun	207	59	63	40	3	41	0	–
Astonconqueror	D	27-May	206	75	52	48	-10	42	0	****
Aberplentiful	T	8-Jun	204	59	63	50	11	26	-6	**
Ballintoy	T	4-Jun	195	36	60	43	23	32	0	****
Meiduno	T	3-Jun	195	45	56	46	27	21	0	****
AberGreen	D	31-May	193	38	69	70	5	11	0	*
Aberchoice	D	11-Jun	190	15	65	58	22	30	0	***
AberBann	D	10-Jun	190	5	81	75	-25	54	0	***
Fintona	T	24-May	190	49	52	49	-5	45	0	*****
Ballyvoy	D	3-Jun	186	65	46	47	19	10	0	*
Dunluce	T	29-May	184	23	58	52	24	34	-6	****
Gusto	D	31-May	176	50	51	64	2	9	0	****
AberBite	T	1-Jun	175	-2	56	53	32	36	0	*****
Elysium	T	27-May	170	43	52	32	12	32	0	–
Bowie	D	16-Jun	170	19	53	54	28	16	0	–
Briant	T	3-Jun	156	10	58	46	13	29	0	***
Solas	T	10-Jun	153	10	48	55	1	39	0	***
AstonEnergy	T	1-Jun	151	5	47	43	49	6	0	*****
Oakpark	D	2-Jun	149	32	52	52	-12	25	0	*
Drumbo	D	5-Jun	146	23	44	42	24	13	0	*
Nifty	D	28-May	145	38	61	57	-37	26	0	**
Xenon	T	7-Jun	143	12	49	35	29	17	0	*****
Triwarwic	T	2-Jun	141	20	53	30	7	32	0	–
AstonKing	D	5-Jun	141	61	50	36	-25	18	0	***
Aspect	T	3-Jun	136	11	50	30	27	23	-6	*****
Callan	D	3-Jun	126	71	39	35	-35	16	0	****

Establishing a successful grass/white clover sward

Michael Egan

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

Summary

- White clover can increase animal performance and reduce the need for chemical nitrogen fertiliser.
- When selecting clover cultivars to sow, use the Department of Agriculture, Food and the Marine recommended list.
- Small- and medium-leaved cultivars are best suited to intensive grazing systems, with large-leaf clovers more suited to silage-based systems.
- Optimal soil fertility is essential for establishment and maintaining white clover in swards - soil pH 6.5, and index ≥ 3 for phosphorus (P) and potassium (K).
- Clover should be sown when soils are warm and moist – ideally in early April-to-late May.
- White clover can be established using two methods; 1) direct reseeding and 2) over-sowing.
- Seeding rate of white clover for over-sowing is 5-6 kg/ha and for reseeding is 3.5-5 kg ha.
- Grazing management post-sowing is essential.

Introduction

The inclusion of white clover in grassland has been shown to increase dry matter intake by up 10% which has been shown to increase dairy cow milk yield, and increase annual herbage production with potential savings in chemical nitrogen (N) fertiliser application of up to 100 kg/ha. Similarly, previous research at Teagasc Grange indicated that live weight gain of beef cattle tended to be greater on grass-white clover swards compared to grass-only swards. Current research at Teagasc Grange is investigating the effect of white and red clover inclusion on animal performance and output in a suckler calf-to-beef system. White clover can also improve N-use efficiency and N farm gate surplus. If Irish farms are to successfully establish clover as part of their grazing system, it will need to be undertaken over a period of time (three-to-four years) and a combination of establishment methods will be required.

White clover cultivars

When selecting clover cultivars to sow, use the Department of Agriculture, Food and the Marine recommended list. Small- and medium-leaved cultivars are best suited to intensive grazing systems, with large-leaf clovers more suited to silage-based systems.

Sowing conditions

Soil fertility is a crucial factor in establishing and maintaining adequate clover (average 22% clover content in the annual herbage dry matter production) on farm with a soil pH 6.5, and index ≥ 3 for phosphorus (P) and potassium (K). Rhizobia bacteria that fix N in association with clover are more productive in soils with a pH of 6.5. The P content of the soil is also important when establishing a clover sward. White clover seeds are very small and clover seedlings tend to be relatively fragile. Seedling vigour is favoured by having plenty of P in the vicinity of the establishing seedling. It is usually recommended that clover seed is sown with a fertiliser that contains P compound as this will favour establishment. Clover should be sown when soils are warm and moist – ideally in early April-to-late May. Sowing in the autumn can reduce chances of a successful establishment as soil temperatures are on the decline so it is more difficult for clover to compete with the grass.

White clover establishment

White clover can be established on your farm using two methods; 1) direct reseeding, 2) over-sowing.

Direct reseeding

1. Key steps involved in a full reseed;

- Aim to reseed as early in the year as possible (April, May, June) when soil temperatures are high and increasing, and there is adequate opportunity for weed control.
- Soil sample for P, K and pH.
- Spray off the old pasture with a minimum of 5 L/ha of glyphosate; allow a minimum of 7-10 days after spraying before cultivating.
- Prepare a fine, firm seedbed.
- Use grass and white clover varieties from the Irish Recommended List.
- Cattle sowing rate: 28-30 kg/ha of grass plus 3.5-5.0 kg of medium-leaved clover.
- Avoid sowing white clover seed too deep - sowing depth approximately 10 mm.
- Apply 40 kg N/ha (30 units N/acre) at reseeding.
- Apply P and K fertiliser as required.
- Roll well to ensure good contact between the seed and the soil.
- Apply 25 kg N/ha (20 units N/acre) 4-6 weeks post sowing.

Figure 1. Reseeding white clover in to a fine, firm seedbed.

2. Over-sowing

Over-sowing is a simple and low-cost method of introducing white clover onto your farm. Success is very much dependent on weather conditions around sowing and post-sowing grazing management; therefore, there is a certain amount of risk associated with this approach and it should be undertaken in the early part of the year (early April-to-late May). Key steps involved with over-sowing white clover;

- Do not over-sow old 'butty' swards with a low content of perennial ryegrass – white clover will not establish well in these.
- Control weeds before over-sowing white clover as weed control options afterwards are more limited. Some herbicides have a residue of up to 4 months – always check the residual time on the label of the product or seek advice on a suitable weed control product.
- Take a representative soil sample for P, K and pH analysis and correct soil fertility prior to over-sowing. Optimum soil fertility when over-sowing will help increase the chances of success.
- White clover seed can be broadcast onto the sward or stitched in using a suitable machine.
- If broadcasting with a fertiliser spreader:
    - Mix clover seed with 0:7:30 fertiliser and only add white clover to the spreader when you are in the field to avoid white clover settling at the base of the spreader.
    - Do a maximum of 1 ha at a time (to avoid seed settling) and spread in 2 directions across the field.
- Stitching in white clover seed with a drill/harrow ensures better seed to soil contact.
- Over-sow directly after grazing (≤ 4 cm post-grazing sward height) or after cutting the paddock for surplus bales – ideally only over-sow three to four paddocks at a time.
- Sow at a rate of 5.0 to 6.0 kg of white clover seed/ha.
- Soil contact after over-sowing is one of the most crucial factors affecting germination.
    - Roll paddocks post-sowing to ensure soil contact.
    - Apply watery slurry (if available) – ideally around 2000 gallons/acre.
- Reduce N fertiliser post over-sowing to 15 kg N/ha (12 units N/acre) per rotation for two rotations to reduce grass growth.

Figure 2. White clover cotyledon emerging after stitching in.

White clover establishment blueprint

A targeted multi-year approach should be used in establishing a white clover system, which entails a combination of reseeding and over-sowing.

- Reseed approximately 10% per year.
- Over-sow approximately 20% per year.
  - Year 1 - reseed 10% and over-sow 15-20%
  - Year 2 - reseed 10% and over-sow 15-20%
  - Year 3 - reseed 10% and over-sow 15-20%
  - Year 4 - remaining 10% + any ground that clover did not establish

Paddocks requiring a full reseed should be identified as early as possible in the process to avoid over-sowing clover on these;

- Poor-performing, age of sward, weed content etc.

Select paddocks for over-sowing that will give the best chance of establishment;

- Optimal soil fertility (index 3 or > for P & K, soil pH 6.5).
- High perennial ryegrass content.
- Open/low density swards – dense swards prevent light getting to new clover plant, hindering establishment.
- Low weed content.

Any paddocks that are not suited for over-sowing in the first year (but not ear-marked for reseeding) should have any issues corrected and over-sown the following year;

- Correct soil fertility issues.
- Spray any weeds well in advance of over-sowing to allow for residual time frame.

Management of grass-clover swards after reseeding

Poor establishment results have been obtained where grass gets too strong after over-sowing. This is the single biggest reason for failure that lies within the farmer's control. Swards need to be grazed tight after over-sowing clover. The most important recommendation is tight grazing for the first three grazings post-sowing, both for direct reseeding and over-sowing, keeping pre-grazing herbage mass < 1200 kg DM and grazing swards to ≤ 4 cm. By doing this it allows light to penetrate to the base of the sward which is essential for clover establishment. Soil moisture conditions have a major influence on the success of over-sowing.

Weed control is an essential element in both direct reseeding and over-sowing. Weeds in new reseeds are best controlled when grass is at the 2-3 leaf stage. Docks and chickweed are two of the most critical weeds to control in new reseeds; it is important to control these at the seedling stage, by applying the herbicide before the first grazing. When clover is included in the swards, it is important to use a clover safe herbicide. When over-sowing clover into existing grass swards, it is better to control more established weeds before over-sowing white clover into the sward. For established grass/clover swards the herbicide *Eagle* and *Prospect* are clover safe options. Speak to your advisor or merchant for best advice on the product suited to your needs and weed problem. When applying herbicide, always follow best practice guidelines and read and follow the product label. All pesticides users should comply with the regulations as outlined in the Sustainable Use Directive (SUD).

Red clover

James Humphreys, Dan Barrett and William Burchill

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

Summary

- High yields of multi-cut silage are possible from red clover swards without input of artificial nitrogen fertilizer.
- Red clover is a relatively short-term ley maintaining high levels of production for three-to-six years.
- Red clover has poor ensiling characteristics, with much lower water-soluble carbohydrate (sugars) and somewhat higher buffering capacity than perennial ryegrass.
- These ensiling limitations can be overcome by a 48-hour wilt or by using a suitable preservative to produce silages with high intake characteristics.

Introduction

Red clover in a mixture with perennial ryegrass and white clover can produce very high yields of multi-cut silage without artificial nitrogen (N) fertilizer. Red clover has enormous capacity to 'fix' atmospheric N into plant-available N in the soil supplying the equivalent of around 300 kg per ha per year. High N fertilizer prices is stimulating an interest in using red clover for multi-cut silage, particularly on out-blocks of land. Very high yields are possible. Annual yields of 15 tonne (t) DM per ha have been recorded at Teagasc Grange and Solohead under zero-N fertilizer input. It is a relatively short-term ley maintaining high levels of production typically for three-to-six years. The red clover tends to die out of the sward over time. The high costs of reseeding and risks associated with reseeding explains why it has not been widely used and there is relatively little experience of it on Irish farms. Red clover is typically grown on mixed arable and livestock farms in the UK and Denmark where it is a fertility-building part of an arable rotation, while also producing cheap feed for livestock. Lucerne/alfalfa fills a similar role in regions with warmer and drier conditions during the summer. Red clover is more productive in regions with damper and temperate climates and is highly-productive under Irish conditions.

Growth habit of red clover

Red clover produces a number of erect shoots that grow from the crown of a taproot (somewhat similar to a dock plant; Figure 1). It has a poor capacity to spread out in the sward or replace shoots that are damaged by machinery or disease, which accounts for its relatively short lifespan in swards. In contrast, white clover produces stolons that grow along the surface of the soil in much the same way that ivy grows up a wall. This stoloniferous growth habit accounts for the greater persistence of white clover in swards compared with red clover. Red clover swards should be sown as an arable crop. At Teagasc Solohead, after burning off with glyphosate, the ground is prepared with one or two 'runs' of a disc harrow followed by two runs of a power harrow. The seed is sown during the second run of the power harrow.

Figure 1. The growth habit of red clover

Disease break

The decline in the use of red clover in the UK since the 1960s was caused by greater availability of cheap N fertilizer during the 1970s and by diseases; stem eelworm and Sclerotinia fungus. Stem eelworm is a disease of many arable crops and causes stunting of red clover. Sclerotinia is also a disease of other leguminous arable crops such as beans and causes 'clover rot' in red clover. The risks of these diseases in Ireland are very low at present. These diseases can be controlled by a four-year break; for example by growing red clover in rotation with maize. Alternatively, where red clover is grown with perennial ryegrass and white clover the crop can remain productive even after the red clover has died out of the sward because the red clover is progressively replaced by white clover, which becomes dominant in the sward over time. This creates a disease-break between stands of red clover while extending the interval between reseeding. It is important to plan for a disease break to avoid these diseases building up in the soil, particularly for out-blocks used continuously for silage production.

Longevity

Cost-effectiveness depends on longevity of the crop. At Teagasc Grange between 2002 and 2007, very high yields were recorded over each of six years. An annual yield of 15.9 t per ha was recorded in 2007, the final year of the study, although the red clover content of the sward had declined from 75% in 2002 to 44% in 2007. The saving in fertilizer N over six years was €1,800 per ha at 2019-2021 prices (or 2.5 times that at 2022 prices). Choice of red clover cultivar is important. We do not have a recommended list for red clover in Ireland. Fearga, AberClaret, AberChianti, Milvus and Lemmon are red clover varieties that have performed well on UK recommended lists, although seed of some of these cultivars is in short supply at present. Companion ryegrasses (perennial or/and hybrid) with heading dates in late May are ideal. A typical seed mixture contains 4 kg red clover along with 8 or 9 kg ryegrass and 1 kg white clover. A large-leaved white clover cultivar should be included because it is more persistent and will replace the red clover as the red clover dies out of the sward. Bearing in mind that red clover seeds are three to four times the size of white clover seeds; 1 kg of white clover seed contains more-or-less the same number of seeds as 4 kg red clover seed. Hence, while it might seem that there is much less white clover in the seed mixture, you can end up with the same number of red and white clover plants in a newly-established sward.

Dock control during reseeding is very important. Post-emergence herbicide control of docks can give very effective control that persists for the lifetime of the sward (10 years) and is vastly more cost-effective and eco-efficient than trying to control docks in older swards. The availability of suitable post-emergence herbicides was restricted during 2021. It is anticipated that they will be available under derogation in 2022.

Other key management practices for promoting longevity is zero N fertilizer input, maintaining adequate potassium (K) and phosphorus (P) fertilization, avoiding damage by machinery and animal hooves and adequate lime application. Nitrogen fixation is a biological process and therefore soil pH in the range of 6.5 to 7.0 is optimum. Red clover herbage harvested for silage contains around 25 kg of K and 3 kg of P per t DM. Harvesting 15 t DM per ha per year removes a huge amount of K in particular and this needs to be replaced by slurry or artificial fertilizer. To avoid luxury uptake of K and subsequent problems with milk fever in cows, K fertilization should take place in advance of each crop. For example, if you plan to harvest a first-cut crop of 5 t DM per ha in mid-to-late May, this requires 125 kg/ha of K and 15 kg/ha of P during March or early-April. It is best to hold off spreading slurry until ground conditions are such that avoids any damage to the crop. A light grazing in the spring and in the late autumn is possible although this can shorten the longevity of the red clover content of the sward.

Making silage

The optimum harvest date for first-cut is around 20 May and subsequent harvests at 6-to-8 week intervals. Red clover has poor ensiling characteristics, with much lower water-soluble carbohydrate (sugars) and somewhat higher buffering capacity than perennial ryegrass. These limitations can be overcome by a 48-hour wilt and therefore the weather conditions at harvest are an overriding consideration. A good wilt can be achieved by spreading out the sward immediately after cutting and rowing in after 48 hours or so. Experience at Teagasc Solohead, along with evidence from elsewhere, is that red clover makes reasonably good quality silage with slightly lower digestibility and crude protein than fertilized ryegrass swards (Table 1). High volumes of cheap (in terms of N fertilizer input) silage are produced with very high intake characteristics, which is a redeeming characteristic of red clover silage. High intake compensates for somewhat poorer nutritional characteristics and cattle perform well on red clover silage once it is well-preserved. Where a wilt is not possible it is necessary to use a suitable preservative at harvest, such as molasses.

Target harvest dates are 15 to 20 May (yielding approximately 5-to-6 t DM per ha), early to mid-July (4-to-4.5 t DM per ha) and late August or early September (3-to-3.5 t DM per ha). Large quantities of herbage (>2.5 t DM per ha) can build up during September and October and it is important to remove this before the winter. Otherwise there can be large losses of herbage due to senescence and heavy covers can damage the clover content over the winter.

The approach used at Teagasc Solohead is to zero-graze under good ground conditions during late October and November leaving swards 'cleaned out' to the butt over the winter.

Table 1. Analyses of first-cut red clover silage at Teagasc Solohead in 2021

Silage analyses	Results	Desirable values	Status
Dry matter (DM) (%)	42	20 – 30	
pH	4.4	4.0 – 4.7	Good
Ammonia N (%)	2.7	<10	Good
Ash (%)	8.5	<8.6	Good
Neutral detergent fibre (%)	45	<45	Good
DM Digestibility (%)	71	>69	Good
UFL (per kg DM)	0.79	0.65 – 0.90	Good
ME (MJ/kg DM)	10.2	>9.8	Good
Crude protein (%)	12.3	13.5 – 17.0	Low

Environmental benefits

Red clover swards under multi-cut silage have low environmental footprints compared with alternatives. Greenhouse gas and ammonia emissions are low due to zero input of N fertilizer. Although red clover can fix huge amounts of N (equivalent to 300 kg/ha) this N is almost entirely taken up by the crop, is carried to the silage pit and ultimately ends up in the slurry tank. Recycling of this slurry back to the red clover swards using low emissions application techniques results in low nitrate losses to water. Red clover is potentially useful where N fertilizer is constrained by environmental or financial considerations. *Longevity is key to competitiveness and time will tell how well red clover swards persist on commercial farms*.

Multi-species swards: Potential for beef production systems

Edward O'Riordan, Sarah Burke, Paul Crosson and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- The inclusion of a greater number of herbage species in a sown grassland sward beyond perennial ryegrass and clover offers the potential to further exploit complementarity between pasture species.
- Multi-species swards (MSS, i.e. grasses + legumes + herbs/forbs), if optimally formulated, can markedly out-yield perennial ryegrass monocultures when receiving low inputs of inorganic nitrogen fertilizer, or they can produce similar yields to perennial ryegrass with reduced inputs of nitrogen fertilizer.
- Early results suggests that herbage yield is primarily 'driven' by the legume (clover) component of MSS.
- Research is on-going at Teagasc Grange to quantify the potential benefits of MSS for beef production systems.

Introduction

Irish agriculture, including beef farming, has obligations under EU and national legislation to reduce greenhouse gas (GHG) emissions and losses of nitrogen (N) and other nutrients to the environment. The recent increase in farm input prices, especially fertilizer and feed costs, brings additional challenges. Consequently, low-cost efficient grass-based beef production is now more important than ever.

For many decades perennial ryegrass has been the dominant, sometimes the only, constituent included in grass seed mixtures used to renew grassland. However, to fulfil its production potential, a perennial ryegrass sward requires fertile soil and high rates of inorganic N input. Consequently, the sustainability of these relatively high input, intensively managed single-species systems becomes questionable if the cost of inorganic fertilizer N increases and/or if negative environmental impacts due to its application increase.

Perennial ryegrass + clover swards

More recently, white clover is included in grass seed mixtures at an increased proportion. Including legumes such as white (or red) clover in seed mixes can increase herbage yields and facilitate reduced input of inorganic fertilizer N through fixation of atmospheric N. The potential benefits of 'binary' grass-clover swards compared to grass-only monocultures, in terms of herbage nutritive value, palatability, voluntary intake and animal performance, as well as the capacity of legumes to fix atmospheric N, are well recognised. For example, in a series of experiments at Teagasc Grange, live weight gain of suckler-bred steers tended to be higher on perennial ryegrass-white clover swards compared to perennial ryegrass-based swards. Beef output/ha during the grazing season on the perennial ryegrass-white clover swards receiving 50 kg inorganic fertilizer N/ha annually was equivalent 85 to 95% of that achieved from perennial ryegrass-based swards receiving 150-200 kg inorganic N/ha annually. This demonstrated the capacity of white clover inclusion to fix atmospheric N resulting in annual savings of chemical fertilizer, equivalent to 100-150 kg N/ha for beef cattle grazing systems. Similarly, research at Teagasc Grange has shown that red clover-based swards in the sixth year after establishment produced comparable dry matter (DM) yields (field-plot cutting regime mimicking multiple silage harvests annually) to perennial ryegrass monocultures receiving inorganic N fertilization and demonstrated the potential of red clover to contribute productively to the provision of forage on grassland beef farms. The inclusion of a greater number of herbage species in a sown grassland sward beyond perennial ryegrass and clover offers potential to provide further exploit complementarity between pasture species. In this regard, there is now increasing interest in using 'multi-species' (MSS) swards, which include grasses (perennial ryegrass and other grasses), legumes (white and red clover) and herbs/forbs (e.g. chicory and plantain). These benefits have been attributed to complementary interspecific interactions such as the aforementioned biological N fixation by rhizobia within the root nodules of legumes, as well as improved resource-use efficiency (e.g. acquisition of soil nutrients and water and utilisation of light) that can occur as functional diversity increases. These 'sown' multi-species swards may represent an opportunity to enhance the sustainability of beef production through, reduced variability in pasture yield between years, consistent and superior herbage nutritive value throughout the grazing season, anthelminthic properties, benefits in N-excretion, and ultimately better animal performance. When allied to lower fertilizer N inputs and the potentially higher contribution to soil carbon stocks, the associated environmental footprint is potentially reduced; however, these characteristics need to be quantified for Irish beef production systems.

Multi-species grassland swards – herbage production and ensilability

A two-year field-plot study at Teagasc Grange compared 1. perennial ryegrass (PRG) swards, 2. grass (i.e. perennial ryegrass & timothy) + legume (i.e. red & white clover) swards, and 3. multi-species swards (MSS) (grass + legumes + herbs (i.e. ribwort plantain & chicory)) swards (and monocultures) receiving either 0, 120 or 240 kg of fertiliser N/ha/year and harvested multiple times annually found that:

- When grown without inorganic fertilizer N input, the largest herbage yield increase across the progression from grass swards to grass+legume swards to MSS (i.e. grass+legume+herb swards) derived from the inclusion of N-fixing legumes, with a relatively small additional benefit accruing from including complementary species from the third functional group i.e. the herbs (Figure 1).
- The magnitude of the yield advantage of MSS over a perennial ryegrass sward declined as the rate of inorganic fertilizer N applied increased. However, under the prevailing management, increasing the rate of inorganic fertilizer N application reduced the persistence of the legumes and herbs within these multi-species swards.
- The nutritive value of MSS could not be predicted from the nutritive values of their monocultures.
- Compared to perennial ryegrass, MSS had a slower rate of decline in digestibility prior to the first-cut silage harvest, but they subsequently had lower digestibilities at mid-season harvests.

- Under favourable ensiling conditions, unwilted MSS swards can preserve satisfactorily as silage, comparable to a perennial ryegrass sward receiving inorganic N fertilizer. However, when ensiled under more challenging crop conditions the MSS had a greater requirement than perennial ryegrass for effective preservative or wilting treatments in order to preserve satisfactorily.

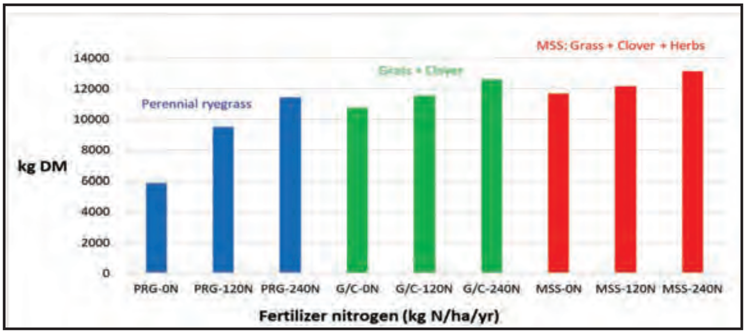


Figure 1. Mean 'annual' (3-cuts) herbage dry matter yield of perennial ryegrass (PRG), grass (perennial ryegrass & timothy) + legumes (red & white clover), and multi-species (MSS) grass + legumes + herbs (ribwort plantain & chicory) swards receiving 0, 120 or 240 kg of fertilizer N/ha/annum. (Source: Moloney et al. 2020, Teagasc Grange)

It was concluded that MSS, if optimally formulated, can markedly out-yield perennial ryegrass monocultures when receiving low inputs of inorganic N fertiliser, or they can produce similar yields to perennial ryegrass with reduced inputs of inorganic N fertiliser. This has potential cost and environmental attractions. However, challenges relating to mid-season digestibility, ease of preservation as silage (ensilability) and possibly persistence still need to be solved.

A more recent experiment carried out at Teagasc Grange in 2021 on newly-sown field plots compared the effect of fertiliser N application levels (0, 75 and 150 kg/ha/year) and inclusion of red and white clover, chicory, plantain and perennial ryegrass (*Lolium perenne*) on annual herbage dry matter yield (Figure 2).

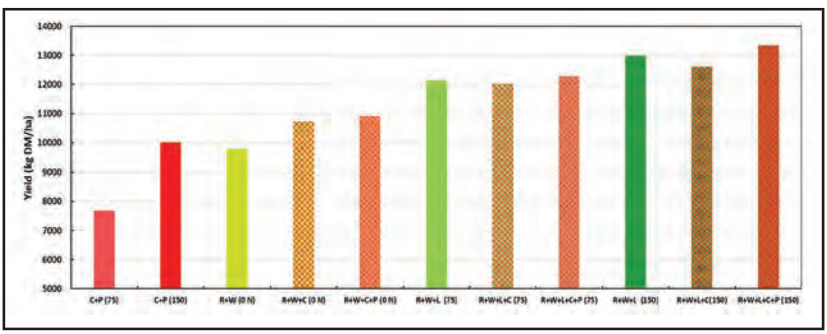


Figure 2. Effect of fertilizer N levels (0, 75 and 150 kg/ha/year) and inclusion of red (R) and white (W) clover, chicory (C), plantain (P) and perennial ryegrass (*Lolium perenne* (L)) on annual herbage dry matter yield (Source: O'Riordan et al. 2022, Teagasc Grange).

Red + white clover receiving zero fertilizer N had an equivalent yield to chicory + plantain receiving 150 kg fertiliser N. At zero fertilizer N, adding chicory to red + white clover increased herbage yield but this was not increased further from adding plantain. At 75 or 150 kg fertilizer N, adding chicory or plantain to perennial ryegrass plus red and white clover did not increase annual yield, which concurs with findings from the previous experiment. This suggests that, under these environmental conditions, herbage yield is primarily driven by the legume (clover) component. Of note is the large seasonal variation in the proportion of grass, legume (and herb) species in perennial ryegrass plus clover swards and MSS, such that the composition of what animals consume differs substantially throughout the grazing season (Figure 3).

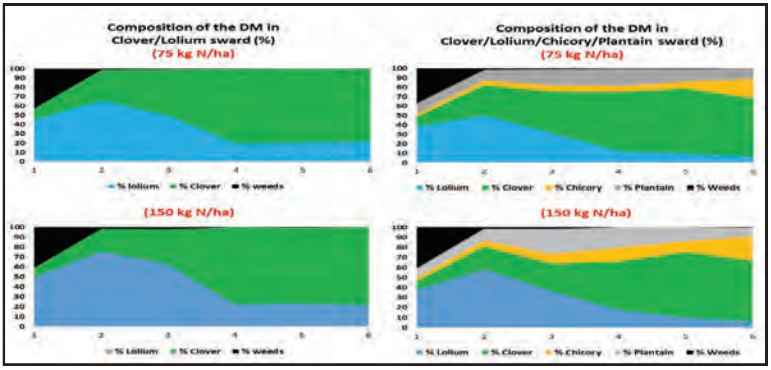


Figure 3. Seasonal variation (~monthly 1-6 from end of April) in the dry matter (DM) percentage of grass, legume and herb species in swards containing mixtures of perennial ryegrass and white plus red clover or additionally, chicory plus plantain, and receiving 75 or 150 kg of fertilizer annually (Source: O'Riordan et al. 2022, Teagasc Grange).

Multi-species grassland swards: beef cattle N-excretion and performance?

There is relatively little published scientific information evaluating the potential of MSS containing a combination of grasses, clovers and herbs to reduce the excretion of nitrogen (or methane emissions, see p 48) and improve beef cattle performance over-and-above a grass-legume sward. Additionally, the limited information published is often conflicting.

In terms of nitrogen excretion, recent research at Teagasc Grange has shown that N-use efficiency in beef cattle offered fresh perennial ryegrass-dominated herbage ranged from 22 to 32%. Compared to perennial ryegrass-dominated swards, MSS may confer benefits in terms of N-excretion but this needs to be confirmed for beef cattle consuming fresh and conserved MSS prevailing under Irish conditions. Likewise, there are comparatively few studies published evaluating the intake, growth and carcass traits of beef cattle from a production 'systems' perspective i.e. incorporating 'complete' grazing seasons and indoor winter periods when offered silage harvested from these swards.

In this context a beef production systems research project has commenced at Teagasc Grange, which is assessing the impact of: 1. pasture-type [grass-legume (i.e. perennial ryegrass + white clover) versus MSS (grasses (i.e. perennial ryegrass & timothy) + legumes (i.e. white & red clover) + herbs (i.e. ribwort plantain & chicory) grazing swards and silage, in conjunction with, 2. genetic divergence for fatness in late-maturing breeds, and 3. slaughter age (~19, 23 and 27 months), on the biological, financial and environmental performance of suckler weanling-to-beef production systems.

PastureBase Ireland – a grassland management tool for all beef farmers

Micheál O'Leary, Anne Geoghegan and Michael O'Donovan

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

Summary

- PastureBase Ireland (PBI) is a web-based grassland management tool.
- The primary reason for farmers to use PBI is to calculate how much grass is grown on each paddock and on their farm. This enables more precise short-, medium- and long-term grassland management decision-making.
- Over 100 beef farms completed 20 farm 'covers' or more in 2021.
- Beef farmers recording farm cover regularly (at least 20 farm covers annually) on PBI have grown annual grass yields between 9.2 and 12.8 t grass DM/ha/year over the last eight years.
- Farmers are encouraged to download the 'PBI Grass' app.
- An array of new tools are available to PBI users.

Introduction

PastureBase Ireland is a web-based grassland management tool incorporating a dual function of grassland decision support while collating and storing a vast quantity of grassland data from grassland farmers in Ireland in a central national database. This provides opportunities to increase the understanding around all aspects of grassland production and utilisation. Data recorded on PBI spans all enterprises –beef, sheep and dairy. Key parameters which PBI measures include the quantification of seasonal and annual grass dry matter (DM) production, which can be further divided into grazing and silage DM production. PastureBase Ireland data can be used to measure the factors that affect grass production including, effects of grassland management practices, region, soil type and soil fertility across a large range of farms.

Measuring grass production on-farm

The primary reason for farmers to use PBI is to calculate how much grass is grown on each paddock, and on their farm. To have an accurate annual grass tonnage report at the end of the year it is recommended that all farmers should record at least 20 farm 'covers' spread across the year. This means that the farmer will have to walk each paddock on their farm, on a given day estimating the quantity of grass in each paddock.

The three main practical methods to estimate the quantity of grass in a paddock are as follows:

Cut and Weigh

The first method uses a quadrat and shears. A 0.5 m × 0.5 m quadrat is placed in an area that

is representative of the amount of grass in the paddock. If the grass is wet, excess water is 'knocked' off before cutting. The grass within the quadrat is cut to 4 cm above the ground. The following equation is used to calculate the DM yield in the paddock:
Weight of grass (kg) × grass DM % × 40,000 = kg DM/ha in the paddock

For example: Assume that the grass cut within the quadrat weighs 200 g (0.200 kg) (remember to subtract the weight of the empty bag) and the grass DM % is 16 % (0.16); 0.200 kg × 0.16 × 40,000 (there are 40,000 quadrats in a hectare) = 1,280 kg DM/ha.

Plate Meter
Using a plate meter, pasture heights are obtained across the entire paddock in a 'W' or 'X' pattern to ensure that the measurement is representative of the paddock. Subtract the 'target' post-grazing sward height/residual (e.g. 4 cm) from the average grass height reading obtained for the paddock and multiply the figure obtained by 250 (as there is 250 kg DM / cm). For example: Assume that the grass height measured was 8.8 cm and the desired post-grazing residual is 4 cm. Therefore, (8.8 cm – 4 cm) × 250 kg DM/cm = 1,200 kg DM/ha.

Eye-Balling
Very experienced operators may be able to 'estimate' the quantity of grass in a paddock by eye ('eye balling').

Weekly farm covers are needed when grass growth is high (May-to-August), whereas pasture covers obtained every two weeks will suffice outside this period.

How much grass are beef farms growing?

Over the last number of years beef farms using PBI that measure and record 20 or more covers in a given year have been growing on average 11,038 kg DM/ha (Figure 1); however, there is a large variation between individual farms, from 16,200kg DM/ha to 7,013kg DM/ha.

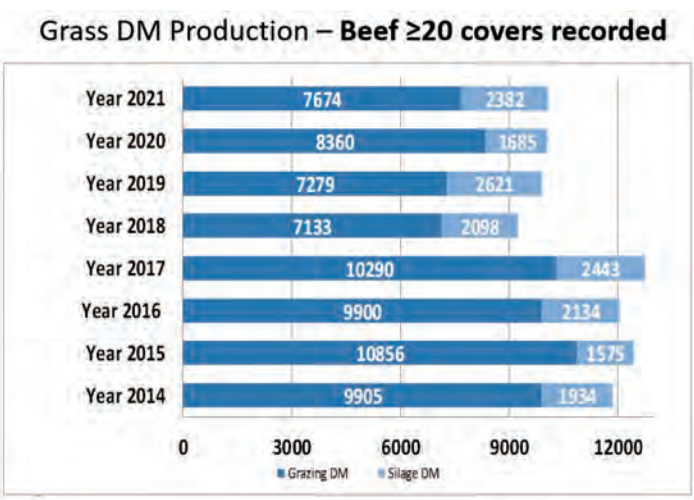


Figure 1. Annual grass dry matter (DM) production (kg) (grazing + silage area) on PastureBase Ireland beef farms that recorded at least 20 farm covers from 2014 to 2021

Why are farmers using PBI?

The advantages for farmers in using PBI are:

1. *Short-term:* after completing a farm cover, the programme displays a grass wedge and calculates the average farm cover, growth rate, number of days ahead etc. This helps farmers to make day-to-day decisions.
2. *Medium-term:* when a farmer records 20-30 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 inform appropriate corrective action.
3. *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 animal stocking rate accordingly.

New tools on PBI

1. Farm Map

The most recent tool added to PBI is the farm mapping option. Having the correct area of each paddock is the starting point to grass measuring and budgeting. Now a farmer can map their own farm on the application and a range of parameters can be displayed on the map (paddock covers, soil fertility, annual tonnage, days last grazed/fertilised, etc.). This is a move away from tables to a more 'visual' approach. This visual paddock layout facilitates grazing management practices and should help ensure that grass quality in all paddocks is optimised. The farm map should also help farmers communicate and manage their farm better especially when employing labour and contractors.

Figure 2. A map of a PastureBase Ireland beef farm

2. Linking with soil laboratories

Correcting soil fertility is key to increasing grass production on Irish dairy farms. Farmers who use Dairygold, FBA Laboratories or IAS Laboratories for soil testing can now have their latest soil fertility results automatically uploaded to their PBI profile. All the farmer needs to do is activate this link up in the 'Soil Results' module. There are two informative soil fertility reports on the PBI Grass app - the soil fertility data for each paddock can be viewed, and if recorded, the total kg per hectare of Nitrogen (N), Phosphorus (P), potassium (K) and sulphur (S) applied is available. This information is expected to greatly aid farmers in selecting the appropriate fertiliser type for individual paddocks.

3. Nitrogen management planning

More beef farmers are now recording their fertiliser and slurry applications on PBI. However, up to now no fertiliser advice based on paddock use (grazing, grazing/one cut of silage, grazing/two cuts of silage and grazing high white clover content paddocks) was provided in PBI. The new N planner is now available to help farmers plan chemical and organic N applications providing monthly recommendations. These recommendations are taken from the Teagasc 'Green Book'. Once the plan is created, as the year progresses actual fertiliser applied can be recorded and compared with the monthly target.

4. Farm Weather Data

The weather has a major influence on grass growth and grass utilisation. In early 2021 a new 'farm weather' module was deployed onto the PBI application. A PBI farmer can now:

1. Link to a Met Eireann or Teagasc weather station located near their farm to download the latest actual weather recorded.
2. Manually enter weather data recorded for their own farm.
3. Enter the location of their farm to download the forecast and actual weather data.

This tool should aid farmers in making informed decisions such as whether or not to apply fertiliser or slurry, or predicting grass growth rate for next week.

Conclusion

The unique selling point of Irish products abroad is Ireland's grassland image and its sustainable food production model. 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 beef 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** or contact your Teagasc advisor.*

Grass10 campaign: summary of phase 1 (2017-2020) and focus of phase 2 (2021-2024)

John Maher, Micheal O'Leary, John Douglas and Joseph Dunphy

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

Summary

- The Grass 10 campaign promotes sustainable grassland excellence.
- The objective of the campaign is to achieve 10 grazings/paddock per year utilising 10 tonnes of grass DM/ha.
- The number of livestock farmers recording grass measurements and using PastureBase Ireland to manage grass on their farms has increased significantly over the campaign.
- New focus is on improving nutrient management and incorporation of clover into grazing swards.

Introduction

There is a strong relationship between the amount of grazed pasture in the diet and the costs of beef production, with operating costs of production declining with increased reliance on grazed pasture. Teagasc analysis has indicated that net profit per hectare increases by €105/ha for each additional tonne of grass DM utilised on drystock farms.

Grass10 Campaign

Teagasc launched a multi-year Grass10 campaign (four years, 2017-2020) to promote sustainable grassland excellence on Irish livestock farms (dairy, beef and sheep). The Grass10 partners are Grassland Agro, AIB, FBD, Department Agriculture Food & the Marine and the Irish Farmers Journal. As well as working closely with all partners and Teagasc advisory programme, the Grass10 programme works closely with the Grassland Science Department in Teagasc. The primary objective of the Grass10 Campaign is to utilise 10 tonnes of grass DM/ha/year using 10 grazings per paddock on grassland farms. The following farm practice changes are prioritised:

- Improving grazing infrastructure
- Soil fertility — improve soil pH, P and K levels.
- Increase the level of reseeding
- PastureBase Ireland (PBI) usage
- Improving grassland management skills

Grass measurement

The number of farmers recording 20 or more grass measurements and using PBI to manage grass on their farms has increased by over 100% since the Grass10 Campaign began. Over 2000 users (predominantly dairy farmers) now record grass measurements on a regular basis (20 or more measurements) using PBI. Increasing the level of PBI usage has been one of the key objectives of the Grass10 campaign. The level of regular pasture measurement needs to increase to gain greater improvements in grassland management and nutrient use efficiency. There has been a strong focus on training farmers on PBI particularly through the Grass10 courses.

From Teagasc National Farm Survey data, grass utilisation on drystock farms is 5.6 tonnes DM/ha. This corresponds to a grass production of 7.5 tonnes of DM/ha annually. This estimated 7.5 tonnes DM/ha grass grown on drystock farms is much lower than the 10.7 tonnes of DM/ha recorded by drystock farms measuring on PBI, indicating that there is still significant potential to grow and utilise more grass on the average drystock farm. Soil fertility has improved significantly and currently approximately 16% of soils are at optimal fertility compared to 10% at the start.

Grass10 courses

Forty five farmer-training courses were delivered during the last two years of phase 1. The location for these training courses was on-farm, and the aim was to up-skill farmers in grassland management and associated decision-making. The courses used the concept of a 'Grazing Coach', a format where course members attend the same farm every month and monitor grazing decisions and performance throughout the year. The 'Grazing Coach' selected is a farmer who wants to learn, and has the potential to improve grass production and grazing efficiency on the farm.

Weekly Grass10 newsletter

The Grass10 newsletter is now dispersed to over 12,000 farmers, advisors and industry members each week. It is a very successful communication tool for the Grass10 programme. It is produced every Tuesday using the grass measurements taken by farmers obtained from PBI. Also included in the newsletter is the predicted grass growth for the upcoming week, predicted soil temperatures, and grass dry matter percentage from Teagasc research centres. Being able to predict grass growth for the following week at farm level would help farmers to better anticipate variations in grass growth. The Moorepark St Gilles Grass Growth (MoSt GG) model is a dynamic 'prediction' model working at the paddock and farm level. The model takes into account soil type, weather and the grazing management practice to predict farm grass growth. Farmers' daily grass management decisions is of huge importance to ensure good quality feed availability for the cows during the grazing season.

Grassland Farmer of the Year competition

Grass10 launched a grassland competition to recognise those farmers who are achieving high levels of grass utilisation in a sustainable manner. The Grassland Farmer of the Year was launched in 2017 to coincide with the Year of Sustainable Grassland supported by the Department of Agriculture, Food and the Marine, in collaboration with the other stakeholders as part of the Grass10 campaign.

Aidan Maguire was awarded the title of 2021 Drystock Grassland Farmer of the Year. Pictured with Aidan is (from left to right): Eamonn O'Reilly (AIB), Liam Woulfe (Grassland Agro), Martin Heydon (Minister of State at DAFM), Padraig Walshe (FBD), Aidan Maguire with his wife Liz, Aidan Brennan (Irish Farmers Journal), Liam Herlihy (Chairperson Teagasc Authority), and Frank O'Mara (Director of Teagasc).

Grass10 Phase 2 (2021-2024)

The requirement for resilient sustainable systems of meat and milk production has never been as high. There is continual change in global agriculture due to fluctuation in markets, agricultural policy, societal expectations and environmental constraints. As a result, there will be further requirement to increase efficiency and sustainability in Irish pasture-based systems.

Given the success of the Grass10 campaign over the last five years it is critical to maintain this momentum. The Grass10 campaign is now in phase 2 and will continue to focus on increasing grass growth and utilisation of home-grown feed on Irish grassland farms. The main focus of the campaign is to ensure the long-term sustainability of Irish pasture-based beef, sheep and dairy production systems. The main opportunities to improve the sustainability of our grassland systems are outlined in the following graphic:

- **Increasing the level of pasture measurement and decision making with Pastsurebase Ireland**
- **Incorporate white clover to grass swards nationally and creating more awareness of the benefits of including white clover in grazed pasture**
- **Improving nutrient (N, P, K and Lime) management on farm**

Improving the level of grass measurement and management

Currently, there are over 50 Grass10 grazing courses operating across the country and this model of improving the level of grassland management and measurement locally has worked well. This is fundamental work carried out during the Grass10 campaign and the plan is to further develop this knowledge transfer model to increase farm level adoption of grassland measurement and management using PastureBase Ireland (**www.pbi.ie**). Every extra day the animal spends at grass reduces greenhouse gas (GHG) and ammonia emissions.

Emissions are primarily reduced by animals feeding themselves and spreading their own slurry but also because the animal is eating a superior diet. Greenhouse gas emissions are further reduced when the animal grazes pasture at the correct growth stage. Animals grazing high-digestibility swards (e.g. 1300-1500 kg DM/ha) will reduce GHG emissions by 15% compared to a more mature sward (e.g. >2000 kg DM/ha) exhibiting lower digestibility.

White clover

There is now an increasing demand to include white clover in grazed pastures due to its ability to biologically fix nitrogen (N) making it available for grass growth and thereby potentially reducing inorganic N fertilizer use. There are challenges in establishing clover in swards at farm level (see page 90). These issues revolve around time of sowing, soil fertility, herbicide choice and grazing management. There is a huge requirement to inform the grassland industry on successful establishment and management of grass/clover swards. Some of the key developments planned in the Grass10 campaign will be:

- **Establishing 20-25 pilot clover-focussed farms nationwide, across enterprises, building a knowledge transfer programme around these farms**
- **Hosting clover workshops on Teagasc Research Centre farms**
- **Publication of a Clover Management Guide – monthly clover updates in the Grass10 Newsletter**

Nutrient management

Grass requires a continuous and balanced soil nutrient supply to achieve its production potential. Many farms are capable of growing in excess of 12-14 tonnes DM/ha annually. This level of grass production requires reasonable quantities of nutrients such as N, Phosphorous (P), Potassium (K) and Sulphur (S) supplied at the correct time. The response in grass production from correcting soil fertility is very high. Improving nutrient use efficiency has become a priority due to the ambitious targets to reduce fertilizer use, as outlined in the EU Farm to Fork Strategy (2030). PastureBase Ireland can facilitate the process of improving nutrient use efficiency, by providing farmers with up-to-date information on fertilizer use, level of fertilizer requirements and soil fertility. Improving nitrogen use efficiency, along with technologies such as protected urea, low emission slurry spreading (LESS), GPS, etc. will assist Ireland achieve its commitments to reduce GHG and ammonia emissions from agriculture. To promote the concept of better nutrient management and nitrogen use efficiency, the profiles of farmers who excel in this area will be disseminated through the Grass10 weekly newsletter (**www.teagasc.ie/crops/grassland/grass10**) and social media platforms in the programme.

Grass10 wishes to acknowledge the support of our industry stakeholders in the Grass10 Campaign.

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine
Grassland AGRO
AIB
FBD INSURANCE
IRISH FARMERS JOURNAL

Technology Village

SUCKLING SYSTEMS

Calving at two years of age: identifying and rearing suitable replacement heifers

Colin J. Byrne[1], Mark McGee[1], Martina Harrington[2], Alan Kelly[3] and David A. Kenny[1]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *Teagasc, Dublin Road, Enniscorthy, Co. Wexford*
[3] *School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4*

Summary

- It is important that farmers consider their target market when selecting heifers and only produce from heifers and cows with genetics that will produce a suitable weanling or finishing animal.
- Replacement heifer selection is based on; visual assessment for functional traits, adequate weight-for-age and a balanced "Eurostar" Replacement Index that complements the herd's breeding goals.
- Delaying first-calving from 24 to 36 months of age decreases net margin per hectare by 50%, which is mainly attributed to feeding an 'unproductive' heifer.
- Pre-weaning growth rates of at least 1.2 kg/day should be targeted to increase the number of heifers reaching puberty before the breeding season.
- Heifers should be 60% of their mature live weight at breeding and 80% of mature weight at calving.
- Bulls with <8% beef heifer calving difficulty and 80% reliability should be used on heifers for first breeding.
- Calving heifers in the first 21 days of the calving season increases their longevity and lifetime productivity in the herd.

Background

The current national average age at first-calving in suckler-bred heifers is 32 months with only 23% of heifers calving for time at 24 months of age. When compared to 74% of dairy-bred heifers calving for the first time at 24 months of age, there is huge potential for improvement in this important reproductive key performance indicator. The top 10% of commercial suckler herds and research herds are consistently calving heifers at 24 months of age. Work from Teagasc Grange has highlighted that a heifer calving for the first time at 36 months of age consumes 65% more grass, 96% more silage and 33% more concentrates than an equivalent heifer calving at 24 months of age. Calving at two years of age will increase farm productivity but careful planning and a high level of technical efficiency is required to ensure consistent success.

Cow type and sire genetics

As part of the heifer selection process, farmers should clearly define their farming system; understand their target market, the type of animals that are required for the market and the cow traits that are required to produce the correct type of animal. Farmers should look at their current cow herd and decide if the herd is of suitable genetic merit for what they are trying to achieve, i.e. good enough Replacement Index or Terminal Index. Evidence from the 'Maternal herd' at Grange has highlighted that there are differences in dry matter intake and milk yield between cows sourced from the suckler herd versus dairy × beef crossbred cows sourced from the dairy herd. These differences in milk yield can influence weanling performance. While weaning efficiency, defined as calf weight as a proportion of cow weight when calf is 200 days old, may be better in 'first-cross' dairy cows, the additional ~0.75 unit in carcass conformation benefits in the progeny from the suckler-bred cow are very important where a farmer is operating a calf-to-beef system.

Identifying suitable heifers for breeding

Selecting suitable replacement heifers should begin with a visual assessment to ensure that the heifer has all of the necessary functional traits to make a suckler cow. The following visual traits should be assessed as a minimum: 1) good legs and feet are paramount for longevity, 2) docile so as to maintain farm safety and improve labour efficiency and 3) four teats to indicate a normal udder. Once the heifer is deemed functionally suitable for breeding, it is important to consider has she met her target weight for age. Weight-for-age targets are outlined in Table 1; these targets underpin successful calving at 24 months. In addition to ensuring that a heifer is well enough grown and capable of conception by 15 month of age and calving at 24 months of age, the ability of a heifer to meet these targets will also be transmitted to her progeny. Therefore, failure to achieve weight targets should make a farmer question whether the heifer is suitable as a replacement animal. No heifer should be bred at less than 60% of mature weight at 14 months of age; failure to achieve this target will normally mean the heifer is less likely to reach puberty. Mature cow weight can be defined as the average weight of cows in their 4^{th}+ parity when the calf is 200 days old. Weight ranges are outlined in Table 1. Once bred, it is important to remember that the heifer must continue to grow and some preferential management should be considered if heifers are underperforming.

The "Euro-star" Replacement Index is a useful tool for determining the potential of a cow's daughters as a suckler cow and the potential beef performance of the progeny from those daughters. If the heifer identified as a potential replacement resides in a herd registered with ICBF HerdPlus, this information is easily accessible through the "Beef EuroStar" report and farmers should assess her traits and, where possible, her parents traits. Assessing the predicted transmitting ability (PTA) and the reliability of parent traits will give the most accurate assessment of the heifer's phenotypic performance. For any trait, a higher reliability gives greater confidence that that the predicted phenotype will be displayed. Farmer's should take their cow herd averages for various maternal traits such as milk and reproduction into account when deciding which heifers to select as replacements. Replacement heifers should always have a better PTA compared to cows and farmers should try to improve traits of interest by strategically selecting heifers that improve on areas where the herd is poorest without negatively influencing other traits.

Rearing potential replacement heifers

The onset of puberty in heifers is dictated by the animal's genetics and early-life nutrition. Failure of replacement heifers to reach puberty by the beginning of the breeding season negatively impacts breeding policies and herd conception rates. At farm level, if a farmer is rearing his own replacements, they can implement a number of management practices to ensure good growth rates are achieved. Have a breeding policy to ensure cows have plenty of milk, implement excellent grassland management to ensure that cows can milk to their potential and that there is sufficient high-quality grass available to the heifer calf when she begins to graze. Post-weaning, it is important to ensure sufficient availability of high-nutritive value feed. Ensuring that only high-milk producing dams to breed replacements will also give the best chance of increasing pre-weaning growth rate. If average daily gain (ADG) is poor, supplementing concentrates should be considered to maintain high growth rates. If heifers are sourced from the dairy herd, there will normally be more opportunity to intervene with concentrates. Research from Teagasc Grange has shown that Aberdeen Angus (AA) x Friesian heifers fed to grow at 1.2 kg/day from four-to-eight months of age reached puberty 70 days earlier than heifers fed to grow at 0.6 kg/day. In contrast, when Limousin (LM) - and AA-sired suckler-bred heifers were fed a high or low plane of nutrition after eight months of age, to grow at 1.0 kg/day or 0.6 kg/day, the difference in age at puberty was only 13 days. Therefore, high ADG pre-weaning is critical to have heifers cycling at 15 months. In addition to the above, maintaining a high health status in the herd is very important to ensure that a consistently high ADG of the heifer to ensure that she meets her weight for age targets, outlined below.

Table 1. Growth targets for replacement heifers calving at 24 months of age

Stage	Age (mths)	Live weight gain (kg/day)	Target live weight (kg)[1]	How is this achieved on-farm
Birth	0	45		
Weaning/ Housing	8	1.1	275-300	- Good grazing management - High milk in cows
Turnout	12	0.6	335-375	Good quality silage + meal
Breeding	14	1.0	380-420	- 60% of mature bodyweight - Early turnout
Housing 2nd winter	20	0.8	540-570	Good grazing management
Calving	24		550-590	- 80% of mature bodyweight - In correct body condition
Birth to first- calving ADG (kg)		0.7		

[1] Early-maturing breeds and first-cross dairy heifers will be at the lower end of weight range, late-maturing breeds will be at the upper end of the weight range

An important outcome from the research above was highlighting that at 15 months of age 80% of heifers that had grown at 1.2 kg/day were pubertal compared to only 40% being pubertal after growing at 0.6 kg/day between four-and-eight months of age. Although after a 12-week breeding season conception rates are normally comparable in this situation, the six- and eight-week conception rates will be approximately 12 and 13% better for heifers that were already pubertal at the beginning of the breeding season. Research from both the USA and Canada has shown that heifers calving in the first 21 days of their first calving season had increased longevity in the herd (based on pregnancy rates) and weaned one more calf in their lifetime, compared with heifers that calved after 21 days. Therefore, developing heifers to conceive early in the breeding season is critical for heifer longevity in the herd.

Suitable sire selection

Irrespective of breed, the most important trait that a prospective bull should have is low beef heifer calving difficulty (<8%) with an associated high reliability for this trait. Once satisfied that the potential bulls for use are easy-calving then the farmer can shorten the list of bulls for use based on the traits that fit their system best.

Pre- and post-calving care of the replacement heifer

Over their second winter, heifers should be monitored closely. Heifers should be dosed and vaccinated as required to ensure that they have no health setbacks, which could impact their performance. Heifers should have a minimum body condition score (BCS) of 2.75 to ensure that they are 'fit and not fat' pre-calving. If BCS is lower than this, there will be a slower return to breeding; the heifer will be weaker at calving with poorer quality and quantity of colostrum. If BCS is too high, the heifer will have greater difficulty calving and re-breeding could be delayed. It is very easy for maiden heifers to be bullied by older cows when they are in the shed, which can cause injuries and affect their feed intakes. Ideally, heifers should be penned separately from cows to reduce bullying. Ensuring that all heifers have enough feeding and lying space is also important to maintaining intakes. A suitable pre-calving mineral is vital to reduce the risk of dystocia and post-calving infection and metabolic disorders.

After calving, heifers should be given good 'quality' feed to help them meet their energy demands. If housed indoors, they should be given high-quality grass silage (>70% dry matter digestibility), and concentrates should be considered if silage is of poor quality or if BCS is very low. First-calvers should be turned out to grass as early as possible to give them a chance to 'build' condition before breeding again. Following the weaning of her first calf, the 'heifer' usually has a lower BCS compared to mature cows. If the calf is of adequate weight, early-weaning should be considered so that the heifer is given additional time to recover before her next calving.

Cow mature weight

Beef cattle can take up to four years to reach their mature weight. There is no scientific evidence that calving at 24 months of age will reduce the mature weight of a cow. As with all animals, any setback due to poor health, restricted nutrition or anything else that reduces growth may negatively impact mature weight. The above impacts on mature weight can be prevented by high levels of technical efficiency in a suckler system.

Improving reproductive performance in grass-based suckler herds

Colin J. Byrne[1], Martina Harrington[2], Peter Doyle[1] and David A. Kenny[1]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *Teagasc, Dublin Road, Enniscorthy, Co. Wexford*

Summary

- Good reproductive efficiency is central to the economic and environmental sustainability of suckling systems.
- Monitoring body condition score and taking appropriate action is important for good reproductive performance.
- Synchronisation is a useful tool that can reduce labour and allow for increased artificial insemination (AI) usage on suckler farms.
- Stock bulls should receive consistent care throughout the year - breeding soundness evaluations should be carried out well in advance of the breeding season.
- Heat detection and recording is vital for monitoring progress during the breeding season.
- A carefully planned health protocol that focusses on prevention of scouring and respiratory illnesses is necessary for optimising reproductive performance.

Reproductive targets

A key aspect of running an efficient suckler system is good breeding management and herd fertility. Cow nutrition, bull fertility, the incidence of calving difficulty and herd health are some of the main factors that affect fertility in the herd. The traits described below in Table 1 highlight average national reproductive performance of a spring-calving suckler system compared to target performance of research farms or high-performing commercial farms. The difference between current national performance and targets shows that there is potential to improve the reproductive performance of the Irish suckler herd. It is worth noting that these targets are being reached on high-performing commercial farms so this level of performance is achievable. The current national average of 0.86 calves per cow per year means that only 86 cows in a 100-cow herd are weaning a calf every year. Achieving 95 calves weaned per 100 cows in a herd requires excellent cow and calf management, from achieving the correct body condition score (BCS) at key timepoints through correct nutrition, to a good herd health status though a proper health plan to appropriate housing. Calving heifers at 24 months of age is also key to reaching reproductive targets. The necessary practices for successful calving at 24 months of age are described elsewhere (p 112).

Earlier and compact calving of the herd is required to match turnout date with grass growth pattern in spring-calving systems; this date will vary across the country depending upon conditions. The national average six-week calving rate is 25% poorer than the target, indicating that there may be several issues at farm level, such as inadequate heat detection,

Table 1. Reproductive targets for a spring-calving suckler herd vs. national average

Key performance indicator (KPI)	National average	Target
Calves/cow/year	0.86	0.95
Calving interval (days)	396	365
Age at first calving (months)	32	24
6-week calving rate (%)	55	80

anoestrus cows or sub-fertile bulls. Heat detection needs to be excellent and at least 90% of cows should be submitted for AI or served by the stock bull in the first three weeks of the breeding season; there are several options available to improve heat detection which are outlined below.

Suckler cow nutrition

Spring-calving cows should be at a BCS of ~2.75-3.0 (0-5 scale) post-calving to allow for a BCS loss of up to 0.5 units prior to breeding, especially those that calve early relative to turnout to pasture. Cows that are in poor body condition post-calving (BCS <2.5) will have a delayed return to heat. The effects of low BCS at calving are only partially reversed by placing cows on a high plane of nutrition after calving and extra feeding after calving will not fully compensate for poor BCS at calving. For example, a cow with a poor BCS of 1.75 will not cycle until 71+ days after calving, whereas cows with a BCS of ~3.0 will be cycling by day 55. An extended post-partum interval increases overall calving interval. If cows are in good BCS (3.25-3.5) at housing, moderate dry matter digestibility (DMD 65-68%) grass silage fed *ad libitum* during the dry period, is sufficient to allow for some mobilising of body reserves and aim for a BCS of 2.75-3.0, post-calving. It is important to remember that 80% of the calf birth weight is 'grown' in the last three months of pregnancy. Where herd BCS is not uniform, group cows by BCS at housing and feed as appropriate to reach the target BCS at calving. If cows are in good BCS (>3.0) at housing and only better quality silage (>70% DMD) is available, farmers should restrict access to silage or incorporate straw into the silage to dilute the 'quality' of the offered feed. A pre-calving mineral should be offered to cows at least six weeks before calving to reduce the risk of health and metabolic problems around calving. Minerals and vitamins can be offered via water supply, boluses, mineral licks, dusting on silage or in concentrate feed, if offered. Pre-calving calcium should be minimised and magnesium increased to aid calcium metabolism. Vitamins A, D and E should be fed at high levels to ensure good immune function and reduce the post-calving risk of infection and milk fever. Conducting a silage quality analysis will provide the nutritional value, preservation efficiency and mineral profile.

Housing

Adequate feeding space of 0.50-0.65 m/cow should be available to ensure that intake is not restricted, and all cows should be able to eat simultaneously if restricted-feeding is practiced. In slatted-floor sheds, a suckler cow requires an area of 2.8-3.0 m^2 plus pens/creep areas. There is less of a requirement for a calf creep area in a spring-calving herd. In straw-bedded sheds, an area of 4.5 m^2 per suckler cow and 1 m^2 per calf, is required. Calving facilities should include a well-designed calving gate and be well lit. And you should always be able to escape a pen with ease; 12 people have been killed on Irish farms by suckler cows with calves in the last 10 years.

Oestrous synchronisation

In Ireland, less than 20% of calves in suckler beef herds are bred from artificial insemination (AI). Such low usage of AI most likely reflects the difficulty and labour requirements for heat detection, assembly of cows for insemination and land fragmentation in beef herds. Oestrous or heat synchronisation is the process of manipulating the oestrous cycle of the cow using synthetic hormones to better manage the timing of breeding. The benefits of using heat synchronisation include: align breeding and calving to best suit the availability of labour, 100% submission rate using fixed-time AI and inducing heat in anoestrous cows. Increased AI improves the use of higher genetic merit bulls and a more focused replacement heifer policy as well as improving the opportunity to compact the calving season.

To develop and test a robust and repeatable timed AI program for Irish suckler beef farmers, Teagasc conducted a large on-farm trial, which involved fixed-timed AI of over 2,200 cows on 85 herds throughout Ireland. The synchronisation protocol used in this study is outlined in Table 2. An overall pregnancy rate of 55% to the timed insemination (first-time submission) was achieved, which is good considering that approximately 50% of the treated cows were anoestrous (not resumed heat cycles) at the start of the protocol. When combined with repeat breedings, 80% of synchronised cows were pregnant in the first three weeks of the breeding season, which has very positive benefits for average herd calving interval and compactness of the subsequent calving season.

Table 2. Synchronisation protocol for suckler cows

Monday	Monday	Tuesday	Wednesday	Thursday
Day 0	Day 7	Day 8	Day 9	Day 10
Prid in + (GnRH optional)	Prid out, PG + eCG	Record heats and inseminate using AM/PM rule	Record heats and inseminate using AM/PM rule	Continue to inseminate
				Fixed time AI -72hrs after prid removal + GnRH

All drugs are prescription-only medicines and are under veterinary control. Gonadotropin releasing hormone (GnRH), prostaglandin (PG), equine chorionic gonadotropin (eCG)

As the vast majority of replacement heifers should be cyclic during the breeding season, there is a reduced requirement for incorporating an exogenous source of progesterone in the regimen for heifers. Consequently, prostaglandin-based regimens are the method of choice for use on replacement heifers. An effective regimen involves good heat detection initially carried out for six days and all heifers detected in heat are inseminated. On the sixth day, all heifers not yet detected in heat are injected with prostaglandin. The injected heifers will respond to the prostaglandin and show heat 2-4 days after injection and should be inseminated as normal; conception rates of 65-70% should be expected. The remaining heifers not yet recorded in heat and inseminated can be treated with a second prostaglandin injection 10-11 days after their initial injection. Up to 80% of heifers will respond to one or two injections of prostaglandin. Using this protocol drug use, semen costs and veterinary costs are minimised.

Bull Fertility

Bull fertility is key to maintaining a compact calving period and overall herd profitability. The reported incidence of infertility in stock bulls is generally low (3-5%), however, subfertility is much more common (20-25%), with significant differences among individual bulls. Subfertility may be caused by low libido, sperm quality/quantity, defects or physical factors affecting bull mobility or mating ability. Frequently, sub-fertile bulls go undetected and farmers may be unaware of the problem until much of the breeding season has elapsed or until pregnancy scanning. Furthermore, there is no guarantee that a bull will retain his fertility from season to season or even within a season. Thus, farmers must be continually vigilant for potential fertility problems so that corrective action can be taken. Bull Breeding Soundness Evaluation (BBSE) is widely recommended to aid the identification of potential fertility issues in advance of the onset of the breeding season. Ideally, a BBSE should be conducted annually by a veterinary surgeon at least 60 days prior to the start of the breeding season. This will facilitate re-testing and timely replacement of bulls that may fail the examination. The British Cattle Veterinary Association has introduced a certification protocol for evaluating bulls for breeding purposes which involves four steps: i) Physical examination, ii) Semen examination, iii) Assessment of mating ability (if possible) and iv) Classification or overall prognosis. For each of the above examinations, bulls failing to reach a certain threshold will result in the bull being classified as "unsatisfactory". Bulls passing the physical and semen examination and/or assessment of mating ability examinations are classified as "suitable for breeding". While these evaluations identify bulls with substantial deficits in fertility, they do not consistently identify sub-fertile bulls. Therefore, farmers should monitor and record heats during the breeding season to identify potential problems.

Heat detection

Regardless of the breeding strategy used, good heat detection is vital for successful breeding. There are a number of methods that a farmer can choose from.

Visual heat detection: observe all cows for a minimum of twenty minutes, four times per day, spread evenly across the day as much as possible.

Vasectomised bull: a vasectomised bull fitted with a chin ball marks the cows on the top of their backs when he is serving them. Position yourself to see the marks on the backs of the cows, and ensure that the paint in the chin ball is topped up as required.

Digital technology: systems that are based on cow activity and rumination can be used to alert farmers that a cow is in heat or systems that incorporate a vasectomised bull and use proximity alerts to notify a famer that the cow is in heat.

Tail Paint: apply a narrow strip 1.5-2.0 inches in width to the tail head. When the paint is completely rubbed off the cow, she is in standing heat. It is helpful to change the colour of the tail paint when the cow is AI'd, to help identify repeats and undetected cows.

Heat mount detectors: Scratch cards and Kamars applied to tail head - changes in colour indicate heat.

Animal health

A comprehensive health plan is vital for prevention of diseases that may cause reproductive wastage in suckler cows. A farm-specific vaccination protocol should be discussed with your local vet. Some common diseases include, rotavirus, coronavirus (vaccines should be administered between 12 and three weeks before calving), bovine viral diarrhoea, leptospirosis (vaccines should be administered approximately four weeks before breeding) and infectious bovine rhinotrachitis (IBR) (vaccines should be boosted every six months). Other diseases should be vaccinated for if they are found to be present on farm.

Distribution of time of calving in the suckler cow herd

Noeleen Brereton, Bernadette Earley, Colin Byrne, Peter Doyle and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- When daily calving pattern was divided equally into three 8-hour periods defined as, 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00), substantial variation was evident across years; however, the overall mean percentages of cows calving in those three periods were 32, 36, and 32%, respectively.
- When daily calving pattern was divided on the basis of 'darkness' (16:00-08:00, i.e. 16 hours) and 'daylight' (08:00-16:00, i.e. 8 hours) the mean percentage of cows that calved during those two periods was 64 and 36%, respectively.
- The mean percentage of 'assisted' and 'unassisted' calvings over 15 herd-years, during the 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00), was similar.

Introduction

Calving is a critical part of the reproductive lifecycle of the cow, and can be associated with high levels of calf morbidity and mortality, as well as leading to subsequent cow reproduction-related complications, due to calving difficulty (dystocia). It is also the time during which the cow-calf maternal bond is formed, and when the immune-compromised neonatal calf derives its passive immunity through ingestion of colostrum. In this regard time to first-suckling is crucial. The implications associated with a difficult calving for the calf include a poorer maternal bond, delayed colostrum consumption and possible failure of passive transfer of immunity. According to DAFM, in 2021 1.84% of calves died from 0-6 weeks of age on suckler farms in Ireland. Stockperson presence at calving time can reduce calf loss and reduce the dystocia-related stress on the cow and calf. Anecdotally, it is often assumed that animals have a preference to calve during quiet periods on the farm with no noise and in 'darkness' at night to reduce the 'risk-of-predation' when giving birth. Consequently, quantifying the hourly distribution of time of calving during the '24-hour day' in suckler cows is of interest, with a preference for cows calving during 'normal' working hours or during 'daylight' hours, when labour is more freely available, rather than during the 'dark' or 'night'. Teagasc research indicates that livestock accounts for 65% of all on-farm injuries, and that 35% of fatal accidents are from attacks by 'cow with calves'. Calving is an exceptionally busy and labour-intensive period on-farm, and working with calving cows, especially at 'night', can pose an increased safety risk to farmers. As part of a larger project at Teagasc Grange investigating the development of the cow-calf maternal bond, we are also looking at factors influencing time of calving in suckler cows. Therefore, the objective of this study was to examine the normal diurnal and nocturnal distribution of calving using data collected from spring-calving suckler cow herds at Teagasc, Grange.

An evaluation of cow-calving pattern

Time of calving data were available from 15 different 'herd-years'. The dataset comprised of beef × beef (n = 802) and beef × dairy (n=509) cow breed types, of which about 45 % of the total were primiparous (first-calvers) and 55 % were multiparous (parity of ≥ 2). The breeds represented in the cows included Charolais, Limousin, Hereford, Aberdeen Angus, Belgian Blue, Salers, Simmental, and Friesian. The cows were bred to Aberdeen Angus, Blonde d'Aquitaine, Belgian Blue, Charolais, Hereford, Limousin and Simmental sires.

The cows were accommodated indoors each year and generally offered moderate dry matter digestibility grass silage *ad libitum,* pre-partum. In occasional years straw was included in the diet during the weeks immediately prior to calving. Time of daily feeding was usually in the morning. Cows had free access to water and received a mineral and vitamin supplement daily. Prior to parturition (approximately 1 to 7 days) the cows were moved to straw-bedded calving pens. Assistance at calving was recorded: 1 = no assistance; 2 = minor handling ('checking'); 3 = minor assistance; 4 = mechanical assistance (calving jack) and 5 = caesarean section. For the purposes of presentation of results, calving difficulty was divided into two categories namely, 'unassisted' (score 1 and 2 combined) and 'assisted' (score 3-5 combined). Cow body condition score (BCS) was assessed post-calving on a scale of 0 to 5 (0 = emaciated; 5 = obese).

Calving times were expressed hourly over the '24-hour' day. To define daily calving pattern, each '24-day' was divided equally into three 8-hour periods defined as, 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00). A further categorisation representing spring-time 'daylight' (08:00-16:00) and 'darkness' (16:00-08:00) hours, was also evaluated.

Results

The mean hourly distribution of calvings over the 15 'herd-years' is presented in Figure 1. The percentage of cows calving hourly ranged from 2.6 to 5.4%, with a mean of 4.2%.

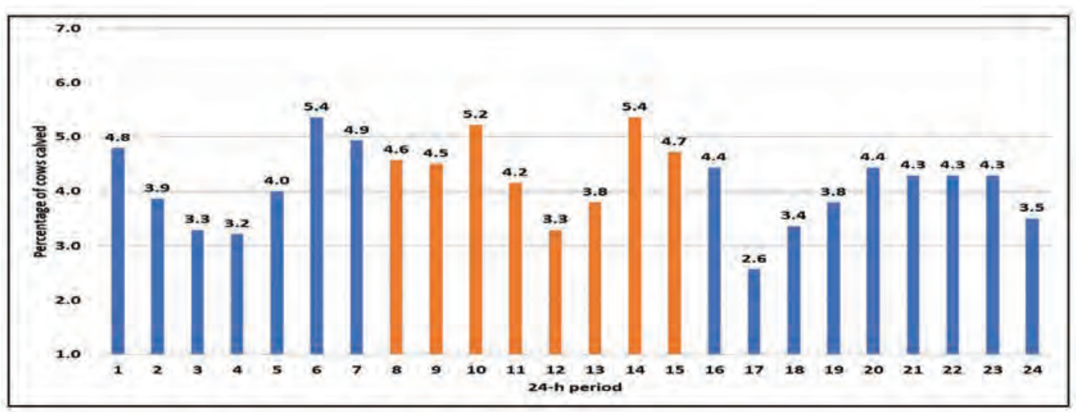


Figure 1. The percentage of cows that calved hourly throughout the '24 hour' day ('daylight', 08:00-16:00) ('darkness', 16:00-08:00)

The distribution of calvings for each individual 'herd-year' expressed as three 8-hour periods, is shown in Figure 2. Large variation existed between years in the distribution of calvings when categorised as 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00). The percentage of 'night' calvings varied from 21-46%, 'morning-day' calvings varied from 27-46% and 'evening-day' calvings varied from 22-46%. However, when averaged across the 15 herd-years the overall mean percentage of cows calving in 'night', 'morning-day' and 'evening-day' was 32, 36, and 32%, respectively, indicating a relatively even distribution.

When the distribution of calvings for each individual herd-year was expressed as the percentage of cows that calved during 'darkness' (16:00-08:00) and during 'daylight' (08:00-16:00) hours, 64% of cows calved during the 16 hours of 'darkness' and 36% calved during the 8 hours of 'daylight'.

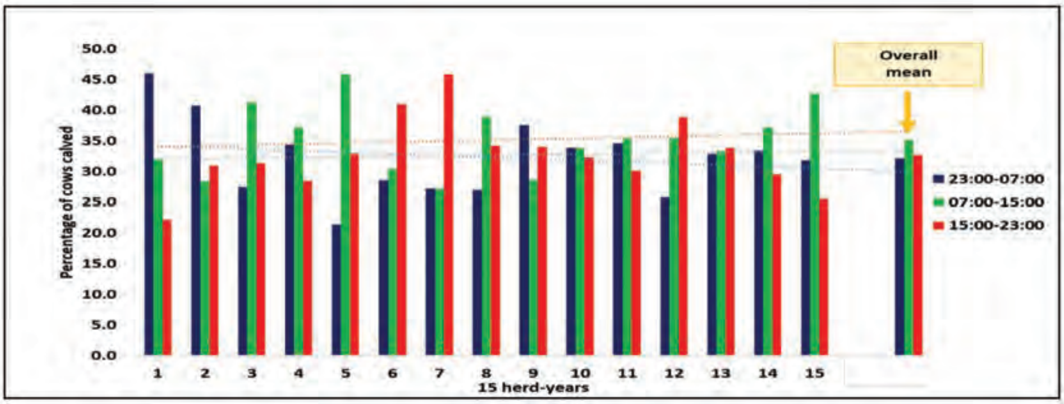


Figure 2. Overall mean distribution of calvings over three 8-hour periods - 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00) - for the 15 individual herd-years

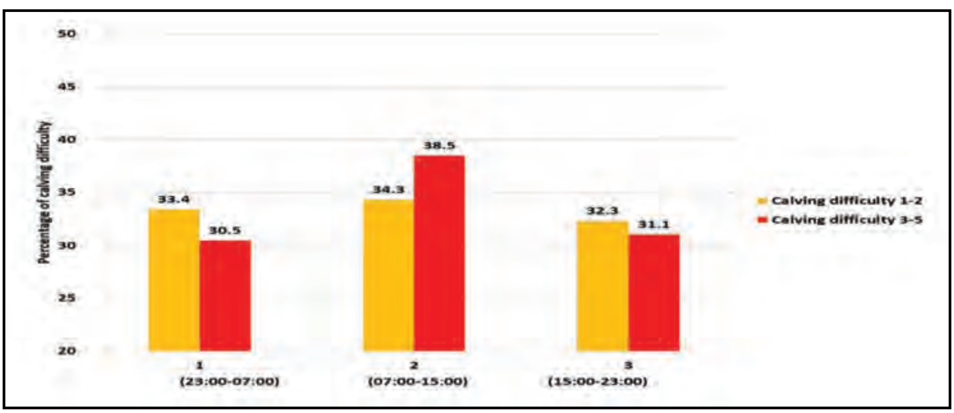


Figure 3. Mean percentage of 'unassisted' (calving difficulty scores 1 & 2) *v.* 'assisted' (calving difficulty scores 3, 4 & 5) calvings over 15 herd-years in three 8-h periods, namely 'night' (23:00-07:00), 'morning-day' (07:00-15:00) and 'evening-day' (15:00-23:00).

The overall percentage of cows that were 'assisted' or 'unassisted' at calving during each of the three 8-hour periods 'night', 'morning-day' and 'evening-day' when averaged across the 15 herd-years are shown in Figure 3. There was a numerically lower percentage of cows requiring calving assistance during the 'night' and 'evening-day' periods with the opposite occurring during the 'morning-day'.

Mean cow BCS post-calving (2.5, scale 0-5) did not differ between the three 8-hour periods.

Cow-calf maternal bond research

In suckler cow production systems, successful calving entails producing a healthy, viable calf without any detrimental effect on the cow. The importance of investigating the maternal bond formed with suckler cows and their offspring is important for the survival of the calf. Calves are born with an undeveloped immune system and rely on antibodies and other components in colostrum (first-milk) for protection from disease, as well as nutrition. Research suggests calf vigour and calving ease play a crucial role in successful passive transfer for the beef calf. At Teagasc Grange, we are studying the development of the cow-calf bond, suckling behaviour and calving times in the suckler cow herds and evaluating the effect of dam breed type (early- and late-maturing beef crossbred and beef × dairy cows) and cow genetic merit (high and average Replacement Index). Calvings were recorded using CCTV footage. The time post-calving when certain behaviours occurred including when the cow approaches the calf, licks the calf, the calf attempts standing, calf stands, calf attempts suckling and calf successfully suckles, were determined for analysis. Additional aims are to evaluate the method of colostrum intake (assisted v. unassisted suckling) based on the calf 'suckle-reflex' at 10-minutes post-birth. Colostrum samples were collected, prior to suckling, for immunoglobulin (Ig) concentration determination. A blood sample was obtained by jugular venipuncture from calves at 48-hours post-birth to determine calf immune status. After parturition animals remained in the calving pens for a minimum of 2 days with the calf having free access to the dam.

Acknowledgements

Funding from the DAFM Research Stimulus grant (RSF Ref. 17/S/269) is gratefully acknowledged.

Effect of age of suckler beef calves on stress indicators and growth performance in response to Burdizzo castration

Bernadette Earley, Mark McGee and Gabriela A. Marquette

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Burdizzo castration is stressful for both 2.5- and 5-month old suckler beef calves.
- An increase in abnormal postures, a prolonged plasma cortisol response, and greater increase in scrotal circumference was observed in older calves compared to younger calves.
- No impact of castration was evident on growth performance for either age.
- The use of analgesics during castration should be considered, especially when castrating older calves.hectare by 50%, which is mainly attributed to feeding an 'unproductive' heifer.

Introduction

Castration of male calves intended for beef production is a common practice in many countries. There is a general perception among producers that delaying castration could extend the production advantages of keeping animals as bulls until weaning or beyond puberty. The question that we addressed in this study was whether a reduction in the age at castration is of benefit to cattle welfare?

Legal position

Castration of cattle is usually performed in order to prevent sexual behaviour, reduce aggression, and increase handling safety. In Ireland, cattle can be castrated, other than by a veterinary practitioner, before 6 months of age using a Burdizzo, or before 8 days of age using a rubber ring (S.I. 127 of 2014), in both cases without the use of anaesthesia and analgesia (S.I. 107 of 2014). Over these age limits, local anaesthesia (VPO), must be administered by a veterinary practitioner only to animals intended for castration.

Burdizzo castration

Burdizzo castration is based on the principle that 'crushing' destroys the spermatic cord carrying blood to the testicles but that the skin of the scrotum remains intact. Each spermatic cord is crushed twice (second crush below the first) for 10 seconds each along the neck of the scrotum with the Burdizzo to ensure completeness of the castration procedure.

With this technique, the testicle is left to atrophy in the scrotum, and because of the lack of open wounds the potential for haemorrhage or infection is minimised.
The Burdizzo must be in good condition. The jaws must be parallel and close uniformly across their width so that pressure will be applied evenly across the jaws. Leave the Burdizzo slightly open when not in use.

Calf castration study

The study objective was to examine effect of age at castration on stress indicators and performance of suckler calves. Forty crossbred (sire breeds; Aberdeen Angus, Charolais, Limousin and Simmental) beef calves from the suckler herd at Grange were used. Calves were assigned to two age groups and two castration treatments; calves 2.5- or 5.0-months old (mean body weight = 121 and 218 kg, respectively) were sham handled (control) or Burdizzo castrated (n = 10 per treatment) (Table 1).

Table 1. Calf age and weight per treatment.

Age	Treatment	Number of calves	Mean age (days)	Mean weight (kg)
2.5-months	Control (sham[1])	10	80	121
2.5-months	Castrated	10	80	120
5.0-months	Control (sham)	10	153	214
5.0-months	Castrated	10	157	223

[1] Sham handled (not castrated) by briefly holding the testes to the side of the scrotum.

All calf-dam pairs were grazed together at pasture before the experiment. Ten calves (5 castrated; 5 sham) were randomly selected each week of the experiment, starting with 2.5-month old calves (May/June) followed by the 5.0-month old calves (August). The timing of experimental procedures is detailed in Table 2.

Table 2. Description of experimental procedures and timing pre- and post-treatment. "X" denotes timing of procedures.

	Hours relative to treatment (0 h)				
Procedures	**-48**	**-24**	**0**	**24**	**48**
Acclimatisation of calf-dam pairs in the housing facility	X	X			
Calf-dam assigned to treatment	X	X	X		
Calf weights		X			
Scrotal measurements		X		X	X
Treatment (castration or control)			X		
Blood sampling of calves			X	X	X
Video recording (continuously)		X	X	X	X

At 48-hour before treatment (castration or control), the calf-dam pairs were housed and penned together for an acclimatisation period. Each calf-dam pair was allocated to a pen in which the dams were restrained for 11 hours each day with access to feed and water, and adequate space to lay down and stand up. Each calf was tethered behind its dam and had free access to suckle and to feed. Treatments were applied at random across the 10 pens containing the dam-calf pairs. Calves in the control group were castrated 99 days (2.5-month old) and 27 days (5.0-month old) after treatment.

Animal measurements

Calves were weighed at -1 d relative to castration (day 0) for a baseline bodyweight. A final bodyweight of calves was recorded at 27 days post treatment for each age group. An additional bodyweight of 2.5-month old calves was recorded before castration of control calves 99 days after castration of this age group. All calves were fitted with jugular catheters on the day before castration, and blood samples were collected at -0.5, -0.25, 0, 0.25, 0.5, 0.75, 1.25, 2, 3, 4, 5, 7, 9, 24, 48 hours (h), relative to castration (0 h).

Results

Growth performance

There was no effect of castration on calf live weight gain (1.4 kg/day) from day -1 to 99.

Stress hormone - plasma cortisol concentration

The concentration of total cortisol increased after castration until 0.5 h and decreased until 4 h post treatment (primary response). There was a secondary increase in plasma cortisol concentration 4 hours after treatment, which remained high until at least 9 hours post castration (secondary response). Calves 5.0-months old had a greater cortisol concentration than 2.5-month old calves, regardless of treatment, from baseline (0 h) to 4 h and from 4 h to 9 h after treatment. In addition, castrated calves had a greater cortisol concentration than control calves, regardless of age. Cortisol peak and increase to peak were increased in calves castrated at 2.5-month old and in control and castrated calves 5.0-months old compared with 2.5-month old control calves (Table 3).

Table 3. Effect of Burdizzo castration at 2.5- and 5.0-months old on changes in plasma cortisol concentrations in calves.

	2.5-month old		5.0-month old		Sig.[1]	
	Control	Castrated	Control	Castrated	Age	Castration
Cortisol baseline (0 hour), ng/ml	8.9	9.3	9.0	9.2	NS	NS
Interval to peak, hour	0.4	0.5	0.5	0.7	NS	*
Peak cortisol concentration, ng/ml	10.4[a]	26.1[b]	21.7[b]	33.9[b]	**	***
Increase to peak, ng/ml	5.7[a]	19.8[b]	16.7[b]	27.7[b]	***	***

[1]NS = not significant; * = P<0.05; ** = P<0.01; *** = P<0.001

Behaviour

Following castration, calves spent more time standing during the first hour, regardless of the treatment. Duration spent lying was decreased in the first hour compared with the second and third hour after treatment. There was no difference in time spent standing in an abnormal position between 2.5- or 5.0-month old control calves for any sampling time. However, calves castrated at 5.0-months old spent more time standing in an abnormal position (928 seconds) compared with calves castrated at 2.5-months old (358 seconds), in the first hour post-castration. Castrated calves exhibited more foot stamping compared with control calves, regardless of the age at castration. In addition, a greater number of foot stamping events was observed in the first hour after treatment.

Scrotal swelling

Before treatment (-24 h), the mean latitudinal scrotal circumferences was greater for 5.0-month old calves compared with 2.5-month old calves. Both latitudinal and longitudinal scrotal circumferences were increased in castrated calves at 24 and 48 h after treatment compared with their respective baseline. Calves castrated at 5.0-months old had a greater increase in latitudinal scrotal circumference at 24 and 48 h compared with 2.5-months old castrates. No difference was observed in longitudinal scrotal circumference between 2.5- and 5.0-month old castrated calves.

Conclusion

The increased plasma cortisol concentration following castration observed in this study suggests that Burdizzo castration is stressful for both 2.5- and 5.0-month old suckler beef calves. However, an increase in abnormal postures, scrotal swelling and a prolonged plasma cortisol response observed in older calves suggest that these calves suffered more stress induced by handling and castration. Therefore, castration of younger suckler calves is preferable from an animal welfare point of view.

The age-related differences in stress response found in this study need to be considered when recommending the use of anaesthesia and analgesia during castration, especially for older calves. The timing of pain relief (analgesia) administration should be planned to effectively reduce the stress response according to the age of the calf.

The practical implications of the study are that if calves are to be castrated without analgesia or anaesthesia, then it would be preferable to do this at 2.5-month old rather than later, in order to minimize the stress associated with Burdizzo castration.

Castration procedures in calves/cattle – best practice

- A person castrating calves must have the relevant knowledge, experience and skills, or be under the direct supervision of a person who has the relevant knowledge, experience and skills.
- Care should be taken to ensure that an animal is in good health and not suffering from any disease that is likely to hinder its progress after castration.
- On rare occasions, calves will have a larger than normal opening between the abdominal cavity and the scrotum, allowing intestines and/or fat to descend into the scrotum. An inguinal hernia will look like a large swelling on one side of the scrotum, often near the top. This swelling will often feel soft, due to the intestines or abdominal fat descending into the area. Do not attempt to castrate a calf if an inguinal hernia is suspected. Consult with your veterinarian.
- The efficient handling and restraining of animals is necessary if accidents to the operator, his/her assistants, and the animals are to be avoided. Calves should be adequately restrained and held by experienced handlers.
- The degree and duration of restraint for calves should be the minimum necessary to allow a procedure to be done efficiently and safely.
- Castrated animals should be checked frequently during the days following castration to detect any signs of infection or abnormal scrotal swelling. Seek veterinary assistance if needed.

Early diagnosis of bovine respiratory disease using clinical respiratory signs and thoracic ultrasonography

Bernadette Earley, Mark McGee and Inmaculada Cuevas-Gómez

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Diagnosis of bovine respiratory disease (BRD) by examination of clinical respiratory signs or listening to lung sounds is insufficient to determine the type, severity and extent of BRD, especially sub-clinical BRD.
- Detection of sub-clinical BRD in cattle with lung lesions without showing clinical respiratory signs, can only be confirmed using thoracic ultrasonography (TUS).
- The combination of clinical respiratory scoring and TUS provides a more accurate classification of BRD and sub-clinical BRD.
- Thoracic ultrasonography is also useful for evaluating the prognosis of BRD and monitoring the efficacy of treatment.

Introduction

Bovine respiratory disease (BRD) is a disease of multifactorial aetiology affecting cattle of all ages. The multifactorial syndrome results from a complex interaction between infectious agents (bacteria, viruses), host immune status and external stressors (e.g. weaning, transport, changes in diet and/or the housing environment). It is the most prevalent disease of calves (one to five months of age) and weanlings (six months to one year of age) in Ireland, accounting for 33% and 40% of deaths, respectively (all-island animal disease surveillance report, 2020). The economic impact of BRD is significant and it poses a major challenge to efficient bovine livestock production and welfare as well as indirect economic losses due to reduced animal growth.

Clinical diagnosis of BRD

Evaluation of clinical respiratory signs (cough, nasal discharge, eye discharge, ear drooping or elevated rectal temperature) is widely used at farm level for BRD diagnosis. Different respiratory scoring charts have been developed, especially for pre-weaned dairy calves (birth to 2 months old). These BRD-scoring systems are one way to standardize diagnosis that can be easily applied by stockpersons. The one most frequently applied, with some modifications, is the Wisconsin calf respiratory scoring chart. This scoring system classifies rectal temperature, presence of cough, appearance of nasal and eye discharges, and ear position with scores ranging from 0 to 3 (from normal to very abnormal), and the sum of all scores of each clinical signs define the total clinical respiratory score.

Lung lesions detection: thoracic ultrasonography

Thoracic ultrasonography (TUS) is a rapid, non-invasive, on-site diagnostic and prognostic tool for detecting lung abnormalities. Thoracic ultrasonography has greater accuracy for BRD diagnosis compared to conventional methods such as auscultation (listening to lung sounds) or clinical scoring criteria. Different abnormalities that can be detected using TUS are the presence of pleural fluid accumulation, abscesses or lung consolidation. Transrectal probes are already widely used by bovine veterinarians for pregnancy diagnosis and are suitable for thoracic ultrasonography. Large-size calves (>70 kg) should be restrained in a chute to perform the technique, whereas restraining in a chute is not required for small-size calves. Clipping the hair of the thorax overlying the lung area is usually not necessary though hair can be clipped for a better ultrasonography image. Isopropyl alcohol (70%) is used as the transducing agent and is applied using a spray bottle to the left and right thorax. Maximal depth of the ultrasound probe should be set between 8 and 10 cm for calves of larger sizes (> 250 kg) and between 6 and 8 cm for smaller calves. Both sides of the thorax should be evaluated. The probe should be placed in the intercostal spaces parallel to the ribs and moved from dorsal to ventral along the grain of the hair (Figure 1). The key for an accurate scanning lies on systematic evaluation, starting from the 10th intercostal space and moving cranially to the 1st intercostal space for the right lung and from the 10th intercostal space to the 2nd intercostal space for the left lung. In small-size calves, access to the cranial thorax in the axillary region can be performed using transrectal probes. However, with large size calves, particularly when restrained in a chute, it is not possible to scan the 1st to 3rd intercostal spaces, due to access when restrained, limiting the evaluation of the cranial lung lobes where lung lesions are more likely to be found. Nevertheless, lung lesions placed within the 4th, 5th, and 6th intercostal spaces have been associated with negative health outcomes in large size calves.

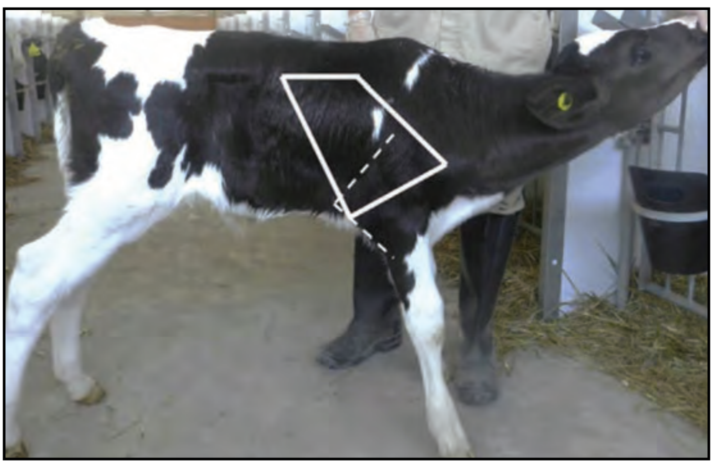


Figure 1. Lung field of calf showing area where thoracic ultrasound measurements are taken

The ultrasonogram of a normal aerated calf lung is characterised by the presence of a bright hyperechoic line representing the pleura with several reverberation artefacts below it (Figure 2).

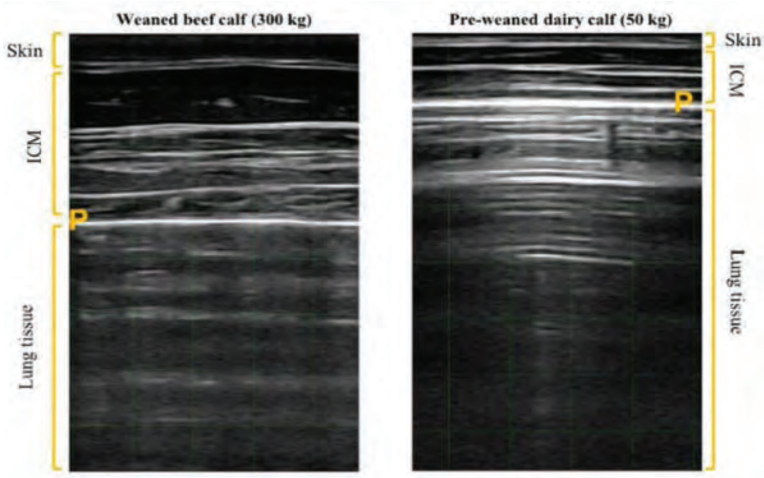


Figure 2. Ultrasonogram of a normal aeriated lung in weaned and pre-weaned calves. Thoracic ultrasounds performed using an 8 MHz WiFi linear transducer (Tecnoscan SR-1C, Imporvet, Spain) at a maximal depth of 8cm and gain of 60 dB. ICM, intercostal muscles; P, pleura

Lung consolidation (also referred to as lesions) appear in the ultrasonogram as a hypoechoic area of varying size that disrupts the reverberation artefacts and, sometimes, the pleura (Figure 3).

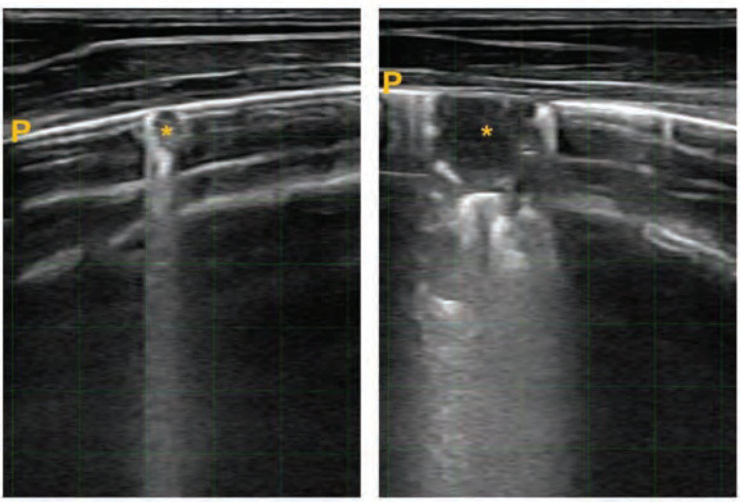


Figure 3. Ultrasonograms with different sizes of consolidation (lobular pneumonia). Lung consolidation (star); P, pleura.

The importance of an early and accurate BRD diagnosis

Early and accurate diagnosis of BRD is essential to guide more prudent use of antimicrobials, lower relapse rates and reduce animal morbidity and mortality. Nonetheless, the diagnosis of BRD remains a challenge due to the lack of "gold standard" diagnostic methods for the live animal meaning that delayed and under-detection of BRD is a significant problem. Recent studies at Teagasc Grange, showed that 18% (28/153) of purchased suckler weanlings and 28% (15/53) of purchased dairy-bred calves had lung lesions that were not detected using the Wisconsin calf respiratory scoring chart (i.e. were scored 'CRS -') in the first month after their arrival to the research centre (Table 1). This implies that using only clinical scoring (i.e. CRS) may present “false negatives” in terms of BRD detection. Animals not showing a clinical presentation of BRD (i.e. ‘CRS -’) but having lung lesions were classified as sub-clinical BRD cases. This “silent” presentation of BRD is important since economic losses are associated with sub-clinical BRD. Suckler weanlings with lung lesions, detected using TUS, had a reduction in live weight gain of 28% (0.23 vs. 0.32 kg/day) during the first 65 days after housing compared to those without lung lesions. The live weight gain of the artificially-reared dairy calves with severe lung lesions (lung lobe completely consolidated or pulmonary emphysema) was 0.09 kg/day less than calves without lung lesions during the first 53 days after arrival. The association of BRD with decreased live weight gain and increased morbidity and mortality, therefore has important implications for farm profitability.

Table 1. Distribution of 153 purchased suckler ‘weanlings’ and of 53 purchased dairy calves according to clinical respiratory score and thoracic ultrasonography up one month post-arrival at Teagasc, Grange.

	CRS[1] status		Total number and %
	-	+	
	TUS[2] status		
Suckler ‘weanlings’			
No lung lesion	71	30	101 (66%)
Lung lesion	28	24	52 (34%)
Artificially-reared dairy calves			
No lung lesion	15	4	19 (36%)
Lung lesion	15	19	34 (64%)

[1] Clinical respiratory score (CRS). Calves were considered CRS **+** when the score was ≥ 5 (this score results from the sum of rectal temperature, ear, nasal, eye and cough scores which are evaluated from normal (0) to very abnormal (3)). [2]Thoracic ultrasonography (TUS) status, presence or absence of lung lesions.

Conclusion

Thoracic ultrasonography detected sub-clinical cases of BRD that were undetected by clinical respiratory signs alone. The presence of severe lung lesions was associated with reduced pre-weaning growth. These findings emphasise the importance of using TUS in addition to clinical respiratory scoring of calves for an early and accurate detection of clinical and sub-clinical BRD.

Acknowledgements

Funding from the DAFM (Dr. B. Earley project leader) under the US- Ireland Tri Partite Grant (2018US-IRL200) is gratefully acknowledged.

Bovine respiratory disease (BRD) diagnostics

Kerrie Duffy, Matthew McCabe, Paul Cormican and Bernadette Earley

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Novel diagnostic protocols for the identification of bovine respiratory disease (BRD) pathogens are being developed at Teagasc Grange.
- Two 'sequencing' approaches i) Oxford Nanopore and ii) 16S amplicon sequencing, characterised viruses and bacteria, respectively, that were isolated from nasal swabs from 'healthy' and BRD-positive suckler weanlings and dairy calves.
- Viruses identified in suckler weanlings included bovine coronavirus (BCoV) and bovine rhinitis A virus (BRAV), while Filobacterium, a genus of uncertain BRD aetiology, was found in higher abundance in BRD positive animals.
- Accurate BRD diagnosis using 'sequencing' can guide appropriate animal treatment, thereby reducing antibiotic use on farms.

Introduction:

Bovine respiratory disease (BRD) or pneumonia, is one of the most common and costly diseases in global bovine production and develops from numerous contributing factors, stemming from the complex interaction concerning the health status of the animal, the environment (housing, transport) and infectious agents. The disease has a high morbidity and mortality rate, which presents significant economic costs and an animal welfare challenge to the beef industry. Multiple opportunistic agents of viral and bacterial origins cause BRD by manipulating and suppressing the animal's immune system. Typically, this is initialised and established by a primary viral infection and subsequently leads to a secondary bacterial infection. The main tools used to attempt to reduce the impact of BRD have been vaccines and broad-spectrum antibiotics; however, the large-scale use of antibiotics to treat infectious diseases has coincided with an increase of antibiotic resistance. Multi drug resistance has been observed in BRD associated bacteria such as *Pasteurella multocida,* highlighting the necessity to fully characterise BRD pathogens in order to develop alternatives to antimicrobials such as vaccines. Rapid detection and identification of animal health pathogens is essential in the efficient and timely treatment of disease outbreaks.

The infectious agents associated with BRD:

According to the animal health surveillance report (DAFM, 2020), bovine respiratory syncytial virus (BRSV) and IBR virus (bovine herpesvirus 1) were responsible for 8.1% and 2%, respectively, of total BRD cases in Ireland based on post-mortem examination. In terms of bacteria BRD-related cases, *Pasteurella multocida, Mannheimia haemolytica, Histophilus* *somni* and *Mycoplasma bovis* contributed to 12.3%, 17.7%, 7.9% and 9.6%, respectively, of the total cases. Bovine coronavirus (BCoV) was detected in low abundance (1.3%); however, this report highlighted the uncertainty of this virus and its association as a BRD agent.

How do we define clinical BRD cases?

Conventional methods of BRD classification involve assessing animals using a total clinical respiratory score (CRS), ranging from a score of 0 (normal) to 3 (abnormal). There are five clinical signs that are used to calculate the CRS. These are: (1) rectal temperature >39.5°C, (2) ear position, (3) cough, (4) nasal discharge, and (5) eye discharge. Internal assessment of the animal's lungs by thoracic ultrasonography (TUS) can detect subclinical BRD cases where animals are not displaying any of the five CRS clinical signs (see p 128). Teagasc research has shown that TUS provides an early diagnosis of BRD by detecting lung consolidation ($\geq$ 1 cm^2) in animals where CRS has failed to diagnose BRD.

Novel diagnostic tools being developed in Teagasc Grange

Molecular and *in vitro* culture investigations into the causative agents of BRD are measured using a gold standard technique, quantitative polymerase chain reaction (qPCR), and bacteriological and viral culture. These techniques however, have limitations. Firstly, the turnover time from nasal swab collection to the laboratory for sample preparation, analysis and culture, is slow, which means they are not useful for informing timely and targeted therapeutic intervention by veterinarians. Secondly, qPCR targets only previously documented pathogens and considering many bacteria are too difficult to culture, these techniques fail in characterising unknown BRD pathogens.

Two novel diagnostic tools (Figure 1) capable of detecting unknown BRD pathogenic agents are in use and development in Teagasc Grange, namely: The Oxford Nanopore MinION M1kC and 16S ribosomal amplicon sequencing.

Figure 1. The Oxford Nanopore MinION M1kC (on the left) and the Illumina MiSeq instrument (on the right)

Overall our research aims to describe the nasal viral (virome) and bacterial (microbiome) agents by Nanopore and 16S ribosomal amplicon sequencing, respectively, that are associated with BRD in beef suckler weanlings and pre-weaned dairy calves. Previous research in Teagasc Grange led to optimised sequencing protocols in calves that were artificially-challenged with two of the common BRD pathogens (BRSV and BoHV-1). We now aim to assess the potential of the MinION M1kC sequencer for identification of all viruses (known and unknown) in naturally-infected beef and dairy cattle.

Research study

Suckler weanlings purchased through auction marts and dairy calves purchased from commercial farms, respectively, and housed indoors were used in the study. Animals were vaccinated 24 h post-arrival (day 0) against bovine respiratory syncytial virus (RSV), parainfluenza-3-virus (PI3), *Mannheimia haemolytica* A1 (Bovilis Bovipast RSP, MSD Animal Health), bovine herpesvirus type 1 (Bovilis IBR marker live, MSD Animal Health), and against clostridial diseases (Covexin 10, Zoetis). Clinical respiratory score (CRS) and thoracic ultrasonography (TUS) were used to classify BRD positive (CRS+ and TUS+) and BRD-negative (CRS- and TUS- i.e. 'healthy') calves. Nasal swabs were taken from sixty suckler weanlings (30 BRD-positive and 30 BRD-negative) and 20 pre-weaned dairy calves (10 BRD-positive and 10 BRD-negative) and DNA and RNA (nucleic acids) was extracted before sequencing on each technology. Key time points were targeted for sequencing including; the day of calf arrival from auction marts or commercial farms to Grange (day 0), day of BRD detection (dayBRD) and end of study sampling (day 28, microbiome only).

1. The Oxford Nanopore MinION:

The MinION M1kC sequencing device successfully characterised both RNA and DNA viruses in suckler weanlings (Table 1). Results of the Nanopore sequencing confirmed both healthy and BRD animals were infected with BRD-associated viruses, with BCoV and bovine rhinitis A virus (BRAV) showing high prevalence over the common BRD-associated viral agents. At day of BRD detection, BRD calves had a statistically significant (P=0.01) higher BRAV load (i.e. more virus replication) as determined by qPCR. The quick turnaround time from swab collection to result, coupled with the portability of the M1kC DNA sequencer, means that this approach has potential for use as a pen-side diagnostic tool. The MinION M1kc sequencing results of the dairy virome are being processed and analysed.

Table 1. Viruses and the day of sequencing identified by the Oxford Nanopore MinION Mk1C sequencer from nasal swabs of healthy and BRD suckler weanlings

	Time points sequenced and viruses identified in both healthy and BRD animals	
	Day 0	**DayBRD**
Nasal virome identified to species level	BCoV	BCoV
	BRAV	BRAV*
	BRBV	BRBV
	BRSV	BRSV
	BVDV	BVDV
	BPIV3	BPIV3

* **BRAV was significantly higher in BRD animals than healthy controls at dayBRD**

2. 16S ribosomal amplicon sequencing:

Defining the bacterial agents of BRD is further facilitated by 16S ribosomal (r) RNA gene sequencing, which is performed on the Illumina MiSeq instrument. This technique exploits the conserved and variable sequences of the 16S gene in all bacteria and enables accurate bacterial genera identification. Using 16S rRNA gene sequencing of the nasal microbiome, we have identified the common bacterial genera associated with BRD ie *Mannheimia, Pasteurella* and *Mycoplasma* (Table 2), with significant differences in the genus *Filobacterium* between healthy and BRD suckler beef weanlings. Furthermore, we have identified longitudinal changes in relative Mycoplasma abundance with greater increase of abundance occurring at dayBRD. Currently, sequencing results of the dairy microbiome model are being processed and analysed.

Table 2. Bacteria and day of sequencing identified by 16S ribosomal amplicon sequencing in nasal swabs of healthy and BRD suckler weanlings

	Time points sequenced and bacteria identified		
	Day 0	**DayBRD**	**Day 28**
Nasal microbiome Identified to *genus level*	*Moraxella*	*Mycoplasma*	*Filobacterium*
	Mycoplasma	*Moraxella*	*Moraxella*
	Filobacterium	*Mannheimia*	*Pasteurella*
	Mannheimia	*Pasteurella*	*Filobacterium**
	Streptococcus	*Filobacterium*	*Mannheimia*
	Corynebacterium	*Corynebacterium*	*Ureaplasma*
	>20 more	*>20 more*	*>20 more*

***Filobacterium* was significantly higher in BRD animals than healthy controls at day 28**

Early diagnosis of BRD is vital to maintaining the overall health of the animal and reducing the likelihood of severe disease or even death. The sequencing technologies from Oxford Nanopore and Illumina provide early molecular knowledge on the species of virus and/or bacteria infecting the herd, meaning the veterinarian can provide appropriate and precise treatment for the specific pathogenic agent in circulation.

Presently, using this technology, rapid gains can be achieved in tracking disease progression, identifying the pathogens involved, and mapping pathogen interactions with the host. Precise, targeted diagnosis of BRD agents may also lead to the development of novel vaccines, thus reducing antibiotic usage. The prominent concern of antimicrobial resistance amongst BRD associated bacteria warrants further research and development into novel diagnostics such as these tools utilised in Teagasc, Grange. In addition, monitoring for emerging pathogens of interest that may become BRD associated agents is vital for early response and treatment strategies to these new pathogens.

Acknowledgements

Funding from the DAFM (Dr. B. Earley project leader) under the US- Ireland Tri Partite Grant (2018US-IRL200) is gratefully acknowledged.

The Derrypatrick Herd

Peter Doyle, Michael McManus, Colin J. Byrne and Paul Crosson

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- The Derrypatrick herd is a spring-calving suckler calf-to-beef research herd, finishing heifers at 21 months, and steers at 22 months of age.
- The current experiment is comparing the performance of the progeny of two sire types which are divergent in maternal traits (Replacement Index).
- The herd comprises of two suckler cow types which 'originate' from either the suckler herd (predominantly Limousin/Simmental crossbreds) or the dairy herd (predominantly Limousin × Holstein-Friesian).
- Sire type did not influence weaning weight, slaughter weight or carcass conformation and weight.
- Future research will examine the potential of incorporating red and white clover into grass-based suckler systems and the role of genetics in reducing age-at-slaughter of suckler progeny.

Introduction

The Derrypatrick Herd at Grange is a spring-calving suckler cow (n=100) research demonstration herd on 65 ha of intensively-managed grassland. The herd comprises suckler cows which 'originate' from either the dairy herd (Limousin × Holstein-Friesian; ½ beef, ½ dairy) or the suckler herd (pre-dominatly Simmental/Limousin crossbred) and are mated to Angus, Charolais, Limousin and Simmental sire breeds. A calf-to-beef system is operated with heifers slaughtered at 21 months and steers slaughtered at 22 months of age. Stocking rate is 3.0 LU/ha.

The objective of this herd is to conduct research and demonstrate best practice in suckler calf-to-beef production systems. The current experiment is comparing the performance of the progeny of sires divergent in maternal traits (Replacement Index) as outlined below.

Breeding and calving

Over the past three years (2018-2021), the breeding season in the Derrypatrick herd has reduced from 12 to 9 weeks, with consequent reductions in calving duration. During this period, the herd used 100 % artificial insemination (AI), with appropriate heat detection methods. Cows were tail painted and each group of cows had a vasectomised bull with a chin ball fitted, to aid heat detection. Cows were checked for signs of heat 3-4 times daily and the AM/PM rule was applied for artificial insemination; cows seen in heat each morning (am) were served that evening (pm), and cows seen in heat in the evening (pm) were served the following morning (am). A pre-breeding scan and three-week breeding scan is completed to identify non-cycling and problematic breeding animals, and they are treated as appropriate. A final scan is completed after the breeding season to confirm 'in-calf' animals. Cows and heifers not in-calf are culled from the herd post-weaning.

In 2021, 90% of the cows and heifers were submitted for AI in the first 3 weeks of the breeding season, with 100% submitted in the first 4 weeks. 70% of the cows and heifers held to first service. The final pregnancy scan took place on the 7 September and 91% of the herd were pregnant after 9 weeks of breeding. In 2022, calving commenced on 2 February and finished on 22 April (11-weeks calving following 9-weeks breeding). A total of 102 cows (+ heifers) calved resulting in 100 live calves (three mortalities and one set of twins). Mean calf birth weight was 45 kg and 86% of cows calved down within the first six weeks.

Post-calving, turning cows and calves out to grass as soon as conditions allow is a priority, in order to reduce feed costs but also from a calf-health perspective. In 2022, the first batch of early-calving cows and calves were turned out to grass on the 2 March. From mid-March onwards cows and calves were let out to grass two days after calving, if conditions allowed. Colostrum management is critical at calving, with calves receiving 2-3 litres of colostrum, in the first two hours of life from the cow's first milking. Dry bedded pens are maintained throughout the calving season by regularly cleaning out and liming pens, and disinfectant footbaths are placed at the entrance to each shed. Calves are administered oral suspensions and vaccines for the prevention of scour, pneumonia, coccidiosis and clostridia diseases, as appropriate.

Grassland management

In 2021 the farm grew 13.9 t DM/ha of herbage with an input of 250 kg chemical nitrogen/ha. Farm walks are completed weekly to measure grass supply and the data is uploaded to PastureBase Ireland. A key aim is to increase the length of the grazing season. Cows and calves are turned out to pasture in early March and housed in November, depending on grass supply and grazing conditions. Approximately, 60% and 40% of the farm area is harvested for first and second cut silage, respectively. High 'quality' silage (> 75% dry matter digestibility, DMD) is produced for weanlings and finishing cattle to reduce the reliance on concentrates, whilst moderate 'quality' silage (~68% DMD) is targeted for suckler cows. A key objective over the coming years is to increase clover content in the sward and reduce the reliance on chemical nitrogen fertiliser.

Table 1. Example of sires used on the Derrypatrick herd in 2021

	'Balanced' sires ('high' Replacement Index & 'high' Terminal Index)				**'Terminal' sires** ('low' Replacement Index & 'high' Terminal Index)			
Breed	**AI Code**	**Name**	**RI**	**TI**	**AI Code**	**Name**	**RI[1]**	**TI[1]**
CH	CH4202	Tombapik	150	119	CH4159	Knockmoyle Loki	82	164
CH	CH6271	Whitecliffe Orwell	175	165	HJD	Hideal	62	172
LM	JSS	Usse	164	137	LM2206	Elite ice cream	68	150
LM	CWI	Castleview Casino	124	122	LM4185	Laurel	37	136
SI	SI4250	Lis-Na-Ri Gucci	156	74	SI4083	Clonagh Frosty King	155	111
SI	SI2152	Curaheen Earp	203	90	SI4657	Coose Jericho	176	103
AA	ZLL	Lanigan Red Deep Canyon	163	88	ZEP	Hawkley Red Zeppelin	103	83
AA	KYA	Tubridmore Gizmo ET	134	61	AA2037	Bova Lord Bonanza	97	73
Average 'balanced' sires			159	107	Average 'terminal' sires		98	124

[1] RI = Replacement Index (€) and TI = Terminal Index (€)

Current research

The current (2018-2022) research programme is comparing the growth-related performance and carcass characteristics of progeny from sires divergent in genetic potential for 'maternal' traits (Replacement Index) but exhibiting similar genetic potential for 'terminal' traits i.e. where 'balanced' sires had a high Replacement Index and 'high' Terminal Index and 'terminal' sires had a low Replacement Index and 'high' Terminal Index (similar Terminal Index to balanced sires). A mixture of Angus, Charolais, Limousin and Simmental sires was used as outlined in Table 1. Relatively 'easy-calving' sires were selected for this experiment (calving difficulty < 8 %); however, it is acknowledged that when not constrained as much by selecting for a reasonably low calving difficulty, sires with a much higher Terminal Index could have been selected.

Progeny performance

Preliminary results from the first three years of the study are outlined in Table 2. Mean weaning weight for steers was 307 kg and heifers was 288 kg, and did not differ between the sire 'types' ('balanced' sire vs. 'terminal' sire). Carcass weight was not influenced by sire type, and averaged 380 kg (21.8 months of age) for steers and 338 kg (20.6 months of age) for heifers. Carcass conformation score of steers and heifers (average R+) was unaffected by sire type. Steers and heifers from 'balanced' sires had a 0.4 and 0.6 unit greater carcass fat score (1-15 scale), respectively, than those from 'terminal' sires.

These provisional findings indicate that it is possible to select sires within a replacement breeding policy without negatively impacting progeny growth-related performance (assuming a corresponding 'high' terminal index for these 'balanced' sires).

Table 2. Preliminary growth and carcass traits performance of steers and heifers from suckler cows bred to 'Balanced' and 'Terminal' sires

	Steers		Heifers	
	Balanced	**Terminal**	**Balanced**	**Terminal**
Weaning weight (kg)	314	302	295	282
Weaning value (€)	829	791	792	759
Slaughter weight (kg)	693	678	612	614
Carcass weight (kg)	386	381	336	334
Kill-out (%)	56.0	56.0	54.7	54.6
Carcass conformation (1-15)	8.9	8.7	9.0	9.2
Carcass fat (1-15)	8.8	8.3	9.7	9.1

Future research

Beef production systems that maximize the proportion of grazed pasture in the diet are most profitable and give Irish farmers a unique competitive advantage over the majority of their European counterparts. Despite this, there are a number of economic and environmental challenges facing the beef industry. For example, the recently published Climate Action Plan outlined that farmers need to reduce GHG by between 22% and 30% by 2030, mainly through reducing nitrogen fertiliser input and slaughter age. Furthermore, the increased price rise and volatility in input prices has prompted the requirement to focus research on

lower-input grass-based systems, whilst retaining high carcass output per hectare.
Incorporating clover and improving animal genetics in grass-based beef systems could support the reduction in farm inputs costs and GHG emissions, respectively. Although it is known that inorganic fertilizer nitrogen application rates can be reduced for the same level of herbage production and dairy cow milk production is greater in clover-based systems, it is currently relatively unknown if red and white clover can support increased live weight gain of beef cattle in grass-based systems. Therefore, 'grass-only' vs. 'grass-clover' pastoral systems are currently being set up in Teagasc Grange to investigate this. White clover is being stitched into paddocks in 2022 and its progress will be monitored.
Furthermore, the role of animal genetics in reducing slaughter age (but maintaining a high carcass output/ha) and associated methane emissions and input costs requires quantification. Suckler cows will be bred to Charolais and Angus sires, with both sires selected for greater carcass fat deposition (high predicted transmitting ability for carcass fatness) within breed, in order to permit earlier 'finishing' of cattle from grass-based systems.

Acknowledgements

Thank you to all the staff at Teagasc Grange for looking after the day-to-day running of the herd, particularly Liam Kirke and Grange Farm Managers Edward Mulligan and Francis Collier.

Figure 1. A selection of beef cattle in the Derrypatrick herd.

Newford suckler demonstration farm update

Michael Fagan[1], Padraig French[2] and Matthew Murphy[3]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2]*Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co Cork*
[3]*Newford farm, Athenry, Co Galway*

Summary

- The Newford suckler demonstration farm in Athenry was set up by Teagasc and Dawn Meats Group to demonstrate best-practice in sustainable suckler beef production with an objective to optimise profitability from a grass-based system.
- The 95-cow herd (Angus and Hereford dairy crossbreds) are mated by artificial insemination (AI) to high Terminal Index sires.
- Calving (10-weeks) occurs close to turnout to grass in spring.
- Steer and heifer progeny are finished at 19 to 21 months of age.
- All variable, fixed and 'set-up' costs have to be funded by the farm, except for land cost and the farm operator salary; the farm has no Basic Payment Scheme (BPS).
- Farm practices are designed to optimise labour efficiency.
- Despite excellent animal performance and technical efficiency, net profit to date is relatively modest.
- Newford Farm is part of the 'Signpost' and 'Future Beef' programmes.

Introduction

In 2015 Teagasc and Dawn Meats established a stand-alone suckler herd at Athenry, Co. Galway with support from the Irish Farmers Journal and McDonalds, to demonstrate best-practice in sustainable suckler beef production. The objective for the Newford farm is to demonstrate the potential of a large, well-run suckler calf-to-beef (steer and heifer) farm to generate a viable family farm income.

The farm is laid out in four separate divisions. The main block of land (26 ha) in Newford is dry, good-quality grassland and is used for grazing the suckler cows and calves. The nearest outside block Gortnahabhainn (14 ha) is 4.5 km away and has a 'heavy' soil type. The other two blocks are 12 km away. Tuohy's farm (13 ha in Bengarra) also with a 'heavy' soil type, has shed accommodation and handling facilities; the male weanlings are housed there each year. Cones farm (18 ha of limestone soil) has no sheds or handing facilities, and usually most of the first-cut silage is harvested there; the beef heifers are moved onto this farm.

Suckler cow type, breeding and productivity

The cow breed types at Newford are Aberdeen Angus × Friesian and Hereford × Friesian with an average live weight of 660 kg. They have good maternal traits, especially milk production, resulting in high pre-weaning live weight gain of the calves. The average Replacement Index of the cows is €134 and the heifers is €168. Replacements for the herd are purchased as calves by selecting female progeny of high Replacement Index from proven Hereford and Angus AI sires. These calves are contract-reared elsewhere until approximately 4 months of age. All of these heifers are calved down at approximately 24 months of age. The criteria for selecting high Terminal Index AI sires such as Charolais, Limousin and Belgian Blues used by the Newford management team, are as follows:

- 5-Star Terminal Index (within & across breed)
- < 8 % calving difficulty for 'strong' mature beef cows
- < 5.8 % calving difficulty for 'young' beef cows
- > 70 % reliability calving difficulty
- > 1.86 carcass conformation
- > 35 kg carcase weight for mature cows
- >25 kg carcase weight for young cows
- < 6 % for first-calvers difficulty: 80% reliability
- > 25 kg carcase weight for first-calvers
- Cost of AI straw = less than €20

The reproductive and maternal performance of the herd to-date is shown in Table 1. The breeding season is kept short to ensure compact-calving to grass and that the calving season is finished before breeding starts. This is very important for overall labour and management efficiency.

Table 1. Newford cow numbers and performance from 2015 to 2021

	2015	2016	2017	2018	2019	2020	2021
Cows (number)	74	81	85	88	90	89	94
Heifers (number)	24	15	22	22	20	11	0
Calving interval (days)	-	371	349	362	366	360	366
Breeding season (weeks)	12	10	10	10	10	10	10
Weaning weight (kg)	262	303	301	315	289	314	316
Calf live weight gain pre-weaning (kg/day)	1.20	1.23	1.26	1.21	1.24	1.35	1.35
Weaning date	10 Oct	15 Oct	21 Sept	4 Oct	17 Sept	12 Sept	17 Sept
Calf mortality (% dead at 28 days)	4.5	5.2	0.9	4.5	5.3	5	4.3
% of mature cows empty	-	6	6	9	13	10	6

Newford calving performance

Calving performance on Newford has been positive with few problems and much of this success can be attributed to sire selection and management of the cow. The average weight of all calves born in 2022 was 42 kg, with the bull calves averaging 44 kg and the heifer calves 38 kg. The first calf was born on the 27 January and the last calf was born on the 5 April. Out of the 93 cows calving there was 2 sets of twins and 89 live calves; unfortunately, the farm had six calf mortalities. After six weeks, 89% of the herd had calved with 100% of the herd calved by 10 weeks.

Progeny performance post-weaning

All progeny from the Newford herd are finished on-farm, with slaughter between 19 and 21 months of age (Table 2). In terms of carcass conformation, the beef × dairy cows are primarily O-grade cows but when mated to high-genetic merit 'terminal' sires they can produce U and R grade progeny. The carcass weight has been increasing gradually over the last seven years due to a combination of increasing cow age (all first-calvers in 2015), selection of better sires and extending the grazing season. The target for the farm is to slaughter as many of the progeny as possible before the second winter.

Table 2. Slaughter and carcass traits of steer and heifer progeny between 2015 and 2021

	2015	2016	2017	2018	2019	2020	2021
Steers							
Conformation score	R -	R =	R -	R =	R +	R =	R =
Fat score	3 =	3 =	3 +	3 +	3 =	3 -	3 -
Slaughter weight (kg)	596	652	653	685	642	647	663
Carcass weight (kg)	320	337	341	367	350	350	357
Kill-out (%)	54	52	52	54	55	54	54
Slaughter age (months)	22	19	21	21	21	20	21
Value	€1,290	€ 1,305	€1,400	€1,434	€1,315	€1,389	€1,611
Price / kg	€4.05	€3.87	€4.10	€3.90	€3.76	€3.96	€4.51
Heifers							
Conformation score	R =	R +	R =	Sold Live	R =	R =	R =
Fat score	3+	4 -	4 -	-	3 =	3 =	3 -
Slaughter weight (kg)	521	574	560	460	569	570	583
Carcass weight (kg)	280	296	291	-	299	299	311
Kill-out (%)	54	52	52	-	53	52	53
Slaughter age (months)	21	20	19	16	20	20	20
Value	€1,172	€1,176	€1,167	€1,035	€1,117	€1,188	€1,396
Price / kg	4.20	3.97	€4.01	€2.25	€3.74	€3.97	€4.49

This year (2022), Newford farm has modified its production system and is aiming to draft the 2021-born heifers at 16-to-17 months of age in June/July to coincide with higher seasonal demand and higher beef prices, due to lower beef supplies. The target drafting live weight will be 550 kg and a 285 kg carcass is expected. If successful, this will reduce variable and fixed costs and the farm's carbon footprint.

Financial performance

The financial performance data for Newford farm between 2015 and 2021 is presented in Table 3. The farms fixed costs are exceptionally high due to the interest repayments on the debt associated with the establishment of the farm, and the depreciation of the significant capital investment associated with the initial conversion from a sheep farm to a cattle farm. The key focus is to increase the amount of grass grown and utilised, and to reduce the quantity of feed purchased, as well as increasing output through genetic selection on both the sire and the dam side.

Table 3. Profit monitor data (€/ha unless stated) for Newford farm for 2015 to 2021

	2015	2016	2017	2018	2019	2020	2021
Gross output	1,869	1972	2005	2476	1657	1936	2124
Variable costs	1374	1539	1332	1853	1584	1115	1439
Gross margin	495	432	674	624	73	820	685
Fixed costs	695	835	723	781	651	761	633
Net margin	-200	-402	-49	-158	-578	60	52
Net margin + premia (BGDP + BEEP)	-17	-251	77	11	-378	298	276
Net margin (€/farm)	-11168	-22448	-3145	-7883	-36725	4068	3517
Net margin + premia (€/farm)	-968	-14006	4954	559	-23975	20278	18771

Future farm plans

- Newford farms' main priorities for the future are to;
- Incorporate more clover into the paddocks and reduce the amount of chemical nitrogen fertilizer applied.
- Reduce age at slaughter.
- Reduce environmental losses by using Protected Urea.
- Continue to maximise profitability.

The farm is planning to maintain cow numbers but to improve the 'quality' (conformation) of the replacement heifers purchased through better sire selection.
The farm aims to draft the beef heifers earlier for slaughter by having an earlier turnout to grass in spring, and to reduce the numbers of animals being finished indoors in the second winter.

Newford farm will host an Open Day for all farmers on Tuesday 13th September 2022.

The Future Beef Programme

Martina Harrington[1], Aisling Molloy[2], Gabriel Trayers[3], Colin J. Byrne[4] and Pearse Kelly[4]

[1] *Teagasc, Dublin Road, Enniscorthy, Co. Wexford*
[2] *Teagasc, Sandfield, Mallow, Co. Cork*
[3] *Teagasc, Upper Dublin Road, Tuam, Co. Galway*
[4] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*

Summary

- Future Beef is a network of 24 suckler beef demonstration farms positioned across Ireland and supported by three experienced advisors.
- Each farm is representative of their region in terms of farm size, soil type, production system, stock numbers etc.
- Key objectives of the programme are to:
  - Create more sustainable and profitable farms.
  - Reduce greenhouse gas (GHG) and ammonia emissions.
  - Improve water quality.
  - Improve biodiversity.
- The key focus areas are breeding, grassland management and health.
- Future Beef farmers will increase efficiencies and adopt technologies, new and old, to make beef farming more profitable, while also making it more environmentally and socially sustainable.
- Through farm walks, discussion group visits, press articles, regular updates on the website and social media, the Future Beef programme will show these technologies working on the demonstration farms.

Background

Future Beef is Teagasc's new suckler beef demonstration farm programme that comes under the umbrella of the Signpost Programme. It comprises of a network of 24 demonstration farms (22 commercial family-run farms, and the Newford Farm in Athenry and the Kepak Feedlot in Caulstown, Co. Meath.) positioned across Ireland supported by three experienced advisors. Each farm is representative of their region in farm size, soil type, production system, stock numbers etc. Farm size ranges from 13 hectares to 114 hectares, and the herd size ranges from 12 to 87 suckler cows. The production systems vary between farms and include; calf-to-weanling/store, calf-to-steer/heifer beef, calf-to-bull (under-16 months of age)/heifer beef; and four are also buying in dairy-bred calves. Mixed beef and sheep farms are also featured with flock sizes ranging from 50 to 250 ewes, along with two organic farms. When designing the programme, we wanted to represent the majority of systems within the beef sector - not a small task in the context of Irish agriculture. Regionally, each farm faces the same climatic and environmental challenges as their farming neighbours, while nationally the financial and time pressures are the same – they are one of you.

Irish beef farmers already produce a top-quality product, which is exported worldwide. With the support of the Future Beef team, each farmer will endeavour to increase efficiencies and adopt technologies, new and old, to make beef faming more profitable, while also making it more environmentally and socially sustainable. This will be achieved by focusing on reducing inputs and the costs of production, while increasing the performance of every animal on the farm.

Key objectives are to:

- Create more sustainable and profitable farms.
- Reduce greenhouse gas (GHG) and ammonia emissions.
- Improve water quality.
- Improve biodiversity.

To achieve the objectives, the main focus areas are:

- Breeding
- Grassland management
- Health
- Financial
- Monitoring

Breeding

Every cow should produce a calf every year. If a cow is not doing this, she should be culled and replaced. For many this will involve a refocus on: nutrition, health and housing. By increasing calves/cow/year from the national average of 0.85 to 0.95 calves per cow the net margin per cow can be improved by €98, there is also a 6% reduction in carbon footprint. Each calf must be of good genetic merit for beef traits, targeting a 200-day live weight (LW) of 250 kg as a heifer and 300 kg as a bull. To bring that into focus, that is an average daily gain of at least 1.15 kg LW.

All replacement heifers should be calving at two years of age. This is key to reducing costs on farm while also reducing the overall carbon footprint of beef production. Calving at 24 months vs. 32 months can reduce the greenhouse gas emissions per farm by 4-5% while increasing profitability by €77 net profit per cow.

Key focus areas are:

- Calve heifers at two years of age by focusing on target weight gains: 1.2 kg LW/day until weaning from the cow, 0.6 kg LW/day over the first winter, turnout to grass early in the second grazing season and gaining >1 kg LW/day. Replacement heifers should be 60% of their expected mature bodyweight at 14/15 months of age. Ideally, you should measure this on your own farm by weighing a selection of 5+ parity cows; many suckler farmers will have this completed under BEEP-S scheme.
- Increase the average daily live weight gain of all animals on the farm from birth, mainly through better genetics and improved grassland management. By increasing calves' average daily gain from 1.05 to 1.20 kg LW you can increase the value of your weanling by €97, assuming that a kg of live weight is worth €2.50. This will also help to reduce the age at slaughter, and thus the amount of methane produced per animal.
- Body condition score (BCS) cows and heifers. Body condition score estimates the 'cover' of subcutaneous fat on the 'frame' of the animal. The range goes from 0 (emaciated) to 5 (grossly over-fat). Individual condition score units are usually divided into half and

quarter scores. A spring-calving suckler cow should have a BCS of ~2.5-2.75, while an autumn-calving cow should have a BCS of ~3.0, post-calving.

- Nutrition: test silages and balance each cows diet for energy and protein based on her BCS at housing, thin cows may need extra feed, while fat cows will need to be restricted. After calving all suckler cows should be fed top quality silage (>70% dry matter digestibility, DMD). For best results try to calve cows at a time of year when they can be turned out to grass straight away.
- Pick appropriate sires/bulls: understand the breeding indexes and how they can help improve the herd, i.e. Replacement Index vs. Terminal Index, calving difficulty, carcass weight, daughter milk and what the 'reliability' is for the trait.
- Health: have a robust animal health plan; sick animals or animals with a parasite burden will not perform to their optimum.
- Housing: appropriate housing for all types of stock. The requirements of suckler cows differ from those of finishing animals. Space allowance for lying and feeding is also critical and farm safety should always be in mind when designing sheds.

Grassland management

Good 'quality' grass is the cheapest feed available to any beef farmer. Intake of good quality grass must be maximised by the animal to achieve high live weight gain. This will reduce the amount of silage and concentrates that needs to be fed, while also decreasing the length of time an animal stays on farm. This equates to fewer inputs' lower costs and increased profitability, while also reducing GHG and ammonia emissions.

Key focus areas are:

- Developing practical grassland management programmes for each region and system.
- Taking soil samples and correcting soil fertility to grow more grass with less inputs. The EU Green Deal and Farm to Fork strategies are seeking a reduction of up to 20% in fertilizer usage by 2030. On beef farms it is estimated that a 25% reduction in fertilizer usage can reduce GHG by 1%. Start with lime application to fields with a pH <6.2.
- Introducing clover to pastures, where appropriate.
- Extended grazing: ensuring early spring grass by having a 'closing plan' in autumn to help build 'covers'. An additional two weeks grazing can reduce farm GHG emissions by 2%.
- Getting slurry and farmyard manure spread as soon as ground and weather conditions allow in spring will reduce the amount of methane produced.
- Increased use of low emission slurry spreading (LESS) can reduce GHG emissions by 1%, while also reducing ammonia emissions.
- Switch, as far as possible, from calcium ammonium nitrate (CAN) to protected urea; Teagasc trials have shown it has 71% lower nitrous oxide emissions than CAN.
- Paddocks, infrastructure and rotational grazing to maximise grass utilisation and the amount of grass grown annually on the farm. Every extra tonne of DM/ha/year utilised = €106/ha (Grass10). Improved grassland management will also lead to improved animal performance and a reduction in age at slaughter, thus reducing GHG emissions. If concentrate is used to make up for poor grassland management, GHG emissions will not be reduced as concentrate has an associated carbon footprint.

Animal health

A sick animal or an animal with a parasite burden will not perform to its potential. A farm needs to have a plan in place that will deal with parasites, viruses, bacteria and illnesses. Key focus areas are:

- Implementing a comprehensive health plan.
- Vaccination to prevent disease.
- Correct dosing policy using faecal sampling to reduce the risk of anthelminthic resistance.
- Improved ventilation and environment in sheds.
- Nutrition: Diets based on forage analysis and animal requirements.

Monitoring

Performance on the farms participating in the programme will be recorded throughout the year - you cannot manage what you do not measure. Monitoring on the farms will permit measurement of the impact of improved technical efficiency on profitability and the environment. The National Farm Survey (NFS) will collect all data on the farms. All results will be communicated through the Future Beef website, social media, discussion group visits and farm walks. Improving water quality and increasing biodiversity on these farms are key aspects of the programme. Future Beef will work closely with the Agricultural Sustainability Support and Advisory Programme (ASSAP), to inform the participants what can be done on their own farms to reduce their impact on water quality. Simple measures like how to maintain drains and watercourses, when should I clean a drain and how should I do it? Similarly, for biodiversity, are farms and farmyards too "*picture-perfect*". Can I as a farmer leave more space for wildlife; should I just fence off that awkward corner and let it re-wild or could I plant it with oak trees? What about the spaces I do have, can I manage them better to encourage more biodiversity, how should I manage my hedgerows etc.? We do not want to look at any one area in a vacuum; there is no advantage to reducing GHG's if we destroy our watercourses. Through farm walks, discussion group visits, press articles, regular updates on the website and social media, the Future Beef programme will show these technologies working on our 24 farms. We will demonstrate how they reduce the GHG emissions, improve water quality and biodiversity, and also how they are affecting the profitability of each participant. If you see these technologies working on your leader's farm, will you adopt them too?

Further information about the Future Beef Programme is available on the website at the following link: https://www.teagasc.ie/animals/beef/demonstration-farms/future-beef-programme/

Acknowledgements

We wish to thank the farmers that have agreed to take part in the programme. We look forward to working with them and their local advisors over the next five years. We are confident that all parties involved in the programme will benefit hugely from the experience. We wish to acknowledge all the sponsors of the Future Beef Programme and thank them for their commitment to the programme: ABP Food Group, Ashbourne Meats, Dawn Meats, Euro Farm Foods, Foyle Food Group, Kepak Group, Kildare Chilling, Liffey Meats, Moyvalley Meats and Slaney Foods.

Technology Village

DAIRY-BEEF SYSTEMS

Genetics is a key driver of performance in dairy-beef systems

Alan Twomey[1], Chris Daly[2], Andrew Cromie[2], Matthew Murphy[3] and Nicky Byrne[4]

[1] *Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork*
[2] *Irish Cattle Breeding Federation, Ballincollig, Co Cork*
[3] *Dawn Meats, Grannagh, Co. Waterford*
[4] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*

Summary

- Genetics of dairy-beef cattle has a large influence on the performance and output of dairy-beef systems.
- The Dairy Beef Index is a tool for dairy farmers to select short gestation, easy-calving beef sires that are superior for beef traits.
- Commercial Beef Value is a genetic value, expressed in euros, for farmers buying animals to produce for slaughter.
- Breeding for age at slaughter will be critical for the economic and environmental sustainability of beef systems.

Introduction

Genetic merit of animals in dairy-beef systems has a large influence on overall farm performance. There is a concern by many beef farmers that they have no control over the genetic merit of animals in a dairy-beef system as breeding decisions are determined by the dairy farmer. Recently launched, the Commercial Beef Value (CBV) is now available to beef farmers to help them identify and purchase beef cattle based on their genetic merit for beef production traits.

Breeding decisions on dairy herds

The main focus on dairy herds is to improve the performance of the cow herd, through improved milk production and fertility. Intense selection for dairy traits has led to a decline in the beef merit of animals from the dairy herd. Breeding tools have been developed for dairy farmers to ensure that beef animals from the dairy herd do not deteriorate any further, and ultimately reverse this trend. Coupled to this, fertility improvements of the dairy herd, coupled with the increased usage of sexed semen, will result in a reduced number of male off-spring sired by dairy bulls, and thus increase the number of calves sired by beef bulls.

Dairy Beef Index

Although the portion of calves from the dairy herd that are sired by beef bulls is expected to increase in future years, this does not guarantee the improvement in beef merit of animals coming from the dairy herd. The distribution of genetic merit of beef and dairy sires is presented in Figure 1. Not all beef breed sires are superior for carcass weight compared to dairy breed sires; they overlap in the 'middle' (Figure 1). Therefore, there is a requirement for dairy farmers to ensure that they select beef bulls with good carcass merit. The Dairy Beef Index (DBI) is a breeding tool to help dairy farmers select beef bulls which are easy calving and short gestation (which are both economically important to the dairy farmer), as well as being good for beef traits.

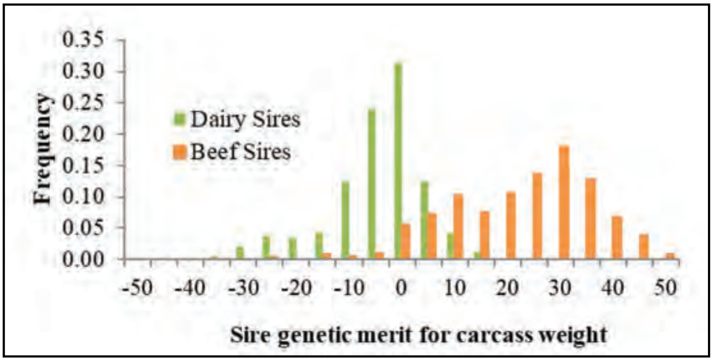


Figure 1. Distribution of genetic merit for carcass weight for active dairy and beef AI sires.

Commercial Beef Value

Recently the Commercial Beef Value (CBV) was launched by the Irish Cattle Breeding Federation (ICBF). This is a genetic value to aid beef farmers in the purchase of calves/ store cattle by giving them a better insight into the animal's genetic merit for beef traits. It compromises of five key traits that are important for animals destined for beef production/ slaughter (i.e. non-breeding): carcass weight, carcass conformation, carcass fat, docility and feed intake. The CBV is divided into star ratings within three different breed types (sire × dam): beef × beef, beef × dairy and dairy X dairy. A '5-star' animal is in the top 20 % of the national population within that genotype and the '1-star' animal is in the bottom 20 % of the national population within that genotype. This is the first tool to allow non-breeding beef farmers to select animals based on their genetic merit and control the type of animal that enters into their beef system. The CBV combines the genetic merit of both the sire and dam. So even if a calf is from an excellent beef sire, this will only contribute to half of the calf's CBV and the genetic merit of the dam will contribute the other half.

Does it to work?

The question many farmers will ask, can we really predict the difference between two calves just by their genetic information and the answer is yes! The CBV was validated on two datasets: Firstly on the Grange dairy-beef research herd and also in a Teagasc study on 10 commercial dairy-beef farms in conjunction with Dawn Meats. For both studies, CBVs were predicted for all animals when they were born and animals were followed through their life until slaughter.

Grange dairy-beef research herd: The average performance of 113 Holstein-Friesian steers for each star rating based on dairy × dairy is present in Table 1. Holstein-Friesians classified as 5-star for CBV at birth had a 33 kg heavier carcass than Holstein-Friesians that were only 1-star for CBV. For the 229 Angus-sired animals, carcass weight increased and age at slaughter reduced as CBV increased (Table. 2). For both the Holstein-Friesian and Angus-sired steers, carcass conformation and fat scores for 1-star versus 5-star animals were broadly similar. Within this research setting, the CBV correctly identified animals with superior carcass growth within the breed types.

Table 1. Carcass performance of Teagasc Grange Holstein-Friesian steers per CBV star rating within dairy × dairy breeds.

CBV rating	Number of animals	CBV (€)	Carcass weight (kg)	Conformation Score (1-15)	Fat score (1-15)	Age (d)
1 star	11	-14	301	4.2 (O-)	9.1 (3+)	715
2 star	17	12	310	4.4 (O-)	9.1 (3+)	721
3 star	17	24	307	3.8 (O-)	8.4 (3=)	710
4 star	27	35	324	4.3 (O-)	9.1 (3+)	713
5 star	41	58	334	4.1 (O-)	9.1 (3+)	716
Diff. between 1 and 5 star		*72*	*33*	*-0.1*	*0.0*	*1*

Table 2. Carcass performance of Teagasc Grange Angus × Holstein-Friesian steers per CBV star rating within beef × dairy breeds.

CBV rating	Number of animals	CBV (€)	Carcass weight (kg)	Conformation Score (1-15)	Fat score (1-15)	Age (d)
1 star	78	21	289	4.7 (O=)	9.5 (4-)	653
2 star	46	52	290	4.9 (O=)	9.2 (3+)	651
3 star	57	69	301	5.0 (O=)	9.3 (3+)	652
4 star	40	92	305	5.1 (O=)	9.3 (3+)	649
5 star	8	131	316	4.6 (O=)	9.4 (3+)	648
Diff. between 1 and 5 star		*110*	*27*	*-0.1*	*-0.1*	*-5*

Dairy-beef commercial herds: It is important that the benefit of the CBV also reflects performance in commercial herds across a range of breeds. There were 705 beef heifers and steers reared across 10 'rearing' herds, which were sired by a wide range of breeds (Angus, Aubrac, Belgian Blue, Limousin, Salers, Hereford, Charolais, Parthenaise and Shorthorn). The performance of these animals is presented in Table 3. Animals classified as 5-star had a 29 kg heavier carcass, 0.7 units better conformation (O+ to R-) and were 1.1 fat score units leaner (3+ to 3=) at slaughter compared to 1-star animals; however, they were also 25 days older, which must be taken into account too.

Table 3. Carcass performance of animals in 10 commercial herds per CBV star rating within beef × dairy breeds.

CBV rating	Number of animals	CBV (€)	Carcass weight (kg)	Conformation Score (1-15)	Fat score (1-15)	Age (d)
1 star	34	27	310	6.1 (O+)	8.6 (3+)	684
2 star	40	52	308	5.9 (O+)	8.5 (3+)	682
3 star	52	69	323	6.0 (O+)	8.8 (3+)	693
4 star	215	105	331	6.4 (O+)	8.0 (3=)	700
5 star	364	155	339	6.8 (R-)	7.6 (3=)	709
Diff. between 1 and 5 star		*129*	*29*	*0.7*	*-1.1*	*25*

Developments in beef breeding

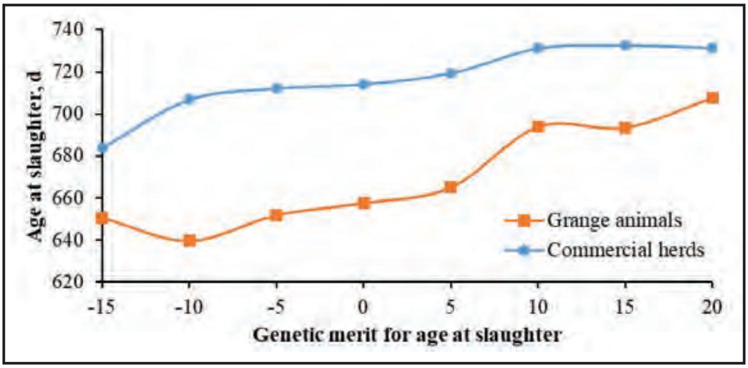
New research continues to advance beef breeding with a range of new traits being investigated including methane production, health and age at slaughter. Improving age at slaughter in beef systems will be important to reduce the environmental footprint of cattle systems and also reduce costs on farms. Although the current breeding objectives involves selecting animals that can breed heavier progeny at a specific age (i.e., faster growing), there are some animals within and across specific breeds that require extra days to reach 'fitness' (a suitable carcass fat score) for slaughter. Animals that are older at slaughter require a more 'feed days' and also are emitting methane for longer.

Teagasc research has identified that 46% of the observed differences in age at slaughter within herds is under genetic control. This percentage is similar to other carcass traits such as weight and conformation. Test breeding proofs have been developed for age at slaughter in Teagasc (Table 4). There is a large genetic variation between and within breeds. The estimated breeding values predict that there is a month in the difference between the top and bottom 10% percentile in age at slaughter. These test proofs for age at slaughter also show that they can predict which animals will be slaughtered at a younger age within herds. On average as the estimated breeding value for age increased by 5 days the actual difference between animals in the aforementioned Grange dairy-beef research herd was 9 days and on the 10 dairy-beef commercial herds was 5 days (Figure 2).

Table 4. The median, top 10% percentile and bottom 10% percentile for estimated breeding values for age at slaughter for proven AI sires.

Breed	Median	Top 10%	Bottom 10%
All breeds	4	-14	18
Angus	-21	-12	-37
Belgian Blue	3	14	-4
Charolais	-5	4	-16
Hereford	-17	-11	-37
Limousin	1	-7	10
Simmental	-9	-19	0
Holstein-Friesian	8	-3	19

Figure 2. Effect of genetic merit for age at slaughter on 'actual' slaughter age of dairy-beef animals in Teagasc Grange and on 10 commercial herds.



Optimising calf health on dairy-beef farms

Bernadette Earley, Orla Keane and Donall Fahy

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Calves should be bought from a minimal number of known sources.
- A well-planned herd health programme is an effective tool to prevent disease.
- Pay particular attention to nutrition, environment, sanitation, and care of the newborn calf.
- A well planned and consistent vaccination programme is an effective tool to prevent scours and pneumonia in calves but is not a replacement for good management, good hygiene or good biosecurity.
- Calves are naïve to gut and lung worm in their first season and good worm control will depend on minimising exposure to parasites and judicious use of wormers.

Introduction

On dairy-beef farms the aim is to purchase and rear healthy calves which are capable of optimum performance throughout their lives from birth through to finishing. A suitable calf rearing system should be labour efficient, achieve high levels of calf health and welfare, while striking a balance between calf performance and production cost.

To ensure a healthy calf, the aim is to minimise the calf's exposure to disease, and maximise its defence against disease.

In minimising a calf's exposure to disease, providing a clean, disease-free environment is fundamental on the farm or birth and rearing. This involves:

1. Minimising the number for sources from which calves are purchased, while ensuring farms and calves of high-health status are selected.
2. Thorough cleaning and disinfection of all areas used by calves before arrival and during the rearing phase.
3. Providing a clean, straw-bedded lying area with no draughts and good ventilation.
4. Accommodating calves in batches so that young calves are never mixed with, or accommodated in areas used by, older calves.

A herd health programme that includes bio-security, vaccination, disease surveillance and prevention and, if necessary, the culling of disease-carrying animals, drawn up in consultation with a veterinary practitioner, is the best way to address disease problems. A successful herd health programme for a specific herd must be re-examined on a regular basis, both to adjust for changes in herd management and to incorporate new information and technologies.

Infectious disease agents

The main non-statutory infectious disease agents which Irish dairy-beef calves are at risk of exposure to include, bovine viral diarrhoea (BVD), infectious bovine rhinotracheitis (IBR) virus (bovine herpes virus-1 (BoHV-1), Johne's disease, leptospirosis, salmonellosis and a variety of internal and external parasites. Multiple infectious agents causing pneumonia (e.g. *Pasteurella (Mannheimia) haemolytica*, parainfluenza-3 (PI-3), respiratory syncytial virus (RSV) and diarrhoea (rota and corona viruses, *E. coli*, cryptosporidia)) result in poor thrive and mortality in calves. Leptospirosis, clostridial disease (e.g. blackleg), BVD, salmonellosis and calf scours are the most common diseases that farmers vaccinate against. The major parasitic diseases of concern in 'first-season' grazers are coccidiosis, hoose (caused by the lungworm *Dictyocaulus viviparus*) and parasitic gastroenteritis due to gutworm infection.

Calf scours

Scours are the main causes of calf mortality. The majority of calf scours are caused by six organisms: viruses such as rotavirus and coronavirus, bacteria such as E. coli and Salmonella sp., and protozoa, such as cryptosporidia and coccidia. Vaccination of the dam will help reduce the probability of calf scours but cannot solely be depended upon for prevention. Furthermore, there are no vaccines available to combat protozoa. However, good hygiene and management practices will reduce the likelihood of infection from cryptosporidia and coccidia. Scour in calves results in dehydration and loss of electrolytes, such as sodium bicarbonate, chlorine, and potassium. Calves with diarrhoea can lose 10 to 12% of their body weight in water losses. Depending on the severity of the scour and dehydration, calves may need to receive oral electrolyte solutions once daily or up to four times a day. Calves should be fed their regular allowance of milk when receiving oral electrolytes. Scientific evidence has accumulated that continued milk feeding does not worsen or prolong the course of diarrhoea, despite a somewhat lowered digestive capacity. The milk supplies the calf with energy and other nutrients that are essential for survival.

Calf pneumonia

The underlying cause of pneumonia or bovine respiratory disease (BRD) is extremely complex with the involvement of viruses, bacteria and mycoplasma. The incidence of infection is usually high, but the mortality rate is variable. The main viruses that cause outbreaks of pneumonia in calves are BoHV-1/IBR, RSV, PI-3, and BVD. Factors associated with susceptibility to pneumonia in calves are; stress (transport, disbudding, castration), overcrowding, inadequate ventilation, draughts, fluctuating temperatures, poor nutrition and/or concurrent disease. In most cases the main infective agent is a virus, which causes respiratory tract damage. This effect is worsened by Mycoplasmas and secondary bacterial infections (e.g. *Mannheimia (Pasteurella) haemolytica*). Viruses and Mycoplasmas are unaffected by antibiotics, however, antibiotic treatment is usually administered to kill off the secondary bacterial infections and offer the calf the opportunity to fight the disease. In order to direct the appropriate treatment strategy, in consultation with the vet, nasal swabs should be submitted to the Regional Veterinary Laboratory for accurate identification of the pathogen(s) involved. Calves should be vaccinated where specific problems arise. Veterinary advice should be sought and the widest protection against pneumonia will be achieved where a vaccination programme includes the three most common respiratory viruses (BoHV-1/IBR, RSV and PI-3) and the bacterial pathogen *Mannheimia (Pasteurella) haemolytica*.

Housing requirements for calves

The reasons for housing artificially-reared calves are mainly management-related. The calf born outdoors is capable of finding its own shelter. In the confinement of a house away from its mother the calf needs to be provided with:

- A dry surface to lie on
- Protection from draughts
- Adequate ventilation

If these criteria are met the healthy calf should be insensitive to weather changes outside the house, i.e. temperature, humidity and wind speed. Dry, draught free housing will reduce the environmental stresses on calves and adequate air changes resulting from good ventilation reduce the infection load on the calves. It may not prevent pneumonia. However, the severity of pneumonia will be less and the mortality associated with it will be reduced. From an animal health and welfare viewpoint it is important to develop a combination of management procedures which will minimise the adverse effects of respiratory disease on calf performance and health/welfare indicators. The choice of calf house will depend to a large extent on the size of the enterprise and on labour availability, feeding system, penning arrangement and intensity of use. Ideally the calf house should meet the environmental requirements of the calf and accommodate the feeding routine of the stockperson.

Gutworms and lungworm

Two of the most important parasites for grazing calves are gutworms and lungworm. The most important gutworms infecting calves in Ireland are *Ostertagia ostertagi*, which is found in the abomasum, or fourth stomach, and *Cooperia oncophera* which is found in the small intestine. *Ostertagia* is generally considered more pathogenic than *Cooperia* but *Cooperia* is more prolific and is often the main contributor to worm eggs in dung of calves during their 'first' grazing season. Gutworms can cause disease including scour and ill-thrift in naïve calves but more commonly they are associated with appetite suppression and sub-clinical disease resulting in reduced growth rates. Lungworms cause parasitic bronchitis, commonly known as 'hoose'. The most common symptom is coughing, while heavily infected calves may have difficulty breathing. Heavy or untreated infections can result in deaths. Worm larvae accumulate on pasture over the grazing season and consequently worms are generally a greater problem in the second half of the grazing season.

When calves are first turned out to grass they have no immunity against gut or lungworms. If well-managed in their first grazing season they usually develop sufficient immunity to subsequently prevent clinical disease, although heavy infections can still impact performance. Therefore, the goal in the first grazing season is to manage worms in a way that allows sufficient exposure for the calf's natural immunity to develop, without impacting performance. Control of these worms is generally achieved by a combination of preventing exposure to heavily contaminated pasture and the strategic administration of broad-spectrum anthelmintics (wormers). The risk of disease can be minimised by turning out calves as one group to lowly contaminated pasture, or if that is not possible, turning out later groups to pasture not previously grazed by calves. Keeping the cleanest grazing, such as reseeded ground or hay/silage after grass, for the most naïve (youngest) animals will limit exposure to worms. Calves can also be grazed ahead of older animals in a leader-follower system. As older animals generally have immunity to these worms they remove larvae from the pasture when they graze. Mixed or sequential grazing with sheep will also reduce the worm challenge as the majority of worms that infect cattle will not infect sheep and *vice*

versa. The impact of worms is lessened when animals are well-fed so ensuring that all calves receive adequate nutrition will also help prevent disease.
Monitoring for disease should be an integral part of a herd health strategy and the judicious use of wormers is a key component of a worm control strategy. Young stock should be monitored for signs of clinical disease such as coughing, scour or poor thrive that may indicate a problem with worms. Gutworm burden can also be monitored using faecal egg counts. In calves, a faecal egg count of greater than 200 eggs per gram may indicate a need to treat for gut worms. When treating calves with an anthelmintic it is important that an appropriate product is selected, the correct dosing technique is used and that the animals are treated according to the manufacturer's instructions and dose rates.

Anthelmintic resistance

Anthelmintic resistance refers to the ability of a worm to survive a dose that should kill it. Anthelmintic resistance has recently been detected in gutworms on Irish dairy calf-to-beef farms. To-date resistance has not been detected in lungworm, although it may arise in the future. Frequent use of wormers can lead to the development of resistance and will also impede the development of natural immunity in the calf. For that reason it is important that wormers are used appropriately. Despite the large number of wormers on the market, there are currently only 3 classes, benzimidazole (white wormer), levamisole (yellow wormer) and macrocyclic lactones (clear wormer). Wormers from different classes have different modes of action. However, within the same class all products share the same mode of action. Therefore, when resistance develops to one product within a class, generally other products in the same class are also affected. Determining which anthelmintic classes are effective against the worms on your farm is the first step in ensuring the right product is used when treating calves. Avoiding the continual use of wormers from the same class and only using a combination product when it is necessary to treat for both fluke and worms will also help mitigate the risk of wormer resistance.

Calf diarrhoea – prevention is better than cure

Sabine Scully, Bernadette Earley and Sinéad Waters

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Diarrhoea or scours is the most common disease in calves under one month of age.
- Calves with diarrhoea are commonly infected with rotavirus and cryptosporidia, which cannot be treated with antibiotics.
- A comprehensive herd health plan is necessary to prevent calf diarrhoea.
- Optimized colostrum management supports calf gut health and immune function.
- Biosecurity and sanitation procedures are of the utmost importance.
- The "Holoruminant" EU-funded project is investigating the role of microbiomes in developing solutions to reduce early-life diseases such as diarrhoea.

Introduction

Diarrhoea is the most common cause of death for pre-ruminant calves (one month of age and younger). On-farm research by Teagasc Grange has shown an incident rate for diarrhoea of 8.7% in suckler calves and 25.5% in dairy calves. Calves are particularly vulnerable at this age since the components of the active immune system are under-developed and calves rely on the passive transfer of antibodies from the dam through colostrum. Currently, the best way to manage scours in calves is to prevent it using systemic management practices, strict sanitation procedures and developing a comprehensive herd health plan.

Causes of infectious and non-infectious scours

Scours are classified as infectious (i.e. caused by pathogens such as viruses, parasites, and bacteria) or non-infectious (i.e. caused by nutritional stress and poor management practices). Non-infectious scours often leads to infectious scours. Infectious scours frequently manifest as one or more pathogen causing disease. Table 1 summarises scour-inducing agents, the calf age at which it is most likely to occur, and the prevalence of that infectious agent. Scours are generally caused by a viral or parasitic infection. Although less common, bacterial scours often result in severe disease, which can lead to systemic infection.

Rotavirus

Rotaviral infection is the number one cause of scours in calves under one month of age in Ireland. It most commonly presents in calves around 5 to 14 days of age. The virus attaches to cells lining the small intestine (epithelial cells), leading to cell death and permanent damage. Eventually, enough epithelial cells will die, leaving the virus without a place to replicate. Calves become infected via faecal-oral transmission. As there are no curative treatments, calves can only be treated using supportive therapies like oral rehydration and anti-inflammatory administration. There is a vaccination that, when given to the dam at the appropriate time-point in gestation, can increase the presence of Rotavirus antibodies.

Table 1. Pathogenic causes of infectious scours

Type	Agent/Disease	Calf age	Occurrence
Bacteria	*E. Coli* (ETEC)	1-5 days	Rare
	Salmonella spp.	4-28 days	Less common
Viruses	Rotavirus	5-14 days	Extremely common
	Coronavirus	5-30 days	Less common
Parasites (protozoa)	Cryptosporidiosis (*Cryptosporidium parvum*)	5-30 days	Extremely common
	Coccidiosis (*Eimeria spp.*)	Over 3 weeks	Common

Cryptosporidiosis
Often referred to as "crypto", it is a scouring disease caused by the protozoa *Cryptosporidiosis* spp. In calves, it is almost always caused by the species *Cryptosporidium parvum*. This is a zoonotic disease, meaning that crypto can be transmitted to humans. It is especially dangerous to young, elderly and immunocompromised humans and animals, so strict biosecurity protocols should always be practiced when working with calves positive for crypto. Like rotavirus there are no curative treatments, only supportive therapies. Halofuginone (Halocur) can be used in prevention, but its therapeutic value is not yet fully understood and use of the product should only be done after consulting with a veterinarian.

Coccidiosis
It is a common cause of scours in calves reared in pasture environments. It is caused by a parasite in the *Eimeria* spp. family. Infected calves will often have severe bloody diarrhoea, but it is possible that they show no signs of infection. This parasite uses the small intestine as a breeding ground and has a three week lifecycle, and so is usually seen in older calves. The damage caused by replication in the small intestine has a severe impact on growth and development, even if there are no clinical symptoms. Talk to your veterinarian about getting faecal samples tested if you suspect calves have coccidiosis. If positive, use the coccidiostat prescribed by your veterinarian to treat your calves. Further information is available at Animal health Ireland who have published very good guidelines on the management of coccidiosis in calves http://animalhealthireland.ie/?ahi-publication=bovine-coccidiosis-the-facts.

Summer Scour Syndrome
This condition is not well understood, and no definitive cause has been determined. Summer Scour Syndrome is used to describe scours in calves that happen shortly after turn out to pasture (within 6 weeks). It presents with the same clinical signs as other scours cases. The traditional scour causes must be ruled out diagnostically before calves can be diagnosed with Summer Scour. The only common factor between calves with Summer Scour is that

they are on a grazing diet and it is their first time out to pasture. Immediate removal from pasture helps to resolve the issue. The disease is believed to be associated with rich, lush pastures in combination with an underdeveloped rumen. Consult your veterinarian to rule out all other possible causes of scours in freshly weaned calves at pasture.

Transmission of diarrhoea

Transmission and factors that influence disease manifestation vary depending on the infecting pathogen. Calves become infected by coming into contact with infectious agents in faecal matter (faecal-oral route). In the case of protozoal infections, the environment becomes contaminated by sick calves, 'healthy' looking calves, older calves, and adult cattle who shed infectious oocysts in their faeces. Calves, who explore their environment orally, ingest contaminated faecal matter and bring the pathogen directly to their gastrointestinal tract. Pathogens then establish themselves in the gut, causing the lining of the small intestines to become inflamed, in serious cases leading to permanent damage. Inflammation and damage results in malabsorption of nutrients and water in the hindgut and has lifelong ramifications on growth, development, reproduction, and performance.

Diagnosis of diarrhoea

Early detection of diarrhoea is key, so knowing the symptoms is important. Be vigilant for:

- Increased defaecation; watery/runny consistency; faeces that is brown, grey, green, or yellow in colour; and blood or mucus in the faeces.
- Weak, depressed, and lethargic calves; with little desire to feed, and a weak suckling reflex.
- Dehydration: sunken eyes and prominent bony areas (hips, ribs), a staggered or swayed walk, too weak to stand.

Diagnosis of a specific pathogen cannot be done using clinical signs alone. Faecal samples can be tested in a laboratory, or by your veterinarian using a rapid detection test. If calves have died, always send them for post-mortem in order to determine cause of death.

Treatment

Specific treatments can vary depending on the causative agent. If experiencing a scour outbreak, control the spread and provide supportive therapies to the calves that are ill. No matter the cause of scours, farmers are advised to:

- ISOLATE sick animals, in a clean, warm, dry space. Remove healthy calves from the contaminated environment. Clean and disinfect *everything*!
- HYDRATE scouring calves, dehydration is deadly. Provide supplemental electrolyte feedings between milk meals to keep calves hydrated.
- Keep FEEDING sick calves their milk meals, the nutrients in milk helps fight disease.
- Keep the calf comfortable by providing clean, deep bedding, and use of calf jackets.

Further information is available at https://animalhealthireland.ie/programmes/calfcare/

At no point should antibiotics be used to treat scours if there is no indication of bacterial infection. Bacteria are one of the least common causative agents of scours in calves. The use of antibiotics, if there is no sign of bacterial infection, only increases antimicrobial resistance leading to less effective drug therapies and more severe disease. As always, talk with your veterinarian about which courses of action are best for your situation.

Prevention

There are many different aspects to prevention that are key to managing scours. Calf husbandry management, biosecurity protocols and vaccination programs are all essential and can be managed systemically through the development and use of a comprehensive herd health plan. The herd health plan should focus on the different parts of the cattle production system and how these parts interact with each other. Consulting with your veterinarian and livestock advisor is critical when developing a comprehensive herd health plan. With regards to calf health and preventing scours, a major component of this health plan should focus on optimizing colostrum management. Colostrum, or first milk, not only provides essential nutrients to the calf in the first hours of life, it also allows for the passive transfer of antibodies needed for the calf to protect itself prior to the full development of an active immune system around 3-4 weeks of age. Ensuring that your calves receive adequate amounts of quality colostrum quickly helps them get the best start in life. You can easily measure the quality of colostrum using a Brix refractometer.

Animal Health Ireland recommend that producers follow the 1 → 2 → 3 method of colostrum feeding for dairy calves:

1) Calves are fed the colostrum from the FIRST milking on their FIRST feed.
2) Calves should be fed their colostrum within TWO hours of birth.
3) Make sure calves get at least THREE litres of colostrum.

Implementing the 1-2-3 approach with suckler beef calves would not be practical. Hence, colostrum management programmes on suckler beef farms need to emphasize the importance of colostrum quality and the timing of colostrum ingestion, and how these factors can be manipulated and monitored by the farmer. The calf's small intestine has the ability to absorb immunoglobulins (Ig) during the first 24 hours of life, but the efficiency of absorption begins to decline within a few hours of birth. Failure of passive transfer (FPT) of immunity occurs when the calf does not absorb sufficient Ig within this time period. It is well established that calves with FPT are at greater risk of morbidity and mortality, begin exhibiting clinical signs of disease at younger ages, and experience an increased number of sick days and reduced growth performance when compared to calves with adequate passive immunity. Cattle develop immune systems specific to their environment which means the colostrum they produce will be tailored to the potential pathogens that are already present in the environment. There are vaccinations for *E. coli*, Rotavirus, and Coronavirus. Vaccinating dams for these diseases at the correct time-point in gestation helps increase antibodies in the colostrum, which protects the calf while the immune system develops. Work with your veterinarian to develop a vaccination program that is appropriate for your farm.

The 'Holoruminant' EU-funded Project:

Ongoing research continually improves our understanding of specific infectious diseases and management practices. Teagasc, as a part of the EU-funded Holoruminant project, is working to uncover links between early-life microbiomes and manifestation of scours in calves. The information uncovered will set up the foundations needed for alternative and holistic scour management. The development of alternative and holistic management strategies will create opportunities to develop more sustainable bovine production systems.

Calf housing design

Tom Fallon

Teagasc, Kildalton Agricultural College, Piltown, Co. Kilkenny

Summary

There are five key requirements for a calf shed:
- Good ventilation to ensure air is fresh and no draughts are created.
- Adequate space: It is recommended to provide 2.0-2.3 m2 pen area per calf.
- Dry/good drainage: Calves spend 80% of their time lying down so they need a dry bed.
- Warmth: Calves perform best at 15-20oC; however, well-bedded calves are comfortable down to about 8°C.
- Clean and cleanable: Floors and walls should be easily cleaned.

Ventilation

Good ventilation takes away moisture, dust, ammonia, bugs and excess heat. It also kills harmful organisms living in the air – viruses for example will survive for a shorter time in fresh air than in stale air. Dust and ammonia irritate the respiratory tract and make the animal more vulnerable to respiratory disease. The recommended minimum air inlet and outlet per calf is 0.08 m^2.

Natural Ventilation

Natural ventilation is used in the vast majority of calf houses. This works in two ways:
1. 'Stack effect': this occurs where warm air rises and leaves the building through an opening in the ridge and it is replaced by cooler, fresher air. The recommended roof slope of 15 to 22 degrees is a major help to the stack effect.
2. 'Wind effect': in this case wind drives fresh air through the building.

Natural ventilation works best when the calf house is positioned at right angles to the prevailing wind and the building is not excessively wide (ideally <12 metres) or excessively high (3.35 to 4 m at the eaves is recommended).

Air inlets can be provided by 'Yorkshire boarding', space boarding or vented sheeting (Figure 1). Yorkshire boarding has two staggered lines of vertical timber so it reduces air speed, water entry and the likelihood of draughts. Specification S101 from the Department of Agriculture, Food and the Marine (DAFM) stipulates that the minimum length of the boarding is 1.5 m that the laths are 25 mm thick, a maximum width of 75 mm with gaps of at least 25 mm. The two lines of laths are 25 to 50 mm apart.

Space boarding can be satisfactory on the sheltered side of a calf house in a suitable site. If in doubt use Yorkshire boarding because wind direction can change and calves are sensitive to draughts. A draught is essentially excessive air movement (air speed >0.5m/s) at calf level.

A capped ridge outlet is recommended with flashing, as required, to prevent wind driven rain getting in. Two alternative designs are shown below (Figures 2 and 3). An adequate roof slope will ensure that the outlet is at least 1.5m above the inlet.

Figure 1. Space boarding on left, and Yorkshire boarding on the right

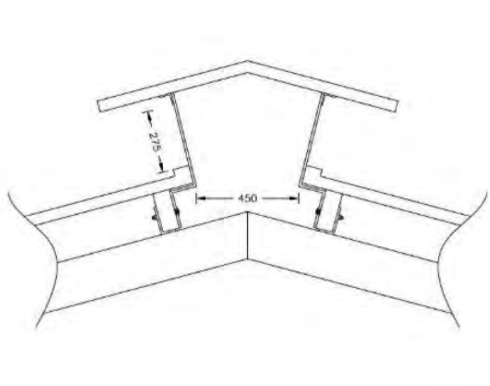


Figure 2. Protected ridge with upstands

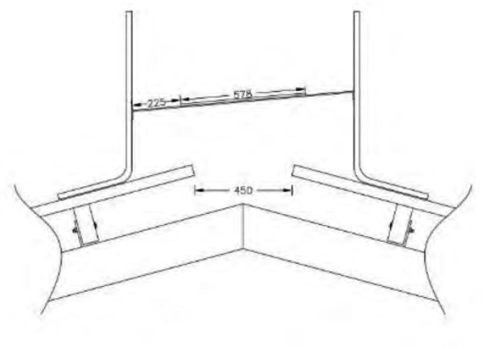


Figure 3. Covered open ridge

Mechanical Ventilation
Ventilation fans can draw fresh air from outside the building and blow it through a plastic duct with numerous small outlets along the length. This system supplements or substitutes for inadequate air inlets.

Space

It is recommended to provide 2.0-2.3 m^2 pen area per calf. Typically, an individual pen must be 1.0 m wide by 1.5 m long, but 1.7 m is recommended, especially for isolation pens.

Dry with good drainage

Calves spend about 80% of their time lying down so they need a dry bed. A dry environment will also reduce the spread and growth of bugs. All calf houses should be built with a damp-proof course to prevent rising dampness.
A slope of 1:20 in the calf pen area is recommended (Specification S124 DAFM). A split drain has the advantage that it will get urine and associated smells out of reach of calves quickly.

Warmth

Calves perform best at 15-20°C but don't generate sufficient heat to insulate themselves from colder temperatures until after they are weaned. Deep beds of straw are effective in protecting calves from the cold. Calves require 15-20 kg straw as bedding per week equivalent to one 150 kg round bale of barley straw to rear each calf. Well-bedded calves are comfortable with ambient temperatures as low as about 8°C.

Clean and cleanable

Floors and walls should be easily cleaned. Floors can be laid in bays of not more than 4.5m by 6m to avoid the need to make contraction joints. Concrete floors that are well-compacted need to be well-cured to avoid plastic shrinkage cracks etc.

Natural light

Natural light is conducive to good animal health and provides for a good working environment. It is recommended that 15% of the roof area should be translucent sheets (as listed on DAFM S.102).

Calf shed layout for different feeding systems

Figure 4 shows a suitable shed layout when calves are to be reared on an automatic calf feeder. Approximately 3.5 m of the pen is not bedded. This facilitates a reduction in straw usage and normal social behaviour among calves. Placing the split drain about 3 metres from the front of the pen helps to divide the fall across the shed (a 1:20 fall can be hard to achieve in practise). This area will, however, have to be cleaned at least daily, preferably with a 'hand yard scraper' since any use of water within the building should be kept to a minimum to keep down humidity. Three training pens, each capable of holding 3 small calves are included. A store with its own air space and access point to receive a pallet of milk replacer is provided (as recommended by DAFM specification S124). Two of the calf pens have small doors to allow calves access to a field, if desirable.

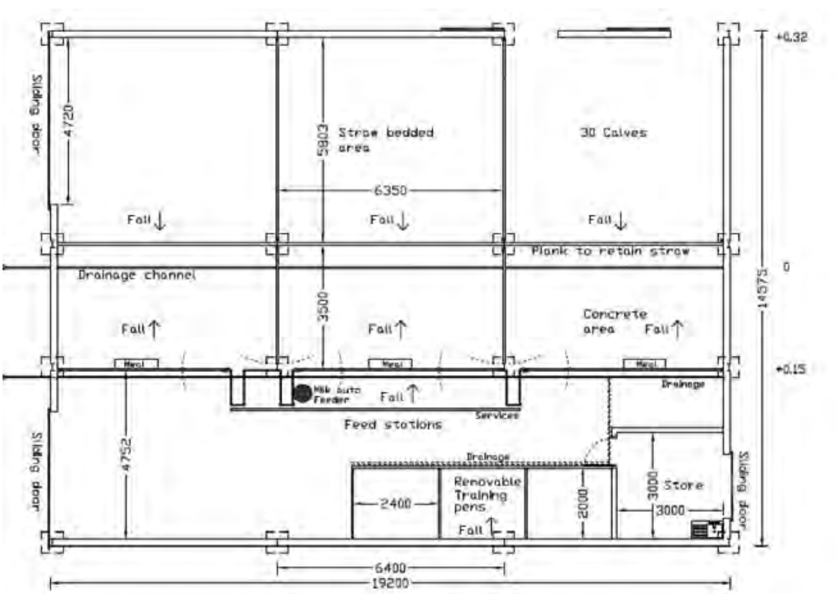


Figure 4. Calf shed suitable for an automatic calf feeder

Common problems associated with calf housing

Problem	Possible Solutions
Calf house too cold or draughty	Purpose built calf houses work best Microclimate from solid partitions and canopy Calf Jackets
Overcrowding	Extra calf housing Allow calves external space Early-turnout to pasture by letting calves out by day (with shelter)
Drainage issues	Repairing channels and using extra straw can help. Redo floors with correct slopes, channels etc.

Cold or draughty calf house

This can be a problem with some new calf houses that have high eaves or excessive ventilation. It can also occur when high sheds such as hay sheds are converted into calf houses. There is a delicate balance between having adequate ventilation while avoiding a cold uncomfortable environment for calves. Draughts can also occur with changes in wind direction, when doors are left open etc.

Prevention of draughts:

- Avoid excessive eave height over 4 m.
- Provide appropriate inlet ventilation on the ‘long’ axis of the building (in general not on gable ends).
- The use of a ‘protected ridge’ will prevent downdraughts from the outlet.
- Use ‘Yorkshire boarding’ or equivalent to dampen air speed especially on exposed sites.
- A high-standard of construction such as carefully fitted doors will help to prevent draughts at calf level.

The use of solid partitions between pens and a canopy at the back of the pens can help to create a comfortable environment for calves. This is equivalent to creating an ‘igloo-type’ environment within the calf house. The feedback from farmers who have used breathable washable calf jackets especially for young calves is positive.

Further information on calf housing design can be found at **https://www.teagasc.ie/media/website/publications/2017/Section5-Calf-accomodation.pdf**

Grange dairy calf-to-beef system evaluation

Nicky Byrne[1], Donall Fahy[1], Jamie O'Driscoll[1], Mark Kearney[1] and Noirin McHugh[2]

[1]Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath
[2]Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork

Summary

- Dairy-beef progeny from beef sires with high-genetic merit for carcass traits, have greater carcass, economic and environmental efficiency.
- Performance, profitability, greenhouse gas emissions, and human-edible protein efficiency improved with carcass merit.
- Increased conformation and reduced feed costs were key profit drivers.
- Grass-based dairy-beef production can be high output and relatively profitable.

Introduction

Due to the expansion of the national dairy herd, the number of dairy-beef animals has increased in recent years, and now account for 57% of the cattle processed in Irish meat plants. Concurrently, there has been a decrease in carcass conformation score of dairy-bred progeny from beef and dairy sires. The selection criteria (calving ease, gestation and breed) for beef sires used on the dairy herd has insufficient emphasis on genetic merit for carcass traits to counteract the poor and declining 'beef' traits of Irish dairy cow genetics. Nationally, for the previous 11 years, the average age at slaughter of dairy and beef × dairy steers is 27 and 28 months, respectively.

Much of the animal variation in carcass traits is under genetic control (46%), but animal health, nutrition and grassland management permit animals and production systems to achieve their potential. Poor performance in any of these areas make it difficult to meet production targets, and consequently limits the economic and environmental efficiency of dairy-beef systems. Reduced animal and financial performance has contributed to the high dropout rate observed in the number of farms rearing dairy calves in successive years. Improved reproductive efficiency in dairy herds will permit a greater use of beef sires with higher genetic merit for beef production-related traits. These superior dairy-beef genetics, coupled with good management practices at farm level, can create more profitable grass-based dairy-beef systems with reduced slaughter age and environmental impact.

Grange dairy calf-to-beef study

A recent study at Grange looked at the effect of sire genetic merit for carcass weight and conformation on dairy calf-to-beef system performance. The objective of the study was to compare the physical and financial performance of male progeny from three dairy-beef genetic groups, within an efficient grass-based production system. The sire genetic groups were Holstein-Friesian (HF) and two Angus (AAX) groups representing the main calf breeds born in the dairy herd. The HF group were the progeny of the top four sires on the Economic

Breeding Index (EBI) active bull list in the previous breeding season. The two AAX groups were the progeny of AA sires that were ranked high (HIGH AAX; +8.1 kg carcass, 0.83 conformation)) or low (LOW AAX; -3.7 kg carcass, 0.53 conformation), for carcass weight and conformation score, but both had similar breeding values for calving ease and were used extensively across the national dairy herd. All progeny were from HF dams and sired by AI bulls.
In both spring 2018 and 2019, 120 male calves, sourced using the ICBF database, were purchased from 33 dairy farms throughout the country and arrived at Teagasc Grange at approximately 21 days of age. The effect of early-life calf nutrition (indoors) on lifetime performance was evaluated, whereby half of the calves in each of the three 'genetic' groups received either 4 or 8 litres (L) of milk replacer/day. Subsequently, each of the three genetic groups were grazed separately but were managed identically. An intensive grass-based system of production was implemented based on 48-hour grass 'allocations' and grazing to a post-grazing sward height of 4 cm. Each group had its own farmlet of 31 acres (12.5 ha), carrying 40 male calves (0-12 months) and 40 yearlings (12-24 months) over the grazing season. When housed for the 'first' winter steers were offered high dry matter digestibility (DMD 75%) grass silage *ad-libitum* and 1.5 kg of concentrates per head daily. During the indoor finishing period steers were offered high DMD grass silage *ad-libitum* and 5 kg of concentrates per head daily. Steers were body condition scored (BCS) fortnightly during the 'finishing' phase, and were drafted for slaughter at a BCS of 3.75 (scale 1-5), equating to a target carcass fat score of between 3= and 4-. All inputs and outputs from each of the farmlets were measured and used to model the economic and environmental efficiency of systems.

Results

There was no difference in lifetime growth or carcass performance of calves reared on 4 or 8 L of milk/day. Despite the 4 L treatment consuming 25 kg more concentrate (fresh weight basis) than the 8 L treatment, there was a saving of €33 per head during the calf-rearing phase as a result of feeding 20 kg less milk replacer. The HIGH and LOW AAX steers had the same slaughter age and finishing period (63 days), which was one month shorter than HF steers (Table 1). Over the calf rearing phase the average daily live weight gain (ADG) for each 'genetic group' was 0.70 kg. During the 'first' grazing season ADG for HF, HIGH AAX and LOW AAX were 0.79, 0.71 and 0.74 kg, respectively. Corresponding values during the 'first' winter were 0.67, 0.73 and 0.76 kg, during the 'second' grazing season were 0.98, 1.04 and 0.98 kg, and during the 'finishing' period were 0.94, 1.04 and 0.98 kg.
There were small differences in carcass weight and conformation score between the AAX groups (numerically in favour of HIGH AAX). The HF steers had a similar carcass weight but were leaner and more poorly conformed than the AAX groups, which resulted in a lower carcass value. The forage (grazed and conserved grass) dry matter consumed in the lifetime diet of each genetic group was high - 87% for both AAX groups and 85% for HF. Over their lifetime the AAX groups consumed a total of 549 kg of concentrate (fresh weight) compared to HF steers consuming 695 kg.
The HIGH AAX steers achieved the highest net margin (Table 1), due to their improved carcass weight and conformation and value/kg carcass, and both AAX groups performed better than HF steers due to higher carcass performance and shorter finishing period.
The HIGH AAX steers also had the lowest 'carbon footprint', producing 9% less CO_2 eq per carcass kg than HF steers. An alternative means of assessing the efficiency of ruminant

production systems is food-feed competition (Page 64), which examines the ratio of human edible protein produced (meat) versus human edible protein fed to cattle (grain). Both AAX groups were net producers of human edible protein, whereas HF steers produced 25% less protein than they consumed in their production, meaning for 1 kg of human edible protein fed to cattle only 0.75 kg of human edible protein was produced in the form of meat.

Table 1. The effect of sire carcass merit on physical, financial and environmental efficiency within a grass-based dairy-beef system.

	HF	HIGH AAX	LOW AAX
ANIMAL			
Age at slaughter (days)	686 (22.8 months)	656 (21.8 months)	657 (21.8 months)
Carcass weight (kg)	300	305	300
Carcass conformation (1-15)	3.8 (O-)	5.3 (O=)	5.1 (O=)
Carcass fat (1-15)	8.4 (3=)	8.9 (3+)	9.2 (3+)
Lifetime concentrate use (kg)	695	552	545
SYSTEM			
Stocking rate (LU/ha)	2.9	2.7	2.7
Grass grown (t DM/ha)	12.7	12.3	12.3
Chemical nitrogen (kg/ha)	250	250	250
Carcass output/ha (kg)	960	976	960
FINANCIAL			
Gross output (€/ha)	3184	3123	3018
Variable costs (€/ha)	1974	1672	1688
Gross margin (€/ha)	1242	1451	1330
Fixed costs (€/ha)	780	723	722
Net margin (€/ha)*	462	728	607
Net margin (€/kg carcass)	0.48	0.75	0.63
Cost of production, (€/kg carcass, incl. calf purchase)	3.07	3.04	3.11
ENVIRONMENTAL			
GHG emissions (kg CO_2e/kg carcass)	14.2	12.9	13.2
Human edible protein ratio (kg/kg)	0.75	1.05	1.02

*Base price of €3.70/kg on the QPS grid; €0.20/kg QA payment and €0.10/kg AA breed bonus. Calf and finishing concentrate price €420 and €300/t, respectively. Protected urea price €387/t. *Net margin excludes land & labour charge and assumes a calf purchase price of €60 and €180 per head for HF and AAX sired bull calves, respectively.*

In summary, all groups achieved similar carcass weight, but the AAX groups produced a carcass of higher value, through improved conformation and, as they were slaughtered at a younger age, they had lower input costs than HF. The use of high carcass merit beef genetics on the dairy herd will play an important role in improving the sustainability of both dairy and beef sectors, but large scope exists to improve the carcass characteristics of beef sires used extensively on the dairy herd, such as those evaluated in this study, based on the carcass potential of bulls ranked highly on the Dairy Beef Index (Page 150).

Current dairy-beef research at Teagasc Grange

Grass-based systems of beef production are the most 'sustainable' due to their lower requirement for imported feed. Compared to the average age at slaughter for dairy-beef cattle nationally, the study described above showed that within a grass-based system much younger slaughter ages are possible (5-months earlier), while achieving a similar carcass weight. However, not all dairy-beef animals have the same 'ability' to meet required carcass specifications at young ages when produced on a grass-based diet.

Given these factors and the policy ambition to reduce age at slaughter in the national beef herd, a new study was formed to investigate the role of genetic selection for reduced age at slaughter and supplementation during the grazing season on the biological, economic and environmental performance of dairy-beef systems. For the purpose of this study, an estimated breeding value was generated to identify animals with potential to produce an 'in-spec' carcass at a younger age; EARLY (younger age at slaughter), LATE (older age at slaughter). An 'in-spec' carcass is defined here as having a fat score between 3= and 4-, and a carcass weight between 270 and 380 kg.

Male calves from HF cows mated to AA sires divergent in genetic potential for 'age at slaughter', or mated to high EBI HF sires, were purchased at three weeks of age. These three genetic groups were then assigned to experimental treatments, differing in concentrate supplementation during the first and second grazing seasons: grass-only for both grazing seasons (Grass-only, GO); calves supplemented with 1 kg concentrate daily for the first, and grass-only for the second, grazing season (INTER); Calves supplemented with 1 kg concentrate for the first grazing season, and with 4 kg concentrate from July of the second grazing season (HIGH). The objective was to explore the role of strategic concentrate use as a means of reducing age at slaughter and to identify the optimum management for animals with different genetic potential for producing an 'in-spec' carcass at a younger age. Animals were drafted for slaughter based on a target BCS of 3.75, equivalent to a carcass fat score of 3= to 4-.

Preliminary analysis from the first year of this study showed that across the concentrate feeding systems, EARLY steers produced an additional 30 kg of carcass at a similar slaughter age compared to LATE steers (Table 2). The implication of this is that a higher proportion of animals can be finished at a younger age from pasture rather than indoors. In terms of the concentrate feeding treatments, there was no difference in carcass performance or age at slaughter between steers on GO and INTER for any of the genetic groups. When meeting the target fat score all EARLY animals on the HIGH treatment produced an in-spec carcass 42 days sooner than those on GO, avoiding the need for a second indoor winter period. Although, LATE animals on the HIGH treatment also achieved the target fatness without the need for indoor finishing, 50% of carcasses were 'under-spec' for weight. Unlike the AAX genetic groups, age at slaughter of HF steers (based on carcass fatness) was not influenced by concentrate supplementation, with GO, INTER and HIGH treatments requiring 145, 138 and 138 days, respectively, of a second indoor winter period (Table 2).

Table 2. Slaughter performance of dairy-beef steers managed on grass-only (GO) or grass supplemented with concentrates (from July) during the second grazing season (HIGH).

	GO			HIGH		
Slaughter performance	**EARLY**	**LATE**	**HF**	**EARLY**	**LATE**	**HF**
Age at slaughter (months)	22.1	22.4	24.7	20.5	20.4	24.4
Finishing days (indoors)	75	79	145	0	0	138
Finishing concentrate (kg)	367	387	720	471	427	1051
Carcass weight (kg)	328	304	328	306	269	344
Carcass conformation	O=/O+	O=/O+	O-/O=	O=	O=/O+	O-/O=
Carcass fat	4-	3+	3+/4-	4-	3+	4-

Maximizing carcass output through increased stocking rate on a dairy-beef systems

Ruth Dunne[1], Alan Twomey[2] and Padraig French[2]

[1] *Teagasc, Johnstown Castle, Co Wexford*
[2] *Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork.*

Summary

- Stocking rate (SR) is the main factor that influences carcass output per hectare on dairy-beef systems.
- Carcass output per hectare is one of the main drivers of dairy-beef farm profitability.
- Animals on high SR systems can compensate for periods of herbage restriction during their finishing periods.
- High SR negatively impacted the performance of 21-month heifers.
- The high SR systems were unable to provide adequate winter forage.
- As SR increased, total grass dry matter produced per hectare decreased under the same level of nitrogen fertiliser application.

Introduction

Stocking rate (SR) is defined as the number of animals on a given amount of land over a certain period of time, and is usually presented as Livestock Units per hectare (LU/ha). Previous research at Teagasc Johnstown Castle, whereby blueprints for alternative dairy-beef production systems were identified, found that the most significant factor determining profitability of dairy-beef production systems was output per ha, i.e. kg of beef produced/ha. In order to increase output/ha, individual animal performance and/or SR intensity must be increased. Research has found that increasing SR reduces individual animal performance due to increased competition, but maximizes overall bodyweight gain/ha. This ultimately leads to increased economic returns. However, it is unclear at which point increasing SR restricts animal performance to the point system economic performance is reduced. Research at Johnstown Castle from the period of 2016 to 2021 looked at the impact of increasing SR beyond 2.5 LU/ha on dairy calf-to beef production systems, and its impact on animal performance.

Experimental design

Each year 216 reared beef × dairy calves were purchased at approximately 16 weeks of age and assigned to one of three SR groups; 'low' (2.6 LU/ha), 'medium' (2.9 LU/ha) and 'high' (3.2 LU/ha). Each group of calves consisted of 36 heifers and 36 steers and were balanced for breed (AAX, HEX and LMX), date of birth and weight on arrival. Across the farm, the paddocks were divided in blocks so that the various soil types and conditions are represented in each SR 'farmlet'.

For their first grazing season, the calves were fed 1-2 kg of concentrate and were subsequently housed in November when grazing conditions deteriorated. The calves were fed 2 kg/head of concentrate over the winter period alongside good quality (high dry matter digestibility) grass silage offered *ad libitum*. The yearlings were turned out to pasture in March and grazed in their group of 72 until September, when the heifers and steers were separated to allow for the heifers to commence their finishing diet. From September, the heifers were fed 3 kg/head daily of concentrate. Those that were not slaughtered off grass before winter housing were housed mid-October and fed 5 kg of concentrate per head daily and grass silage *ad libitum* up to slaughter. The steers remained at grass until mid-October when they were housed and fed grass silage-only *ad libitum* for the winter. Steers that were sufficiently 'finished' indoors from grass silage-only were slaughtered before turnout, and those that were not fit for slaughter were turned out to pasture in March and fed 3 kg/head of concentrate from May until finish in June/July. All animals were drafted for slaughter based on a target carcass fat score of 3+.

Impact of stocking rate on the performance of beef × dairy heifers

During their first and second grazing seasons, the high SR performed the poorest, with significantly lower daily live weight gain (ADG) than the low SR during both seasons (Table 1). There was no significant difference between the treatments during the first winter. There was a significant difference in live weight between treatments at 550 days of age, when the heifers began their finishing diet at grass (Table 2). During the second winter, when the remaining heifers were housed and on their finishing diet, the high SR compensated for their poor performance and grew faster than the medium and low SR systems. Overall, SR had no significant impact on the lifetime ADG of the heifers.

Slaughter data was collected from 420 heifers across the four years of the study. The results show that there was a significant, but small, difference in carcass weight between treatments, with the low SR heifers having a 5 kg heavier carcass than the high SR heifers (Table 2). There was also a significant difference in carcass conformation score. There was no significant difference in fat score or age at slaughter between the treatments.

Table 1. Effect of stocking rate (SR) on daily live weight gain (ADG, kg) of beef × dairy heifers in a 21 month system

	ADG first season	ADG first winter	ADG second season	ADG second winter	Lifetime ADG
High SR	0.63	0.67	0.81	1.09	0.95
Medium SR	0.71	0.65	0.81	0.94	0.95
Low SR	0.68	0.67	0.86	0.99	0.97

Table 2. Effect of stocking rate (SR) on slaughter performance of beef × dairy heifers under a 21 month system

	*Carcass weight (kg)	*Conformation score (scale 1-15)	* Fat score (scale 1-15)	Age at slaughter (days)	Weight at 550 days
High SR	261	5.62	8.98	666	420
Medium SR	262	5.64	8.95	670	428
Low SR	266	5.88	9.06	664	432

**Adjusted to 638 days of age*

Impact of stocking rate on the performance of beef × dairy steers

Slaughter data was collected from 412 steers across the four years of the study. Similar to the heifers, the high SR performed the poorest in the first and second grazing seasons, although this was only significant in the latter (Table 3). There was no difference in performance during the first winter. During the second winter, the medium SR grew significantly better than the high and low SR. During the third grazing season, the high SR compensated for their poorer performance and grew significantly faster than the low and medium SR. The low SR steers were significantly heavier than the high SR at the end of the second grazing season. There was no significant difference between treatments in terms of carcass weight, conformation score, fat score or age at slaughter (Table 4).

Table 3. Effect of stocking rate (SR) on daily live weight gain (ADG, kg) of steers under a 27 month system

	ADG first season	ADG first winter	ADG second season	ADG second winter	ADG thrid winter	Lifetime ADG
High SR	0.66	0.70	0.85	0.52	1.43	0.96
Medium SR	0.70	0.69	0.88	0.63	1.29	0.97
Low SR	0.71	0.70	0.89	0.54	1.30	0.98

Table 4. Effect of stocking rate (SR) on slaughter performance of steers under a 27 month system

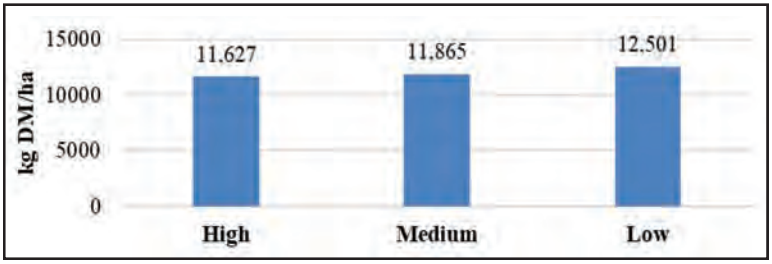
	*Carcass weight (kg)	*Conformation score (scale 1-15)	* Fat score (scale 1-15)	Age at slaughter (days)	Weight at second housing
High SR	335	5.47	8.89	823	499
Medium SR	337	5.56	8.96	825	503
Low SR	337	5.42	8.99	816	507

**Adjusted to 821 days of age, **Adjusted to 620 days of age*

Impact of stocking rate on grass growth and silage production

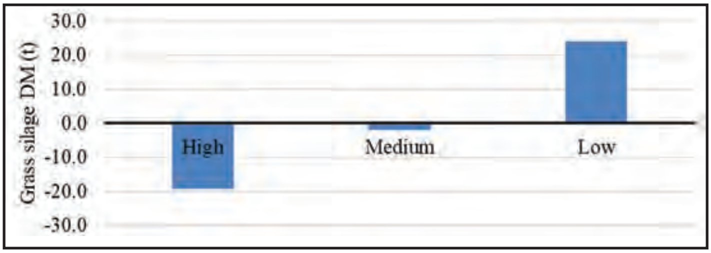
The three farmlets were treated the same in terms of chemical nitrogen (N) fertiliser application, and received an average of 210 kg N/ha across the farmlets (grazing and silage ground). Preliminary data suggests that as the SR increased the total yield of grazed grass and grass silage dry matter per hectare reduced (Figure 1). This is contradictory to other work which suggests that as SR increases, the utilisation and production of grass dry matter (DM) increases. However, if the application rate of N fertiliser had been increased in line with the increase in SR, grass DM production may have increased too.

Figure 1. Total (grazing + silage area) grass dry matter (kg DM) grown per hectare in the high, medium and low stocking rate systems



During the years 2017 to 2020 the average quantity of grass DM harvested for silage from the high SR treatment was not sufficient to meet animal demand over the average winter period, which included a 10% buffer (Figure 2). In contrast, sufficient winter fodder was harvested for the medium SR harvested, whereas the low SR had a large surplus.

Figure 2. Balance of supply and demand for winter forage (grass silage) in the high medium and low stocking rate systems



Results summary

For the heifer system, the low SR animals were heavier and more conformed at slaughter, suggesting that when there is more forage availability, the animal is able to lay down muscle at a greater rate. Before starting their finishing diet in September (550 days of age) the high SR heifers were significantly lighter than the medium and low SR groups. As the majority of these heifers were housed for up to six weeks before slaughter, the weight advantage of low and medium SR animals over high SR animals was reduced during this unrestricted feed period indoors due to compensatory growth in the latter group. Had these heifers not been housed, the difference in carcass performance would likely be greater. Similarly, the performance of the high SR steers was reduced during the second grazing season, resulting in a lighter weight at housing. However, because those steers had a longer 'unrestricted' period (from housing until finishing in June) they were able to fully compensate for the lower earlier growth rate. This resulted in a minimal difference in the slaughter performance of the steers under a 27-month system and suggests that farmers can increase their SR under this system without negatively impacting the performance of their animals. Although there was some negative impact on slaughter performance, the high SR will ultimately have greater carcass output/ha due to the higher number of animals killed on a per hectare basis. However, where N fertiliser application is limited, like in this study at 210 kg N/ha, the higher SR system will not be able to meet the winter demand of the animals within its system.

In summary, a vital element to successfully increasing SR and thereby output/ha is increasing the grass grown and utilised on the farm. Beef farmers must match grass production to grass demand, ensure optimal usage of the grass produced, and also ensure that sufficient forage is harvested to meet the subsequent winter demand. From preliminary analysis, we can see that the medium SR grew sufficient fodder, while not reducing the performance of the animals to the same extent as the high SR, and increased output per hectare compared to the low SR, as SR was better aligned with the farms grass growth potential. A full economic analysis is required to factor in the purchase or sale of winter forage, and the difference in output/ha across the three treatments to gauge the net profit per hectare of these three 'intensive' grass-based SR systems.

Lessons learned from the Teagasc Green Acres Calf-to-Beef Programme

Alan Dillon[1] and Seán Cummins[2]

[1] *Teagasc, Advisory Offices, Gortboy, Kilmallock, Co. Limerick*
[2] *Teagasc, Kildalton Agricultural College, Piltown, Co. Kilkenny*

Summary

- Profitability on Teagasc Green Acres Calf-to-Beef Programme farms increased from a net margin of €100/ha to €650/ha over the course of phase II of the programme.
- Greater live weight output per livestock unit and per hectare were achieved.
- Dairy-beef farmers must implement a defined system, having a clear end-goal for purchased calves.
- Grass production increased from 8.6 t DM/ha to 10.2 t DM/ha.
- Improvements in silage 'quality' contributed to greater first-winter performance and reduced time to slaughter and cost.
- Reducing the number of herds of origin and the implementation of a vaccination protocol led to a higher health status of purchased calves.

Introduction

Phase II of the Teagasc Green Acres Dairy Calf-to-Beef Programme commenced in 2019 and concluded in 2021. Twelve commercial dairy beef demonstration farms, located nationwide, benefited from advice from dedicated programme advisors. Robust farm plans were developed focusing on improving soil fertility, grassland management, animal health and animal performance in order to improve overall farm profitability on commercially-operated, dairy calf-to-beef farms.

Physical and financial performance

Table 1 outlines the average physical and financial performance across the 12 Teagasc Green Acres farms from 2018 to 2021. Although average figures are presented, large variation in profitability levels were recorded across farms, influenced predominately by farm stocking rate, live weight (LW) performance and land type. Higher profits were witnessed on farms with higher stocking rates, achieving early turnout to pasture in the spring and where the number of cattle finished from grazed grass was maximised. Although still profitable, farmers on more 'challenging' land types had less opportunity to finish animals at pasture, meaning a longer indoor/winter period was required resulting in the use of higher levels of silage and meal.

With the large variation in land type, stocking rate and production systems being implemented at farm level, a wide range in profitability (excluding subsidies) extending from €51/ha to €1,342/ha was observed.

Variable costs increased by €418/ha over the course of the programme, which is to be expected given the increased stocking rate. Crucially, however, the increase in spend on variable costs such as feed, fertiliser, vet and contractor was much less than the extra output value and left an increased gross margin of €1,341/ha in 2021 versus €706/ha in 2019. Fixed costs increased from €606/ha to €692/ha. Part of what contributed to the increase in fixed costs was some farmers requiring investment in housing and land improvements.

Table 1. Physical and financial performance of Green Acres farms

	2019	2020	2021	2021 (max)	2021 (min)
Stocking rate (LU/ha)	2.11	2.31	2.31	3.40	1.53
Live weight output (kg/ha)	994	1,178	1,427	2,461	607
Live weight output (kg/LU)	455	491	606	723	396
Gross output value (€/ha)	1,829	2,381	2,882	5,314	1,184
Variable costs (€/ha)	1,123	1,283	1,541	2,491	735
Gross margin (€/ha)	706	1,098	1,341	2,823	449
Fixed costs (€/ha)	606	643	692	1,531	398
Net margin (€/ha)	100	454	650	1,342	51

Live weight output

Maximising LW output on both an individual animal (per livestock unit) and a per hectare basis are key contributing factors to profitable dairy calf-to-beef production systems. Marked improvements in output have been realised on programme-farms increasing from 994 kg LW/ha in 2019 to 1,178 kg LW/ha in 2020 and to 1,427 kg LW/ha in 2021. Through improvements in grassland management, nutrition and health, animal growth recorded at farm level also increased, with LW gains for Holstein-Friesian steers and early-maturing heifers improving by 0.1 kg/head/day from the commencement of the programme through to the conclusion. This, combined with more efficient systems being operated at farm level, resulted in output per livestock unit increasing over the duration of the programme from an average of 455 kg in 2019 to 606 kg in 2021.

Defined systems

At the commencement of the Green Acres programme many of the farmers were not operating a clearly-defined system, with a mixture of finishing and store-trading been undertaken. With the creation and implementation of farm plans, the focus changed to carrying all animals to beef. As a result, the participating farmers were able to make calf purchasing decisions based on the end goal for the animal, leading to greater levels of planning, budgeting and future cash flow awareness. This strategy enabled improvements to be witnessed in terms of the overall performance of animals to the point of slaughter, through regular on-farm weighing.

With defined systems in place, operations on the participating farms were streamlined into clearly-defined rearing, growing and finishing periods, with targets outlined for each period of the production system. By achieving animal performance targets through the various stages of the cycle, a younger age at slaughter and/or heavier carcass weights were achieved, thus boosting the overall levels of profitability of these systems.

Table 2 provides a summary of how slaughter performance has altered for the three main categories of animals on participating farms from the commencement to the conclusion of the programme. These improvements were achieved not through an increase in concentrate feeding levels or longer 'intensive' finishing periods, but through improvements in animal performance from date of arrival right through to slaughter, encompassing a major focus on the calf rearing, grazing and winter housing periods on farm. Appropriate calf feeding programmes were implemented, focusing on milk replacer 'quality' and feeding rates, concentrate supplementation, and provision of 'long-fibre', both post and pre-weaning, to ensure sufficient rumen development. Rotational paddock grazing systems were installed and grassland measurement and budgeting was undertaken on a weekly basis throughout the main grazing season to maximise pasture 'quality', and animal performance achieved from grazed pasture. In addition, winter diets were formulated on the basis of silage 'quality', with concentrate supplementation rates based on silage nutritive values and target animal performance levels.

Table 2. Slaughter performance of Teagasc Green Acre Farms for the first and final year of the programme

Year of slaughter	Slaughter age (months)	Carcass weight (kg)	Carcass conformation score	Carcass fat score
Early-maturing steer				
2018	28	324	O=/O+	3+
2021	26	310	O=/O+	3+
Early-maturing heifer				
2018	25	259	O=/O+	3+
2021	22	261	O=/O+	3+
Holstein-Friesian steer				
2018	27	302	O-	3=
2021	26	317	O-	3=

Grassland management and silage quality

A central focus of the Teagasc Green Acres Calf-to-Beef Programme was maximising animal performance from grass (both grazed and ensiled as grass silage). Through the use of PastureBase Ireland, the participating farmers became proficient grassland managers. As a result of soil fertility improvements, implementing rotational paddock grazing, and grass measuring and budgeting, the quantity of grass grown increased from 8.6 t DM/ha to 10.2 t DM/ha.

Notable improvements in silage quality were also achieved, increasing from an average of 70% dry matter digestibility (DMD) to 73% DMD between 2019 and 2020. This was due to implementation of appropriate fertiliser programmes and targeted cutting dates. Improved silage quality resulted in increased LW gain of weanlings over the 'first' (store) winter period, with the target of 0.6 kg/day being largely achieved. Furthermore, the quantity of concentrates required for both weanling and finishing stock was reduced due to higher quality silage, with many farms reducing the quantity of concentrates offered during the indoor finishing period by 3 kg/head/day in response to higher DMD silage.

Calf health

An increased focus was placed on purchasing healthy calves by programme farmers. Research shows that purchasing calves from a greater number of sources increases the risk of calf health problems. Over the duration of the Teagasc Green Acres Calf-to-Beef Programme, farmers purchasing calves reduced the number of source herds. At the commencement of the programme, each farmer purchased an average of 94 calves from 10 different herds. In 2021, each farm purchased on average 110 calves from six herds. In addition, vaccination programmes for respiratory diseases were introduced, which contributed to reduced morbidity, antibiotic use and mortality at farm level.

Genetics

Calf genetics influences how they will perform in a calf-to-beef setting and is determined by breeding decisions made on the dairy herd. A concerted effort has been made by programme farmers to source calves sired by bulls of high genetic merit for carcass weight and conformation. Although small, improvements have been observed in the Commercial Beef Value (CBV) figures of the dairy-beef animal type as classified by ICBF for spring-born calves purchased between the spring of 2021 and 2022.

Table 3. Commercial Beef Value (CBV) of Teagasc Green Acres Programme calves

Breed type	2021 (CBV)	2022 (CBV)
Dairy × Dairy	€29	€29
Dairy × Beef	€99	€118

Conclusion

The efficiency changes implemented on Green Acres farms in grassland management, animal health and genetics resulted in improved levels of output and profitability. Farmers achieved higher levels of LW output per hectare, derived from a lower cost base than the farms had achieved previously. This indicates that there is significant scope to improve animal performance and production system viability thorough a greater focus on calf genetics on dairy-beef enterprises, which will be encompassed as part of the Teagasc DairyBeef 500 Campaign.

Acknowledgements

The authors wish to acknowledge the financial support of Liffey Mills, Drummonds Ltd., Volac Ireland, MSD Animal Health, Munster Bovine and Corteva Agriscience.

EveryCalf: Contract rearing of dairy-beef calves

Brendan Horan[1], Chloe Millar[1], Alan Twomey[1], Nicky Byrne[2] and Tom Coll[3]

[1]*Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork*
[2]*Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[3]*Teagasc, Mohill, Co. Leitrim.*

Summary

- Contract rearing agreements provide an excellent opportunity for both dairy and contract rearing farmers.
- The Everycalf project aims to evaluate the potential for profitable dairy calf-to-beef systems in collaboration with commercial rearing farmers.
- The results demonstrate the potential of high-quality pasture management on commercial farms to deliver high levels of animal performance in dairy calf-to-beef systems.
- Results from the initial slaughter data indicate the significant impact of both sire and dam genetic merit on carcass characteristics within pasture-based dairy-beef production systems.

Introduction

Increased cow numbers on dairy farms coupled with increased adoption of improved breeding technologies (Economic Breeding Index; synchronised breeding programmes, sexed semen, etc.) have resulted in consistent improvements in the six-week calving rates on Irish dairy farms in recent years resulting in large numbers of additional male calves being born each spring (Figure 1).

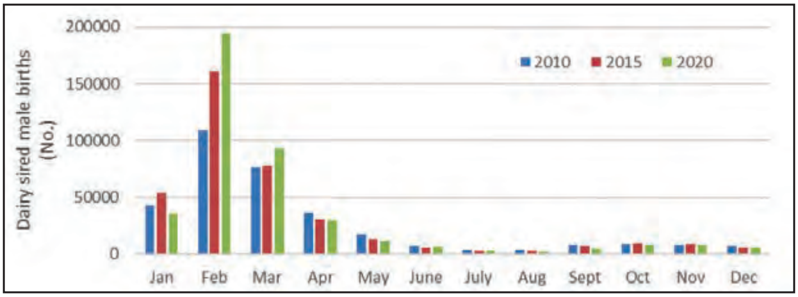


Figure 1. Male dairy sired calf births by month (AIMS, various years)

While this trend has substantial benefits for the productivity of dairy farms (increased lactation length and improved pasture utilisation), it has nonetheless, created additional pressures in managing the peak calving period in terms of increased numbers of young calves, availability of skilled seasonal labour and the adequacy of calf rearing facilities on dairy farms. A substantial increase in both the number and proportion of male dairy sired calves born during early-spring has been an additional consequence of the increased seasonality of dairy calvings. Consequently, there has been a significant increase in the number of male dairy calves which are reared to beef on existing dairy farms, in addition to increased farm-to-farm movements of unweaned calves (<6 weeks old). In response to the changing dynamics of dairy calf-to-beef systems, Teagasc has recently developed a project looking at the biological performance of male dairy and dairy-beef calves in partnership with commercial rearing farms. The objective of the Everycalf project is to evaluate the potential for profitable dairy calf-to-beef systems in collaboration with commercial dairy and rearing farmers. In the programme, Teagasc and 10 drystock farmers have entered a collaborative arrangement where the drystock farmers contract rear all of the male progeny from five Teagasc dairy research farms (Moorepark, Kilworth, Curtins, Clonakilty and Ballyhaise) each year. The 'rearers' were selected as Teagasc clients who are members of Teagasc discussion groups and who have demonstrated their capacity to achieve target weights as existing heifer contract rearers. Teagasc retain full ownership and risk associated with the potential market value of the animal at the end of the rearing period, while the rearers are paid a daily rate subject to the achievement of target animal weight gain during the contract. The calves are contract reared from 3 weeks of age to 14 months of age (mid-April of the subsequent year) or 330 kg live weight (LW) on the 10 rearing farms. Thereafter, the animals are moved to a 'grazier' and finishing unit for slaughter under 24 months of age. In addition to the rearing of animals via commercial rearing agreements, the project is unique as all male animals generated within the source herds comprising of various breeds are included in the study. All animals are weighed every 6 weeks by Teagasc during the programme to monitor animal performance. The project is anticipated to run for 4 years (2020 to 2023 inclusive). A complete financial analysis will be undertaken and published at the end of the rearing period to evaluate the potential of the project to increase the value gained from male progeny from the dairy herd. As part of the programme, the calf rearers are provided with substantial advisory back up and advice and the programme is based on a pre-agreed protocol and contract rearing agreement.

Results to date

In total, 422, 374 and 260 dairy calves were enrolled in the project in 2020, 2021 and 2022, respectively. All animals were transported in accordance with Department of Agriculture, Food and the Marine Guidelines for the transport of live animals (DAFM, 2007) and were monitored closely prior to transport to ensure they were achieving adequate LW gain in the weeks prior to movement. Overall mortality rates have been kept below the target level of 3% during the initial 2 years of the project. Over the initial 2 years of the project the breed composition of the calves born during 2020 and 2021 was 60% dairy (with equal parts Holstein-Friesian (HF), Holstein-Friesian crossbred (FRX) and Jersey Holstein-Friesian cross (JFX)) and 40% beef cross (primarily Aberdeen Angus (AAX) but also including Limousin (LMX), Hereford (HEX), Charolais (CHX), Belgian Blue (BBX) and Aubrac (AUX)) from dairy dams. The proportion of beef crossbred calves increased from 34% in 2020 to 46% and 41% during 2021 and 2022, respectively, due to increased daily use of sexed semen on all research farms. The mean carcass weight breeding value (BV) of the calves born over the initial 2 years of the project was -5 kg based on a maternal population with an average Economic Breeding Index of €190 and a Beef sub-index of -€15 (equivalent to an average mature LW of 575 kg).

The mean birth weight of the calves was 37 kg in both years, and they were moved on average at 30 days of age (and 54 kg LW) to the rearing farms in both years. All calves were weaned at 63 days of age when eating in excess of 1 kg of concentrate per day. During the first grazing season, mean daily live weight gain (ADG) of all calves was 0.80 kg during 2020 and 0.70 kg during 2021 on a predominantly pasture-only diet (Figure 2).

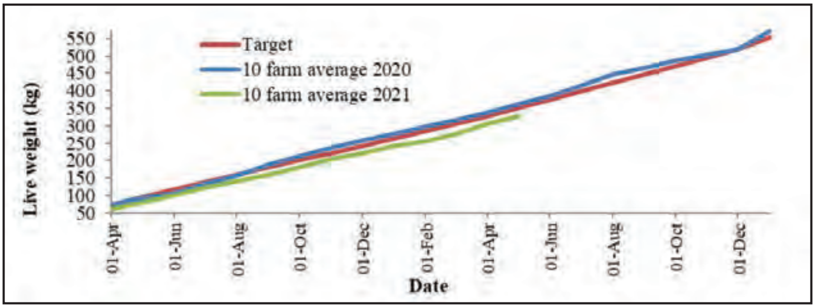


Figure 2. Mean live weight (kg) of dairy-beef cattle during the initial 2 years.

Over the entire measurement period from birth-to-14 months of age, the ADG for the entire group of 2020-born calves was 0.74 kg (exceeded the target of 0.7 kg) and the 2021-born animals was 0.68 kg. Thereafter, the 2020-born animals achieved an ADG of 0.83 kg during the second grazing season and reached an average LW of 486 kg at the beginning of the finishing period in October 2021. Over their entire lifetime, the 2020 born calves achieved an ADG of 0.75 kg from birth-to-slaughter. Mean slaughter weight was 573 kg at 23 months of age resulting in a mean carcass weight of 293 kg at a fat score of 3= and conformation score of O- and a carcass value of €1,278 for all breeds.
Both sire and dam genetic merit for carcass weight (Figure 3) and breed (Table 1) had had a significant impact on both carcass weight (Figure 3) and carcass quality (conformation and fat score) with each additional 5 kg increase in genetic merit for carcase weight corresponding to 6 and 7.5 kg of additional carcass weight for a 24 month steer at slaughter for the dam and sire, respectively.

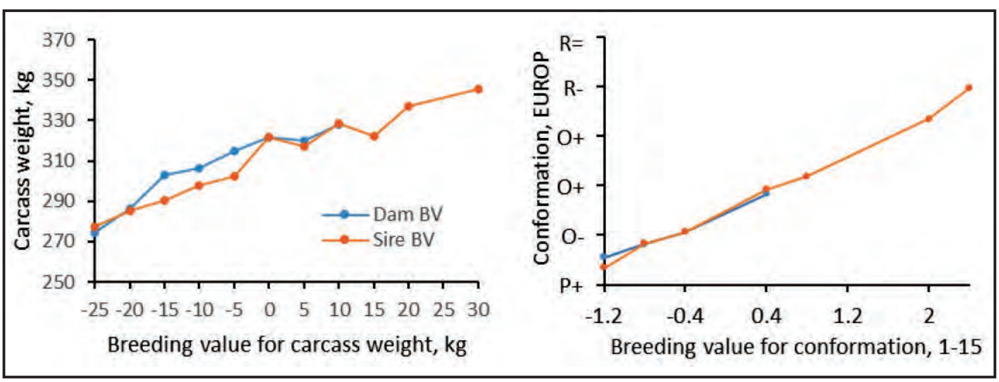


Figure 3. Association between carcass performance of progeny with the breeding value (BV) for carcass traits for sires and dam. Reference animal was a steer slaughtered at 24 months of age.

Table 1. Carcass performance of progeny from each of the sire breeds.

Sire breed	Number of progeny	Carcass weight, kg[1]	Conformation score, 1-15 (EUROP)[1]	Fat score, 1-15 (EUROP)[1]	Age at slaughter, d[1]
AA	89	304	5.5 (O+)	7.8 (3=)	673
BB	8	347	7.1 (R-)	6.6 (3-)	692
CH	7	341	6.5 (R-)	7.5 (3=)	695
HF	200	299	4.0 (O-)	7.2 (3-)	713
HE	20	301	5.0 (O=)	7.8 (3=)	678
JE	60	273	3.4 (P+)	7.1 (3-)	714
LM	17	332	6.8 (R-)	7.4 (3-)	686

AA = Aberdeen Angus; BB = Belgian Blue; CH = Charolais; HF = Holstein-Friesian; HE = Hereford, JE = Jersey; LM = Limousin

In addition to the LW performance of the animals, the project also affords the opportunity to closely monitor physical and financial characteristics of dairy calf-to-beef production systems on commercial farms. While not all rearers are measuring pasture on farm, on average 13.2 t DM/ha per annum were grown on rearing farms during 2020. During the initial rearing period (28 days to 14 months of age), silage requirements were 0.65 (+/- 0.2) t DM per head in 2020 on the rearing farms due to the extended 'winter' indoor period (175 days) during 2021. In addition, 250 kg concentrate were fed to calves up to 14 months of age during the 2020 season (equivalent to €70 per head) while veterinary costs were equivalent to €59 per animal. Total variable costs during 2020 ranged from €0.81 to €1.07 per day with fixed costs of €0.25 per day. Finally, average net margin from the rearing contract was €0.20 to €0.44 per animal per day during the rearing phase in year 1 to remunerate the rearers for their own labour and land. Farms where greater net margins were realised achieved increased ADG by 14 months of age over an extended grazing season to minimise both concentrate and silage supplementation costs.

Preliminary conclusions

The objective of the Everycalf project is to evaluate the potential for profitable dairy calf-to-beef systems in collaboration with commercial rearing farmers. In so doing, the ambition of the programme is to optimise male dairy calf performance and welfare and enhance the profitability of dairy-beef rearing systems on Irish farms. The preliminary results from the project are indicative of the potential of high-quality pasture management on commercial farms to deliver excellent animal performance in dairy calf-to-beef systems and provide a strong basis for the development of such operations into the future.

Acknowledgements

The authors wish to acknowledge the essential contribution of the 10 rearers to the project.

Ballyvadin dairy calf-to-beef demonstration farm

Chloe Miller and Padraig French

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

Summary

Ballyvadin farm is a new 112-hectare dairy calf-to-beef demonstration farm in Fethard, Co. Tipperary that has been established by Teagasc in conjunction with Dawn Meats and Shinagh Dairy Farm to demonstrate the best technologies for profitable and sustainable production of beef calves from the dairy herd.

It will focus on key innovations such as:

- Closer collaboration between dairy and beef farmers in the breeding, management and transfer of calves.
- Excellent pasture management, ensuring high quality grazed grass and grass silage.
- Minimal concentrate supplementation, with a focus on maximising animal performance from forage.
- Maximising animal performance at all stages of its life cycle to reduce age at slaughter.
- Herd health planning to minimise morbidity, and use of antibiotics and anthelmintics.

Background

The recent expansion in the national dairy herd has resulted in an increasing number of both dairy (dairy × dairy male) and dairy beef (dairy × beef breed male and female) calves each year. Currently, a sustainable outlet for these calves has included live exports to mainland Europe; however, all indications are that this may not be possible in the future. Building a sustainable outlet for the ever-increasing dairy and dairy-beef calves coming from the industry is a priority. Additionally, the slaughtering of unweaned calves will not be sociably acceptable in the future. Consequently, there is a requirement to develop profitable dairy calf-to-beef systems. The dairy calf-to-beef demonstration farm based at Ballyvadin, Fethard, Co. Tipperary will demonstrate the deployment of best technologies to display profitable and sustainable dairy-beef production for beef farmers and other key stakeholders.

Farm system

Ballyvadin farm is 112-hectare (ha) of free-draining clay loam soil and will be sown with perennial ryegrass/clover swards. Planned nitrogen (N) application rate for these swards when established is ~ 125 kg/ha. The farm will be stocked initially with 300 calves which will be reared through to beef as steers and heifers. The animals will be slaughtered when they reach adequate fat cover and the age at slaughter will determine the feed demand. The number of animals reared will be adjusted based on forage supply and demand. Although the target will be to maximise animal production from grazed grass and high-quality silage, a proportion of animals will also be slaughtered in the first-half of the year to demonstrate efficient winter finishing systems.

Animal selection

Ballyvadin farm will procure approximately 300 spring born calves each year from a small number of farms at between 2-to-4 weeks of age. These calves will be a minimum of four stars on the Commercial Beef Value (CBV) index and will include both bulls and heifers. All animals will be slaughtered when they reach a minimum carcass fat score of 3- with the majority expected to be slaughtered before the end of the second grazing season.

Ballyvadin objectives

1. Integrate a beef farm with a dairy farm

Closer collaboration between a dairy and beef farmer in management and transfer of calves will lead to significant benefits for both parties. The dairy farm will have a secure outlet for non-replacement calves and the beef farm will have a supply of calves in which they can have influence over the genetics, nutrition and health management prior to the calves arriving on the beef farm.

Ballyvadin farm is a joint venture between a meat processor (Dawn Meats Ltd) and Shinagh dairy farm which is owned by four west cork dairy co-ops; Bandon, Barryroe, Lisavaird and Drinagh. Shinagh dairy farm is a demonstration dairy farm operated in conjunction with Teagasc and Shinagh Estates Ltd. A supply contract between Shinagh dairy farm and Ballyvadin dairy-beef farm will be developed, tested and demonstrated in the operation of the joint venture and this will also be used for other dairy farms supplying calves to Ballyvadin Farm.

2. Operate a financially sustainable dairy-beef enterprise

Dairy calf-to-beef production is financially exposed to significant financial risk in terms of animal performance and beef price. Performance at farm level is significantly poorer than what is achievable with best practice i.e. in Teagasc Grange. This farm will demonstrate a model that can give a competitive return on the capital and labour employed. To achieve this, the following technologies will be demonstrated:

a. Excellent pasture management to ensure animals always have access to high-quality grass and grass silage.
b. Minimal concentrate supplementation, with a focus on maximising animal performance from forage.
c. Optimal animal performance at all stages of the animals' life cycle to reduce age at slaughter.
d. The development of herd health plans to minimise morbidity and use of antibiotics and anthelmintics.

3. Reduce nutrient losses to water ways

Nitrogen and phosphorus (P) are key nutrient inputs into grassland systems and can be applied by either organic or inorganic fertilizers. The soluble P and soil particles can be washed into drainage networks and streams located on farms influencing water quality in the streams and wider catchment. Nitrogen loss typically occurs on soils that have high permeability. There is a stream running through the Ballyvadin Farm that can be monitored for this purpose. Mitigation strategies on the demonstration farm will include:

a. Minimise point source pollution from buildings, farm yards and farm roadways.
b. Minimise diffuse source pollution from drainage and runoff from land using good grazing and slurry/fertiliser application practices.
c. Adopt the use of riparian buffer zones adjacent to watercourses.

4. Implement mitigation strategies that reduce the impact of dairy calf-to-beef farming on climate change.

The agricultural technologies/strategies outlined in the Teagasc Greenhouse Gas MACC will be used to mitigate the impact of dairy-beef farming on climate change. These include:

a. Use of high-merit beef genetics.
b. Inclusion of white clover in swards to reduce chemical N requirements.
All slurry applied using low emissions slurry spreading (LESS) methods.
d. All inorganic chemical N applied as protected urea.
e. Use of low crude protein concentrate feeds.
f. Reaching target slaughter weights as soon as possible to reduce lifetime methane emissions.

5. Incorporate a proportion of the farm into high-diversity landscape features

Wildlife measures on intensive grassland farms can play an important role in halting the decline of biodiversity and achieving the goals of sustainable agriculture. Ballyvadin Farm already has a significant amount of natural and semi-natural habitats. To build on these existing features, a biodiversity plan will be developed for the farm to:

a. Maintain and manage existing habitats appropriately.
b. Improve the quality of existing hedgerows.a
c. Install riparian buffer strips of permanent vegetation adjacent to the existing streams and pond; and avoid fertilizer, slurry or herbicide application in these areas.
d. Establish new habitats where appropriate.

6. Implement mitigation strategies to reduce ammonia emissions

The agricultural technologies/strategies outlined in the Teagasc Ammonia MACC will be used to mitigate the impact of dairy-beef farming on ammonia emissions. These include:

a. Use of low crude protein concentrate.
b. Inclusion of white clover in existing pastures to reduce chemical N levels.
c. All slurry to be applied using LESS methods.
d. All chemical N applied as protected urea.

7. Reduce the use of antibiotics and anthelmintics

The EU Farm to Fork strategy has set a target to reduce the use of antimicrobials by 50% by 2030. On Ballyvadin farm:

a. A benchmark for the use of both antibiotics and anthelmintics will be established.
b. Pasture management will be optimised to minimise the use of anthelmintic.
c. There will be a strict calf pneumonia programme.

Teagasc DairyBeef 500 Campaign

Alan Dillon[1], Sean Cummins[2], Tommy Cox[3] and Fergal Maguire[4]

[1] *Teagasc Advisory Offices Gortboy, Kilmallock, Co. Limerick*
[2] *Teagasc Kildalton, Piltown, Co. Kilkenny,*
[3] *Teagasc Advisory Office, Mohill, Co. Leitrim,*
[4] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*

Summary

- Teagasc have developed a new initiative which focuses on management practices for technically-efficient dairy-beef systems called DairyBeef 500.
- The DairyBeef 500 Campaign will promote the adoption of technologies identified through research, onto commercial farms, while monitoring their impact on farm sustainability.
- The initiative will collaborate with existing Teagasc programmes, which will include the new Teagasc Signpost Farm Programme and the Grass10 Campaign.
- The DairyBeef 500 campaign has set a target of €500 net profit per ha, for dairy-beef farms implementing recommended managements and technologies, across production systems differing in intensity.

Introduction

Since 2008, the number of suckler cows has reduced by approximately 285,000, while the number of dairy cows has increased by 481,000. This change in the national herd has resulted in an increased number of beef cattle slaughtered being of dairy origin, with dairy-bred cattle accounting for 57% of the national kill in 2020, compared to 47% in 2010. Current trends in both dairy and suckler cow numbers indicate further growth in dairy-beef numbers. In 2019, 47% of dairy cows were bred to dairy sires while the remaining 53% were bred to beef sires. Of the beef sires used, 78% were either Aberdeen Angus or Hereford (45% Aberdeen Angus and 33% Hereford), with the remaining 22% being mostly continental beef breeds.
Of the approximately one million Irish dairy calves available for beef production annually, 350,000 are retained on dairy farms where they are finished or sold as weanlings/stores, while a further 350,000 calves are moved/sold to beef farms where they are artificially-reared, with live export, mortality and early slaughter accounting for the remaining 300,000 calves. Over the period, 2015 to 2019, the ICBF identified that there was on average 10,000 beef farmers purchasing dairy-beef calves annually, rearing on average 37 dairy-beef calves per farm. One of the big issues over this period was the high attrition rate of farms rearing dairy-beef calves; only 39% of those who reared dairy-beef calves in 2015 were still doing so in 2019. Typically, 23% of farmers involved in dairy-beef production exited the system in any one year over that period.

DairyBeef 500 Campaign

In response to the changes in both dairy and beef systems, Teagasc have developed a new initiative which focuses on dairy-beef production. The DairyBeef 500 Campaign will incorporate a number of existing dairy-beef projects, including: the Green Acres Dairy Calf-to-Beef Programme; male dairy calf contract-rearing; dairy calf-to-beef system evaluation study; and the evaluation of a range of beef sires used on the dairy herd. Additionally, the initiative will collaborate with existing Teagasc programmes, which will include the new Teagasc Signpost Farm Programme and the Grass10 Campaign.

The DairyBeef 500 Campaign has set a target of €500 net profit per ha (excluding own labour and land charge). It is envisaged that the programme will consist of beef farmers operating a wide range of production systems of varying intensities. On 'intensive' farms, the objective will be to grow and harvest as much grass as possible, supporting high carcass output per hectare. On more 'extensive' farms, there will be a greater emphasis on maximising carcass output per head and on the provision of environmental ecosystem services with lower carcass output per hectare; the optimum mix will depend on the individual farmer's circumstances and priorities.

Objective of DairyBeef 500

The primary objective of the DairyBeef 500 Campaign will be to promote the adoption of best practice at farm level to increase the future viability and sustainability of the Irish beef sector. It will promote greater integration of the dairy and beef sectors through the adoption of key technologies on farms to enhance the competitiveness of dairy-beef systems and ensure a reliable outlet for calves from the dairy herd that meet certain quality and health criteria.

The programme aims to:

- Target a net margin of €500 per hectare, excluding land and family labour.
- Increase the adoption of best practices, especially in relation to grassland management and calf rearing.
- Reduce the environmental footprint of dairy-beef production.
- Establish a cohort of profitable dairy-beef producers.
- Create greater integration between the beef and dairy industries.
- Improve the beef merit of calves coming from the dairy herd.

Table 1. Key performance indicators of the DairyBeef 500 Campaign across three levels.

Outputs	Technology adoption	Impact
Farmers participating Discussion groups Number of events Training courses Blueprint for profitable dairy-beef production systems	20+ grass covers per year Profit monitor completion 70% + DMD silage Grazing 200-240 days Calf mortality <2%	Profit of €500/ha Reduce age at slaughter Reduce carbon footprint Improve beef merit of dairy calves Training courses Develop a cohort of profitable dairy beef farmers

Research-led technologies

Through the implementation of an extensive dairy-beef research programme within Teagasc, the DairyBeef 500 Campaign will be supported with information and technologies identified through independent research from a range of production system and component studies at Teagasc Grange and Johnstown Castle, exploring the role of genetics, nutrition, health and welfare, grassland management and finishing strategies, in developing profitable and climate efficient grass-based systems. The various research herds within the Teagasc beef research programme will host visiting farmer and stakeholder groups, giving an insight into current research and demonstrating key technologies relating to dairy-beef production. The management practices implemented on demonstration farms and the advice given through the campaign will be based on the latest and most relevant research findings.

Demonstration farms

Demonstration farms/units will be a key pillar of the DairyBeef 500 Campaign. The demonstration farms/units will illustrate key technologies including; calf rearing, grassland management, calf health, nutrition, financial management, animal health and welfare, environmental sustainability and appropriate use of dairy-beef genetics. It is intended that the demonstration farms will source calves from farms using high genetic merit beef sires, targeting calves of above-average beef merit.

There will be at least one demonstration farm per Teagasc Advisory Region which will build on the existing network of Green Acres farms. The lessons learned from these farms will be communicated through a wide range of channels such as discussion groups, open days and newsletters, along with social and print media channels.

These farms will link in with an extensive Knowledge Transfer Programme run by Teagasc which will focus on the setting up of at least three Dairy-Beef discussion groups per region along with a number of public events.

Ballyvadin demonstration farm

This dairy calf-to-beef demonstration farm is based at Ballyvadin, Fethard, Co. Tipperary. The Ballyvadin farm will demonstrate the deployment of best technologies in sustainable beef production. Ballyvadin farm is 112 ha of free-draining clay loams and will be sown with perennial ryegrass/clover swards receiving 125 kg N/ha. The farm will be stocked initially with 300 calves, sired by a range of dairy and beef bulls, which will be reared through to beef as steers and heifers. Going forward when the farms true grass growth potential and 'finishing' ability of the animal genotypes is established, the number of animals (stocking rate) will be optimised, taking cognisance of forage supply and feed demand (age at slaughter with adequate fat cover). The target will be to maximise production from grazed grass and high quality silage with animals being slaughtered from 20 to 26 months depending on gender and genetics (see p 170).

Communication

A comprehensive communication effort will be central to the delivery of the DairyBeef 500 Campaign. One of the key elements of the campaign will be the communication of the opportunities within dairy-beef systems and the delivery of key messages regarding best practice farm management. Communication will cover a range of audiences including: farmers engaged in rearing dairy-beef calves; dairy farmers; prospective dairy-beef farmers; students; wider agricultural industry and stakeholders. Communication methods will include a dedicated DairyBeef newsletter, an annual research conference, and features in print and digital media along with updates on Teagasc social media.

Upskilling

The DairyBeef 500 campaign will focus on enhancing the knowledge and capacity of; farmers, advisors, lecturers/teachers, technicians, farm staff and students. A key resource will be the publication of a dairy-beef manual which addresses the key managements relating to dairy-beef production. Specific aspects of the manual will be targeted at farmers and advisors reflective on their individual needs and the depth of information required e.g. more detailed technical information for advisors.

Conclusion

The Teagasc DairyBeef 500 campaign will run initially for a five-year period with considerable resources from Teagasc provided. It will aim to build on the strengths of the Teagasc Green Acres Programme and the research work carried out in Teagasc Grange and Johnstown Castle to deliver environmentally and financially sustainable dairy calf-to-beef systems that farmers of varying acreage, land type, labour availability and infrastructure can adopt to suit their own farming needs.

*The DairyBeef 500 campaign is sponsored by Volac, MSD, Liffey Mills, Drummonds, Corteva and Munster Bovine, while the Ballyvadin Demonstration Farm in partnership with Dawn Meats and Shinagh Estates Ltd.

Technology Village

GROWING & FINISHING CATTLE

High quality silage: a must for beef production systems

Joe Patton

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- National average silage dry matter digestibility (DMD) remains at 66%. This is suitable only for dry suckler cows in good body condition.
- To achieve good performance on silage diets, growing/finishing cattle and calved suckler cows require silage of at least 74% DMD. Consider quality and quantity together in feed plans.
- Cutting swards at the correct growth stage determines silage quality. Soil fertility, reseeded swards and correct rates of nitrogen application are the key elements to maximizing silage quality and quantity across the season.
- Completing a fodder budget after first-cut is advised to plan ahead for feed security next winter.

Introduction

Grass silage typically makes up around one quarter to one third of total feed dry matter (DM) consumed on drystock farms. Compared to grazed grass it is quite expensive to produce (usually twice the cost per tonne DM), however when taken as part of an integrated grazing system it is good value compared to concentrates and alternative forages. Recent experiences with national fodder shortages have underlined the value of having a good reserve of quality silage available on beef farms. Teagasc national fodder surveys in 2020-21 showed that while the majority of beef farms had adequate silage reserves (i.e. 15-20% relative to winter demand), a cohort of 10-12% of farms are consistently running a significant feed deficit of more than 20% of winter requirements. This is a high-risk strategy, especially during periods of fodder scarcity and high input prices. It is likely to be particularly expensive for these farms to bridge deficits with purchased forage and/or concentrates in the winter of 2022/23. Early intervention to correct shortages is advised, starting with completing a winter feed budget. While most beef farms have tended to secure adequate supply of silage tonnage in recent years, average silage quality (as measured by dry matter digestibility, DMD) remains consistently poor on drystock farms at 65-67% DMD. The principal challenge for beef producers therefore is to balance the dual objectives of having adequate supply of silage, while meeting feed quality targets for good animal performance.

Defining targets for grass silage production

The three key elements to cost effective grass silage production are:

1. *High grass DM yields* for first-cut and subsequent cuts, with high total annual grass yield (>14.0 tonnes DM/ha). Guideline yields are 4.8 t DM/ha and up to 6.2 t DM/ha for silage harvested in mid-May and early June, respectively.

2. *Appropriate feed quality* for the category of stock to be fed. This is best measured as digestibility of the crop dry matter (DMD); protein content is also important and is positively associated with DMD. Silage quality is a function of growth stage at cutting (leafy swards have higher DMD than stemmy swards).
3. *Clean, stable feed* with good intake potential. This is achieved through good fermentation and can be assessed from silage pH (3.9 to 4.2 for un-wilted crops), ammonia (target less than 9%), and lactic acid (target over 8%) content. High DMD (leafy) swards can be well-preserved with good management.

First cut silage quality targets for different stock types

Grass DM yield at harvest is the single most important factor determining the cost per tonne of silage in the pit. Fixed costs per hectare (e.g. land charges, contactor fees) may be diluted over the extra tonnage for a given cut, and so too are some variable costs associated with fertiliser and slurry applications. Many beef farms have largely abandoned any consideration of feed quality when planning first-cut silage crops, focussing only on feed 'bulk'. Dry suckler cows can be adequately fed on 67-68% DMD grass silage. However, for growing/finishing cattle (and suckler cows suckling calves) the target is to have silage at 72-74% DMD or higher. The effect of silage quality (DMD) on animal live weight performance was assessed by a study carried out at Grange, where a silage sward was harvested at four different dates and fed to growing cattle the following winter (Table 1). While first-cut yield was lower with earlier cutting as expected, average daily live weight gain was much improved on the leafy silage. Feeding the higher quality (75% versus 65% DMD) silage at farm level would result in approximately 40 kg extra live weight gain over a 150-day housing period, or 2.0 to 2.5 kg reduction in daily concentrate intake for similar daily gain. In fact, it took less than half the amount of silage DM to achieve 1 kg carcass gain with the better quality sward.

Table 1. Effect of silage quality (dry matter digestibility, DMD) on daily weight gain and feed efficiency in growing cattle

	First-cut silage quality			
DMD (g/kg DM)	**750**	**700**	**650**	**600**
Harvest date	20 May	2 June	15 June	28 June
Silage yield (t DM per ha)	4.8	6.0	7.0	7.7
Daily live weight gain (kg)	0.83	0.66	0.49	0.31
Feed efficiency (DMI/kg carcass gain)	17.6	21.1	28.1	46.7

It is clear therefore that poor silage quality is a major limitation to growing animal performance over the winter period on many farms. Feeding low DMD silage made for 'bulk' may actually contribute to a silage shortage in the long-term, because animals require more days on-farm in the subsequent grazing season to achieve a given final carcass weight, reducing area available for silage cutting. Furthermore, delaying first-cut will limit yield and/or delay date of second-cut silage, resulting in a potential reduction in annual forage yield per hectare. Management decisions around first-cut date should prioritize meeting DMD targets and improving annual grass tonnage per hectare, rather than focussing solely on the yield from first cut.

Finding the right balance between yield and quality

While growing cattle require silage made from leafy swards, there is a risk of unnecessary/excess body condition gain for late-gestation suckler cows offered this type of feed. Beef farms with a mix of stock types (e.g. dry suckler cows, weanlings and finishing cattle) must plan for making silage at varying DMD levels. Differences in silage DMD can be created by varying the cutting date within a well-managed grass sward. High quality silage is produced by cutting in mid-May when grass has high leaf content, while lower DMD silage is produced by delaying cutting into early June when grass has become 'stemmy' after seed head emergence. Therefore, while the objectives of good DM yield and excellent preservation remain consistent, target DMD should dictate the optimum stage of grass maturity at which to harvest the crop. The practical reality for beef farms feeding varied stock types over the winter is that no single cutting date is suitable for all stock. A simple silage management plan that takes this into account can be developed for the farm, using the following steps:

1 - Define the highest quality silage required on the farm first.
2 - Estimate the total quantity of this silage needed.
3 - Calculate the area of first and subsequent cuts needed to produce this silage.
4 - Mark on the farm map and set targets for spring grazing, fertiliser, cutting date.
5 - Manage the remaining area to produce silage of standard quality.

Flexibility is needed around cutting date management, and each farm should develop a plan that suits its own scale, facilities, and stock type. For example, a farm carrying spring-calving suckler cows plus some finishing cattle may take an early-cut of high DMD bales in mid-May on 20-30% of silage area, with the remainder of first-cut taken at 67-68% DMD in early June for feeding to dry cows.

Table 2 outlines the potential farm-scale value of taking this approach to achieve the correct target silage DMD. In this simple example, a farm with 40 weanlings and 40 forward store cattle requires 350 silage bales for a standard winter. The cost of total winter concentrates required to maintain target performance is reduced by 47% by moving from national average silage quality to target silage quality for the stock type on hand.

Table 2. Effect of silage quality (dry matter digestibility, DMD) on winter concentrate costs for a calf-to-beef farm

	High DMD	Low DMD
Number of cattle		
Weanling cattle	40	40
Store cattle	40	40
Silage type and quantity of bales needed		
High-quality bales (74% DMD)	350	0
Low-quality bales (66% DMD)	0	350
Winter concentrate cost @ €380/tonne	€5,791	€10,944

Management guidelines for cost-effective grass silage production

Fertiliser and lime: The first step to improving silage yield and quality on most beef farms is to take soil samples and develop a field-by-field fertilizer plan based on the phosphorus (P), potassium (K) and lime requirements (Table 3). Treat P and K separately as silage fields may be adequate for one nutrient but be lacking in the other. Reduce the N application rate by 20-25 kg per ha for old pastures. Soil pH is often the first limiting factor for silage yield so ensure the target pH 6.3 is met. Apply lime through summer/autumn but avoid for 3-4 months before silage cutting as it may adversely affect the fermentation process.

Timing of silage cutting date: Swards should be managed such that good grass DM yields (4.8 to 5 t DM) are present at or before grass heading date. A decision can then be made whether to harvest at high DMD or delay beyond heading date to increase yield (to >6.0 t DM per ha) of a 'maintenance-level' feed. Timely fertilizer nitrogen (N) application and closing is important in respect of silage cutting date. A useful guide for fertiliser N is that grass uses 2.5 kg N (2.0 units) per day on average, so final N should be applied approximately 50 days before planned cutting date. However, the crop may still be safely harvested sooner depending on nitrate and sugar levels. If weather conditions are otherwise suitable, test the grass crop rather than sticking rigidly to the '2-unit rule'. Wilting the crop to >28% DM aids preservation if nitrate readings are high.

Table 3. Fertiliser nutrient application rates guidelines for first cut silage (kg/ha)

Soil Index	**1**	**2**	**3**	**4**
P required	40	30	20	0
K required	175	155	125	0
N required	125 (reduce by 25 kg on 'old' pasture)			
Sulphur required	12-14 (10% of N applied)			

Grazing in spring: To achieve good quality silage in May, it is essential that the sward is clean and green to the base in early March. Graze to <4cm residual in February/March before applying fertilizer for silage. A similar effect can be achieved by tight grazing with young stock in late autumn. Swards with yellow/dead material must be grazed off otherwise silage DMD may be reduced by up to 6-7 percentage points. Re-seeded swards should have been grazed at least twice before closing for silage.

Achieving good preservation: Good preservation occurs when lactic acid bacteria present on the grass crop ferment available sugars to lactic acid. This causes a decline in pH which preserves the feed value of the stored silage. High available sugars, low buffering capacity and air-free (anaerobic) conditions are necessary for achieving good preservation. Grass sugars content is more critical to good preservation than nitrate readings. Ideal conditions for high sugars are ryegrass swards, dry sunny weather, cool nights and mowing in the afternoon. Add a sugar source (e.g. molasses) if conditions are good but sugars readings are low. Under good ensiling conditions, there is no clear benefit to using additives such as inoculants. Adding inoculants will not significantly improve feed value if the standing grass crop is of poor quality. Where wilting is likely to be of benefit, reaching the target DM of 28-32% is a function of swath type and duration of drying. Dry matter will not increase sufficiently in large rows (>3 metres), even if left for 48 hours. Grass tedded out and left for more than 36 hours in good conditions may become be too dry (>40% DM) for pit silage. There is no advantage to wilting beyond 32% DM.

Reseeding: Old permanent pasture with low perennial ryegrass content is less responsive to fertiliser nutrients for first-cut crops, leading to delayed harvest and poor DMD. Lower sugar content makes preservation more difficult. The decision to reseed should be based on sward composition and performance. A rule of thumb is that silage ground should be reseeded every 8-10 years (5-6 years for multiple-cut systems). Many farms do not reach this target, especially if silage ground is on short-term lease. Reseeding is unlikely to be successful if soil fertility and post-emergence management to promote tillering and weed control are lacking.

Managing DM losses: Reducing DM losses at ensiling and feed-out is often overlooked as means of improving efficiency. These losses range from 15-30% of standing crop DM, which can significantly increase the cost per tonne harvested and the requirement for purchased feed. The main sources of DM loss are poor aerobic stability, failure to seal and maintain pits/bales fully, excessive exposure to air across the silage pit face, and waste at the feed barrier.

Concentrate supplementation for growing-finishing cattle indoors

Mark McGee, Edward O'Riordan and Aidan Moloney

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Dry matter digestibility is the primary characteristic that influences the nutritive value of forage and consequently, the performance of forage-fed cattle.
- Increasing the level of concentrates in the diet reduces forage intake and increases live and carcass weight gains, although at a diminishing rate.
- The advantage of concentrate supplementation of young cattle indoors is diminished by compensatory growth at pasture.
- High-digestibility grass silage with moderate concentrate supplementation can sustain a large proportion of the performance cattle achieve on high-concentrate diets.
- Feeding management is more important when feeding concentrates ad libitum than as a supplement.

Introduction

In beef production systems, feed provision is the single largest direct cost incurred, accounting for approximately 75% of total costs of production; therefore, small improvements in feed efficiency can have a relatively large influence on farm profitability. Additionally, feed efficient cattle excrete fewer nutrients, and produce less gaseous emissions, to the environment. Of the predominant feedstuffs available, grazed pasture is cheapest, purchased concentrate is the most expensive and grass silage and other conserved forages are intermediate. Because of the comparatively lower cost of efficiently produced grazed grass, pasture-based beef production systems have evolved to optimise the contribution of high-nutritive value grazed herbage to lifetime intake of feed, and to providing grass silage and concentrate as efficiently and at as low a cost as feasible. However, the seasonality of grass growth and inclement grazing conditions means that an indoor 'winter' period, of varying duration, is required on practically all Irish farms and the main feed costs on beef farms relate to this period.

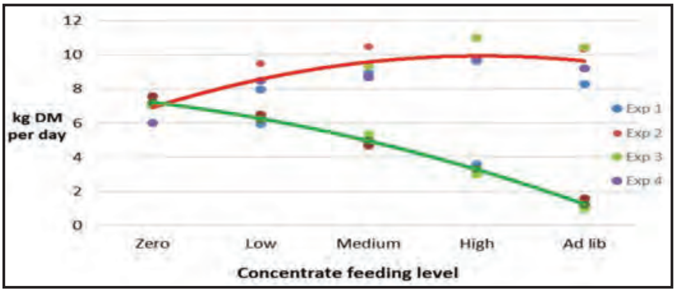
Feeding concentrates: key principles

The role of concentrates is to make up the deficit in nutrient supply from forages to allow cattle reach performance targets. Indeed, in situations where there is a shortage in winter supplies of forage, it may be better to buy concentrates and feed less forage than to purchase expensive low-quality forage.

- Energy is the most important nutrient required by growing-finishing cattle. Comparisons of feedstuffs should always be based on their net energy (and protein) concentrations on a dry matter (DM) basis. It is important to ensure that an adequate level of an appropriate mineral/vitamin mix is included in the ration.

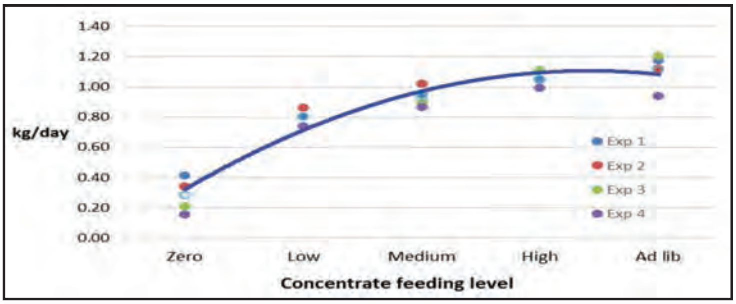
- Dry matter digestibility (DMD) is the primary measure of the nutritive value of forage and consequently, the performance of forage-fed cattle.
- Low DMD forage require higher levels of concentrates to achieve the same growth rate or performance (Table 1).
- Increasing the level of concentrates in the diet reduces forage intake (Figure 1) but increases live and carcass weight gains, although at a diminishing rate (i.e. curvilinear response; Figure 2) especially when high DMD forages are offered.

Figure 1. Effect of concentrate feeding level on silage (**green line**) and total (**red line**) dry matter intake of finishing cattle offered grass silage *ad libitum*.



- 'Substitution rate' of concentrates for grass silage (kg reduction in forage DM intake per kg concentrate DM intake) is a function of silage digestibility, and concentrate feed level – it increases with an increase in both.
- Animal production response to concentrate supplementation is higher with forages of lower DMD.

Figure 2. Effect of concentrate feeding level on daily live weight gain of finishing steers offered grass silage *ad libitum*.



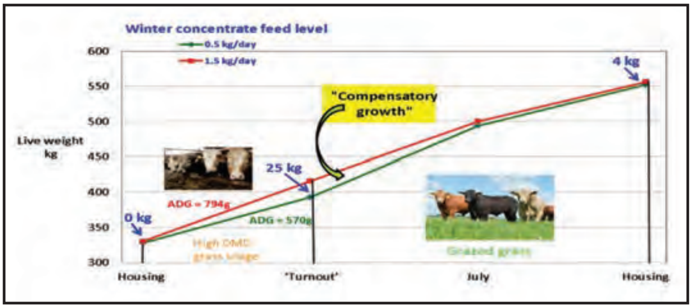
- Increasing the level of concentrate supplementation reduces the importance of forage nutritive value, especially when feeding concentrates ad libitum (to appetite).
- Growth response to concentrate feeding is higher in high-growth potential animals. For example, a recent Teagasc Grange study comparing suckler-bred Charolais with Holstein-Friesian steers offered a high-concentrate diet, found that, at the same age, Holstein-Friesian steers were lighter, grew more slowly and consumed 10% more feed DM resulting in a 20% inferior feed conversion efficiency. Similarly, bulls are inherently more feed efficient - 10 to 20% better - than comparable steers and heifers.
- The optimum level of concentrate supplementation primarily depends on animal production response (kg gain/kg concentrate), forage substitution rate and the relative prices of animal product and feedstuffs.
- It is important to ensure that an adequate level of an appropriate mineral/vitamin mix is included in the ration.

Concentrate feeding

Weanling cattle

Subsequent compensatory growth ("catch-up") at pasture diminishes the advantage of concentrate supplementation of young "weanling" cattle offered grass silage. Research at Teagasc Grange has shown that live weight gains of 0.5–0.6 kg/day through the 'first' winter are acceptable for steers, heifers and suckler bulls destined to return to pasture in spring. Due to compensatory growth, there is little point in over-feeding weanlings in winter as, during the subsequent grazing season, cattle that gained less over the winter had the highest live weight gain at pasture, resulting in most of the winter weight advantage 'disappearing' by the end of the grazing season (Figure 3). This feeding regime reduces feed costs and increases profitability of grass-based production-finishing systems by indirectly 'moving' feed resources from periods when feed is costly (i.e. winter) to when it is cheaper and abundant (i.e. grazed grass). Conversely, cattle growing too slowly during winter (<0.5 kg/day) will not be able to compensate sufficiently at pasture, and consequently, will not reach target weights later in life.

Figure 3. Effect of winter concentrate supplementation level (**0.5** vs. **1.5** kg fresh weight/day) on live weight gain (ADG) of suckler-bred weanling steers offered high-digestibility grass silage *ad libitum*, and on growth during the subsequent grazing season.



This feeding regime also applies to older 'store' cattle in their second winter destined for subsequent finishing at pasture. However, a higher level of feeding is generally warranted during the first winter for replacement beef heifers, who have heavier threshold weight targets to achieve earlier in life.

Target animal growth rates during the first winter can be achieved on grass silage supplemented with concentrates as outlined in Table 1. Low DMD silage means higher levels of concentrate supplementation have to be used to achieve the same growth rates; this highlights the importance of having good silage 'quality' for growing (and finishing) cattle.

Finishing cattle

Performance of finishing beef cattle increases with increasing grass silage DMD and the impact of DMD increases as the proportion of silage in the diet increases. For example, in finishing cattle, a one-unit increase in silage DMD was associated with an increase in carcass gain of 21–29 g/d when supplemented with concentrates at 0.20–0.40 of dietary DM intake, but when no concentrates were offered and silage intake was higher the response was greater (33 g/d). However, even high-quality grass silage is incapable of sustaining adequate growth rates to exploit the growth potential of most cattle so concentrate supplementation is required. Each one-unit decline in DMD of grass silage requires an additional 0.3-0.4 kg concentrate daily to sustain performance in finishing cattle. Concentrate supplementation rates for finishing steers to achieve ~1.0 kg live weight/day with grass silage varying in DMD are shown in Table 1. Correspondingly, when compared to steers, supplementation for finishing heifers (lower growth potential) daily is reduced by about 1.5 to 2.0 kg and for finishing bulls (higher growth potential) rates should be increased by 1.5 to 2.0 kg to achieve 1 kg live weight.

Table 1. Concentrate supplementation (kg/day) necessary for weanlings to grow at ~0.5 kg and for finishing steers (600 kg) to grow at ~1.0 kg live weight/day, when offered grass silage of varying dry matter digestibility (DMD) to appetite

Grass silage DMD (%)	~60	~65	~70	~75
Weanlings	2.0-3.0	1.5-2.0	1.0-1.5	0-1.0
Finishing steers	-	7.0-8.0	5.5-6.5	4.0-5.0

Where silage DMD is poor (e.g. 60%) and/or in short supply, and animal growth potential is high, feeding concentrates *ad libitum* should be considered. However, when feeding concentrates *ad libitum,* particularly cereals, there is a risk of acidosis. Therefore, it is critical to ensure; (i) gradual adaptation to concentrates (over ~3 weeks), (ii) minimum roughage inclusion (~10% of total DM intake) for rumen function, (iii) meal supply never runs out and, (iv) a constant supply of fresh water is provided.

Efficiency of feed utilisation by finishing cattle primarily depends on the weight of the animal (decreases as live weight increases), potential for carcass growth (e.g. breed type, gender, compensatory growth potential) and duration (decreases as length increases) of the finishing period.

Ration 'type' and protein level

In practice, beef rations formulated to have similar energy and protein concentrations can vary from having high starch concentrations of varying degradability to high digestible fibre concentrations. Research at Teagasc Grange has shown that equivalent animal intake and performance is obtained from concentrate rations containing contrasting energy sources (e.g. rapidly-fermentable starch vs. slowly-fermentable starch vs. 'digestible' fibre-based), offered as a supplement to grass silage or *ad libitum* with silage, provided that they are formulated to the same net energy (and protein) concentration.

Teagasc Grange research has shown that weanling and finishing steers and heifers generally do not require protein supplementation when fed barley-based concentrates and high DMD grass silage, but for suckler bull weanlings, a significant, but small, response to protein supplementation occurred. However, weanling and finishing cattle are likely to respond to supplementary protein in barley-based concentrates when grass silage has moderate to low DMD and/or low protein content.

Concentrate feed ingredients for growing-finishing cattle

Mark McGee[1], Rian Kennedy[1,2], Edward O'Riordan[1], Alan Kelly[2] and Aidan Moloney[1]

[1] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath*
[2] *University College Dublin, School of Agriculture and Food Science, Belfield, Dublin 4*

Summary

- The relative nutritive value of by-product feedstuffs depends on their inclusion level in the concentrate and the amount of concentrates fed.
- Finishing cattle offered a maize meal-based concentrate compared to a rolled barley-based concentrate as a supplement to grass silage had similar intake and performance.
- Finishing cattle offered a rolled oats-based concentrate compared to a rolled barley-based concentrate as a supplement to grass silage had similar intake and performance.
- The feeding value of flaked beans or peas were equivalent to each other and also to maize dried distillers grains or corn gluten feed when included in a cereal-based ration offered as a supplement to grass silage. In a second experiment, the feeding value of beans was superior to peas.
- 'Native' cereal and legume grains can be readily included in beef cattle concentrate rations as a supplement to grass silage.

Introduction

Feeding concentrates is a key component of beef production systems, especially during the indoor winter and the finishing period. The primary role of concentrates is to redress the deficit in nutrient supply from forages to allow cattle reach performance targets. In particular, beef cattle rarely consume sufficient grass silage to achieve their production potential and as a result, energy-rich concentrates are routinely supplemented in practice. Ireland has a significant deficit in concentrate feed ingredients and most of the feedstuffs used nationally, especially protein sources, are imported. In order to increase self-sufficiency, it is now acknowledged that there is a need to increase the proportion of 'home-grown' feeds, both native grains and proteins, in livestock rations used in Ireland.

Cereals, (barley, maize, wheat and to a much lesser extent, oats) which make up a substantial proportion of beef ration formulations, are usually supplemented with higher protein-rich feed ingredients to satisfy assumed protein requirements. In this context, it should be noted that at Teagasc Grange, the 'standard' concentrate offered in most beef production systems studies, and the 'control' concentrate offered in experiments evaluating alternative feed ingredients for inclusion in beef cattle concentrate rations, is a barley/soyabean meal-based concentrate (ca. 862 g fresh weight rolled barley, 60 g soya bean meal, 50 g molasses, 28 g minerals and vitamins per kg) prepared as a coarse mixture. In addition to cereals, a wide variety of feed ingredients, both imported and native, is available and used extensively in beef rations.

By-product feeds

By-product feeds, also known as co-products, are secondary products mainly from the food processing and the biofuel/ethanol industries. Key by-products used in Ireland recently include corn gluten feed, soya hulls, maize dried distillers grains, palm kernel expeller meal and citrus pulp. However, a potential limitation of feeding by-products to cattle is that significant variation can exist in their chemical composition and nutrient content, and this can change over time as the primary manufacturing processes evolve and become more efficient. Periodic re-evaluation of the nutritive value of by-products is therefore required for accurate formulation of feedstuffs for beef cattle. Comparisons of feedstuffs should always be based on their net energy (and protein) values on a dry matter (DM) basis.

Interactions or 'associative effects' between grass silage and concentrate feed ingredients have consequences for feed utilisation, and thus, the nutritive value assigned to feed ingredients. Research at Teagasc Grange, has shown that by-product feed ingredients including *molassed sugar-beet pulp, citrus pulp, soya hulls, palm kernel expeller meal, corn gluten feed, maize-dried distillers grains* and *wheat dried distillers grains* can fully or partially replace rolled barley (and soyabean meal) in concentrate rations as a supplement to grass silage without negatively impacting animal performance, depending on particular feeding circumstances. This means that the relative feeding (and economic) value of by-product feed ingredients is influenced by feeding practices, such as inclusion level in the concentrate ration and the amount of concentrates fed. For example, soya hulls were shown to have an equivalent feeding value to rolled barley when 2 kg/day of concentrate supplement containing 933 g soya hulls/kg was offered to weanling cattle. In contrast, when higher levels of concentrate (4 kg/day or *ad libitum*) were offered to growing-finishing cattle, soya hulls inclusion at >200g/kg concentrate resulted in inferior animal performance.

It should be noted that by-products generally have little value as a foodstuff for humans but, as outlined above, many are suitable as a feed for cattle due to the ability of cattle to digest fibrous, plant cell-wall material. In this regard, recent research at Teagasc Grange has shown that substituting cereals (and especially soyabean meal), in beef concentrate rations with by-products substantially improves the human edible protein ratio of grass-based beef production systems and thus, this practice is extremely favourable from a 'food-feed competition' perspective.

'Native' grains and proteins

There is growing interest in increasing national self-sufficiency by exploiting indigenous 'energy' and 'protein' crops such as cereals (e.g. oats) and legumes (e.g. faba beans and peas), and reducing the reliance on imported cereals (maize) and by-products (e.g. maize-based) as animal feedstuffs. Furthermore, crops such as oats and beans are good 'break' crops in tillage rotations. Legume protein crops contribute to nitrogen fixation thus lowering the requirement for inorganic fertilizer, have positive effects on soil condition, can enhance yields of subsequent crops in crop rotations, and can also reduce pest and disease pressure on Irish tillage farms.

Barley vs. Maize

Intake, growth and carcass traits of beef cattle offered grass silage supplemented with rolled barley or maize meal-based rations containing legumes (flaked beans and peas) or maize by-products (corn gluten feed (CGF) and maize dried distiller grains (MDD)) were determined. Late-maturing suckler-bred steers were assigned to one of eight supplement treatments, formulated to have the same crude protein concentration (135 g crude protein (CP)/kg DM):

1. Rolled barley (622 g/kg fresh weight basis) plus flaked peas (300 g/kg), 2. Rolled barley (722 g/kg) plus flaked beans (200 g/kg), 3. Rolled barley (637 g/kg) plus CGF (285 g/kg), 4. Rolled barley (780 g/kg) plus MDD (142 g/kg), 5. Maize meal (507 g/kg) plus flaked peas (415 g/kg), 6. Maize meal (622 g/kg) plus flaked beans (300 g/kg), 7. Maize meal (522 g/kg) plus CGF (400 g/kg), 8. Maize meal (702 g/kg) plus MDD (220 g/kg). All concentrates contained 50 g/kg molasses, and were balanced for minerals/vitamins. To decrease rumen degradable protein concentration, peas and beans were flaked. Steers were individually offered 4 kg concentrate DM daily (in two feeds) in addition to grass silage (DM digestibility, 779 g/kg, 110 g CP/ kg DM) ad libitum, for 110 days.

Intake, growth, feed conversion efficiency (FCE), carcass weight, kill-out proportion, carcass conformation and fat score and ultrasonic measures of body composition did not differ between the cereal 'type' (Table 1). Of note is that there were no differences in any measures of body fatness between the cereal types, which is consistent with results from previous experiments carried out at Teagasc Grange where maize meal partially replaced rolled barley in concentrate rations offered to bulls *ad libitum*. Under these experimental conditions, the feeding value of rolled barley was equivalent to maize meal.

Table 1. Effect of cereal type (rolled barley and maize meal) and protein source (flaked beans, flaked peas, corn gluten feed (CGF) and maize dried distiller grains (MDD)) as supplements to grass silage on steer silage dry matter (DM) intake and performance

	Cereal type		Sig.[1]	Protein source				Sig.[1]
	Barley	Maize		Peas	Beans	CGF	MDD	
Silage DM intake (kg/day)	6.5	6.4	NS	6.2	6.4	6.5	6.5	NS
Live weight gain (kg/day)	0.98	0.99	NS	0.96	0.96	1.02	0.99	NS
FCE (g LW gain/kg DMI)	93.0	95.0	NS	93.9	91.4	97.3	93.3	NS
Slaughter weight (kg)	680	681	NS	678	678	685	681	NS
Carcass weight (kg)	388	385	NS	390	383	387	384	NS
Kill-out proportion (g/kg)	570	565	NS	576	566	565	564	NS
Carcass conformation (1-15)	8.5	8.2	NS	8.8	8.2	8.1	8.3	NS
Carcass fat (1-15)	6.4	6.9	NS	6.4	6.8	7.0	6.3	NS

[1]NS = Not significantly different

Barley vs. Oats

The effects of replacing rolled barley with rolled oats in a supplement on intake, growth, and carcass traits of late-maturing breed steers over a 134-day finishing period, was also examined. Animals were individually offered grass silage (DM digestibility, 713 g/kg) *ad libitum* plus 4.0 kg DM (in two feeds) daily, of one of two concentrate supplements: barley-based 'control' (862 g rolled barley, 60 g soya bean meal, 50 g molasses, and 28 g minerals and vitamins/kg fresh weight) and oats-based (853 g rolled oats, 70 g soya bean meal, 50 g molasses, and 27 g minerals and vitamins/kg fresh weight) concentrate rations. Concentrates were prepared as coarse mixtures and were formulated to have the same CP concentration (135 g/kg DM).

Intake, growth, feed conversion ratio (FCR), carcass weight, kill-out proportion, carcass conformation and fat score and ultrasonic measures of body composition did not differ between treatments did not differ between the cereal 'types' (Table 2).

Table 2. Effect of replacement of rolled barley with rolled oats on silage dry matter (DM) intake, average daily live weight gain, feed conversion ratio (FCR) and carcass traits of finishing steers offered grass silage

	Barley	Oats	Sig[1]
Silage DM intake (kg/day)	5.1	5.4	NS
Live weight gain (kg/day)	1.03	1.03	NS
FCR (kg DM/ kg ADG)	8.9	9.2	NS
Slaughter weight (kg)	570	571	NS
Carcass weight (kg)	328	325	NS
Kill-out proportion (g/kg)	564	560	NS
Carcass conformation (1-15)	9.1	8.6	NS
Carcass fat (1-15)	7.6	7.3	NS

[1]NS = Not significantly different

In a subsequent experiment, intake, growth and carcass traits of late-maturing suckler steers offered 4.0 kg DM daily (in two feeds) of either a rolled barley or oats-based concentrate ration with or without peas or beans as supplements to grass silage (DM digestibility, 725 g/kg; CP, 152 g CP/kg DM) over 146 days, were examined. Animals were assigned to one of six concentrate supplements: 1. Rolled barley (922 g/kg fresh weight), 2. Rolled barley (622 g/kg) plus flaked peas (260 g/kg), 3. Rolled barley (742 g/kg) plus flaked beans (180 g/kg), 4. Rolled oats (922 g/kg), 5. Rolled oats (642 g/kg) plus flaked peas (280 g/kg), 6. Rolled oats (732 g/kg) plus flaked beans (190 g/kg). All concentrates contained 50 g/kg molasses and were balanced for minerals/vitamins. Concentrates containing peas or beans were formulated to have the same CP concentration (144 g CP/kg DM); the corresponding value for those not containing a protein ingredient was 116 g CP/kg DM.
Consistent with the previous experiment intake, growth, carcass weight, conformation and fat score, and ultrasonic measures of body composition did not differ significantly between steers offered barley- and oats-based concentrate rations. Overall it was concluded that, under the conditions of these experiments, rolled oats can replace rolled barley in a concentrate supplement to high-digestibility grass silage without negatively affecting performance of beef cattle.

Legume grains - beans and peas as protein (and energy) sources
In two of the experiments outlined above flaked beans and flaked peas were compared with each other, and in the first experiment they were also compared with corn gluten feed and maize dried distiller grains. In the first experiment , the feeding value of beans or peas were equivalent to each other and also to corn gluten feed and maize dried distiller grains (Table 1). In the second experiment, the feeding value of beans was superior to peas. Collectively, these results suggest that flaked faba beans can be readily used as an alternative feed ingredient when included in a concentrate ration offered as a supplement to grass silage for beef cattle. More research is required on the use of peas.

Achieving animal performance targets at pasture

Edward O'Riordan, Peter Doyle, Aidan Moloney and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath.

Summary

- Grazing excessively high (~2500 kg dry matter (DM)/ha) or low (<1500 kg DM/ha) pre-grazing herbage masses, and grazing too tightly (4 vs. 6 cm), negatively impacts beef cattle growth at pasture.
- Carcass growth response to concentrate supplementation while grazing is variable, and will primarily depend on the availability plus 'quality' of pasture and level of supplemented concentrate.
- Where supplementation at pasture occurs, 'energy' rather than protein sources are required.
- Supplementing grass with a low-protein, high-energy feed is a practical strategy to decrease nitrogen excretion from grazing beef cattle.

Introduction

Irish beef production is largely pasture-based where, collectively, grazed and conserved pasture account for almost 90% of the lifetime feed consumption. As spring-calving predominates nationally, suckler- and dairy-bred progeny taken through to slaughter spend at least two seasons at pasture and in most cases have two indoor winter periods. As levels of animal growth in one period of the production cycle can have an influence on gains at a later stage (compensatory growth, p 196), optimisation of animal performance at the various stages of the cycle is important. An efficient grass-based beef system depends on maximising individual animal performance from grass forage, and this requires excellent grassland management, encompassing both grazing management as well as the production of high-digestibility (> 700g/kg) grass silage for the indoor winter periods. The strategic integration of both grazing and silage production is critical in grass-based beef production systems. As grazed pasture is invariably the cheapest feed resource for beef production, much attention must be focused on performance at pasture.

Maintaining optimum grazing conditions

Planned early-turnout of cattle to pasture in spring has been shown to improve farm profitability where cheaper pasture replaces more expensive winter forage and a further saving in slurry storage and spreading costs are achieved. In grassland management terms, preparation for early turnout, and having high-quality pastures available in spring, starts in the autumn of the previous year, where paddocks are 'closed' in a sequence and rested for the winter. The use of an autumn and spring rotation planner is a beneficial tool in guiding grassland management. If managed properly, pasture quality is invariably high from turnout in spring until mid-summer. However, when grass seed heads appear, sward quality deteriorates and, if not correctly managed nutritive value can become sub-optimal later in the season.

Managing pasture to maximise animal performance

Post-grazing sward height

Grazing pasture to a relatively low post-grazing sward height is desirable to increase grass utilisation; however, grazing too tightly can adversely affect individual animal intake and reduce animal performance at pasture. General grazing guidelines are based on data from lactating dairy cows, where output per hectare rather than per animal is the primary focus, and suggest a target post-grazing sward height of approximately 4 cm. However, in beef production where individual animal performance is essential to produce a commercially saleable product, a balance between output per unit area and per animal is needed.

A series of studies at Teagasc Grange has investigated the effects of grazing management practices, namely contrasting pre- and post-grazing sward heights, on beef cattle live weight gain at pasture. The effect of post-grazing sward height on animal performance was compared over two years using yearling beef × Holstein-Friesian steers turned out to pasture in spring and grazed to a post-grazing sward height of either 3.5 or 5.0 cm in a rotational grazing system from mid-March until late-October. By the end of the grazing season those grazed to 3.5 cm were 30 kg lighter than those grazing to 5.0 cm. It was concluded that excessively tight grazing (to a sward height of 3.5 cm) was not recommended.

In another study with lactating suckler cows and their calves, animals grazed to a post-grazing sward height of either 4.0 or 5.5 cm. At the end of the grazing season, cow body condition score tended to be lower and calf live weight gain at weaning was 8-10 kg lower for the 4.0 cm compared to the 5.5 cm sward height. It was concluded that grazing to 4.0 cm had negative effects on the performance of beef suckler calves.

More recent research at Teagasc Grange compared post-grazing sward heights of 4 and 6 cm using suckler-bred steers in a weanling-to-beef system. Yearlings were turned out to pasture in spring and grazed to their respective post-grazing sward height in a rotational grazing system. The grazing season lasted over 200 days and they were housed in November. Animals were offered a finishing diet of grass silage only plus minerals and vitamins until slaughter in March at 24-months of age. Grazing to a post-grazing sward height of 6 cm rather than 4 cm, resulted in animals being 29 kg heavier at housing at the end of the grazing season (Figure 1), and having a 15 kg heavier carcass, demonstrating that the live weight advantage at housing was retained during the finishing period. As there was no difference between the two post-grazing sward heights in the digestibility of the herbage offered during the grazing season, this suggests the additional growth performance was achieved through higher individual animal intake. The net effect of grazing to 6 cm was to reduce the stocking carrying capacity by 15% and produce ~0.5 t less DM per ha; however, there was no difference in live weight gain per hectare. In practical terms, higher weights at housing can translate into an earlier slaughter date, thereby reducing feed costs and potentially reducing the carbon footprint of beef systems. To reach the same carcass weight as the cattle grazing to 6 cm, those grazing to 4 cm would require an additional month of 'finishing'.

Collectively, these studies indicate that grazing too tightly (~4.0 cm compared to 5.5-6.0 cm) negatively impacts individual animal growth rate, most likely mediated through reduced herbage intake.

Pre-grazing herbage mass

The mass of pre-grazing herbage offered to animals can affect animal performance. Two experiments were conducted at Teagasc Grange to evaluate the effect of pre-grazing herbage mass on animal live weight gain. In the first study, yearling steers, again part of a suckler weanling–to-beef system, were allocated a pre-grazing herbage mass of 1500 or 2000 kg DM/ha in spring and were rotationally grazed as described above for a grazing season of over 200 days duration. Animals were housed in November, offered grass-silage only plus minerals and vitamins, and slaughtered at ~24 months of age. Pastures were topped once in mid-summer. Increasing pre-grazing herbage mass from 1500 to 2000 kg DM/ha resulted in animals being 14 kg heavier at the end of the grazing season and having a 5 kg heavier carcass at slaughter. As the digestibility of the grass offered in the two pre-grazing herbage masses was similar, this suggests that increased individual animal performance associated with the higher pre-grazing herbage mass was due to a higher intake.

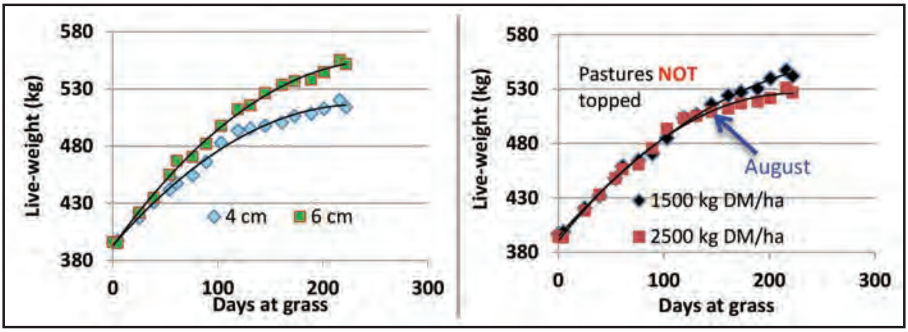


Figure 1. Effect of post-grazing sward height (left) and pre-grazing herbage mass (right) on animal live weight

In the second study, pre-grazing herbage masses of 1500 and 2500 kg DM/ha were compared, and pastures were not topped in mid-season. On this occasion, digestibility of the higher pre-grazing herbage mass was lower from early-August onwards. As a result, animals offered the higher pre-grazing herbage mass were 16 kg lighter at the end of the grazing season. However, all of the difference in live weight emerged from mid-season onwards (Figure 1). Unlike the findings from the earlier study, there was no carcass weight difference at slaughter implying that the high pre-grazing mass animals had 'compensated' during the winter. In both years, increasing pre-grazing herbage mass above 1500 kg DM/ha increased herbage production (~0.9 t DM/ha), but had no effect on grazing stocking rate. These data suggest there is a relatively wide grassland grazing 'tolerance' for beef systems, especially, where animals return indoors for finishing at the end of the grazing season.

Concentrate supplementation at pasture

Due to the seasonality of grass growth, herd feed demand usually exceeds supply in the autumn. This is particularly so on beef farms because, due to accumulated animal growth, feed requirements increase as the grazing season progresses, whereas grass growth declines after mid-summer. Furthermore, when compared with spring grass, autumn grass generally has a lower feeding value. Additionally, weather and grazing conditions in autumn may be less than optimum. As grazed grass is considerably cheaper than grass silage, early finishing of cattle at pasture in autumn, before housing becomes necessary, is less costly. Consequently, there may be a role for strategic concentrate supplementation at pasture to enhance feed-nutrient intake, and thus help animals meet an acceptable carcass fat score, thereby potentially eliminating the need for housing. An important factor affecting nutrient intake of cattle when supplementing forage, is substitution rate i.e. the decrease in grass

DM intake per unit of concentrate eaten. Research at Teagasc Grange observed substitution rates for finishing cattle grazing autumn pasture supplemented with concentrates to range from 0 (no decrease in grass DM intake) to 0.81 (0.81 kg decrease in grass DM intake per kg of concentrates DM fed), and in some cases at higher levels of supplementation, substitution was in excess of 1.0. In other words, where grass supply was limited, substitution rates were low, but where grass supply was adequate, increasing the level of concentrates reduced grass intake but usually also increased total DM and energy intake.

Carcass growth response to concentrate supplementation while grazing can be variable, and will primarily depend on the 'quality' and supply of pasture, and the level of supplemented concentrates. The response is higher (better) where grass supply is low, where grass digestibility is poorer and/or under inclement grazing conditions, and the (marginal) response is poorer as concentrate supplementation level increases. Studies at Teagasc Grange have shown that at adequate (approx. 20 g DM/kg live weight) grass allowances in autumn, feeding 0.50-0.75 kg of concentrate per 100 kg live weight resulted in carcass growth responses between 30 and 110 g carcass per kg concentrate (e.g. Table 1). In practice, feeding a moderate level of concentrate - 0.5 kg concentrate/100 kg live weight - will likely result in carcass growth responses at the upper end of this range.

Table 1. Effect of concentrate supplementation (GC 'X' kg daily) at pasture in autumn on growth and carcass traits of finishing steers compared to unsupplemented animals (G0)

	Suckler steers (95 days)			**Suckler steers** (75 days)			**Beef x dairy steers** (112 days)			
Finishing strategy (FS)	**G0**	**GC5**	Sig.	**G0**	**GC4**	Sig.	**G0**	**GC1.5**	**GC3**	Sig.[1]
Daily live weight gain (kg)	0.34	1.04	***	0.81	1.14	***	0.80	0.88	0.91	NS
Slaughter weight (kg)	547	596	***	604	667	***	459	469	471	NS
Carcass weight (kg)	291	323	***	334	379	***	226	233	236	NS
Kill-out proportion (g/kg)	532	541	***	554	568	**	488	498	500	*
Carcass conformation (1-15)	6.3	7.6	***	7.5	8.8	**	5.2	5.4	5.2	NS
Carcass fat score (1-15)	6.2	7.4	***	7.5	8.3	*	5.1	5.6	5.8	NS

[1]NS= not significant, * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

Supplement 'type' and nitrogen excretion

Grazed grass is characterised by high crude protein concentrations resulting in imbalances in the supply of carbohydrate and protein in the rumen of beef cattle, inefficiency of nitrogen capture, and consequently relatively low nitrogen use efficiency. In autumn, the diet of grazing cattle is generally particularly unbalanced because there is usually excess degradable protein in grass. Therefore, dietary energy rather than protein is the limiting factor and, where supplementation occurs, an energy source is required. Research at Teagasc Grange has shown that supplementing autumn grass with a low-protein, high-energy feed is a practical strategy to decrease total and urinary nitrogen excretion from grass-based beef production systems and that animal performance is similar for starch-based (barley) or fibre-based (pulp) concentrates. For example, supplementation with citrus pulp offered at 0.22 of dietary DM intake reduced total and urine nitrogen excretion in zero-grazed beef cattle, by 10 and 21%, respectively, compared to un-supplemented grass. In the context of increasing environmental regulations relating to nitrogen and ammonia excretion from ruminant production, this is an important consideration

Grass-based suckler beef finishing systems

Edward O'Riordan, Peter Doyle, Aidan Moloney, Paul Crosson and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- There are many suckler beef finishing systems depending on factors including, the progeny breed, gender, purchase age and slaughter age.
- Nationally, mean slaughter age for suckler steers is ~28 months and suckler heifers is ~25 months.
- Technically-efficient farmers following production system 'blueprints' for suckler-bred cattle, are finishing steers at under 24-months of age and heifers under 21-months of age. This shows the potential to reduce age at slaughter, nationally.
- As most suckler cattle are spring-born, the production cycle typically consists of at least two grazing seasons and two indoor winter periods.
- In reality many animals do not reach the performance targets outlined in 'blueprints', necessitating part of a 'third' grazing season or indeed an additional 'winter' before slaughter.
- Increasing concentrate inclusion in the diet increased slaughter and carcass weight, kill-out proportion and carcass conformation and fat score.

Introduction

Steers, heifers and young bulls accounted for ~50%, 34% and 16%, respectively, of the 1,067,000 beef carcases in 2011, and 54%, 36% and 10%, respectively, of the 1,223,000 'prime' carcasses in 2021. Of the total steers produced, suckler and dairy progeny accounted for 48% and 52% in 2011, and 38% and 62% in 2021, respectively. Late-maturing genetics predominate in the cow breed types and sires used in the suckler herd, nationally. As the majority of suckler calves are spring-born, to coincide with seasonal grass growth, their progeny typically have at least two seasons at pasture and two winters before slaughter. Nationally, age at slaughter for suckler-bred steers is approximately 28 months, which implies that many cattle have at least part of a 'third' grazing season. On 'research' farms, 'demonstration' farms and the top 'commercial' farms, slaughter age is typically under 24 months for suckler-bred steers achieving a carcass weight of approximately 395 kg at these younger ages. The difference in slaughter age between the national and research data indicates that there is scope to reduce slaughter age through better overall production system management. It is acknowledged that many suckler-bred cattle are traded more than once in their lifetime, and thus there is a range of contrasting production systems in place depending on when, at what age and weight, the animals are purchased. The data presented below assumes that spring-born animals are purchased in the autumn, as 'weanlings', and remain on the farm until slaughter.

Grassland systems

An efficient grass-based beef production system depends on maximising individual animal performance at pasture. This relies on excellent animal and grassland management, in order to attain target weights in addition to producing high-quality silage for the winter in order to achieve optimum indoor performance for both growing and finishing animals. Concentrate supplementation is used strategically. Indeed, recent research at Teagasc Grange has investigated grazing management practices to increase beef cattle live weight gain at pasture in 'grass-forage-only' suckler weanling-to-beef systems (see page 216).

Suckler steer beef production systems

A recently-completed study at Teagasc Grange compared three contrasting spring-born, late-maturing suckler steer weanling-to-beef production systems namely, '*Intensive*', '*Conventional*' 'and '*Forage-only*', with respective mean slaughter ages of approximately 21-, 24- or 28-months. The mean slaughter ages reflect, respectively, animals slaughtered at the end of their 'second' grazing season, at the end of their 'second' indoor winter or after a short duration at pasture during their 'third' grazing season (Figure 1). All weanlings were purchased in late autumn (~330 kg live weight), housed in mid-November, and offered *ad libitum* high dry matter (DM) digestibility (DMD, >750 g/kg) grass silage. The *Conventional* and *Intensive* systems were supplemented with 1.5 kg DM/head/day concentrate (~2 kg fresh weight) for their first winter and the *Forage-only* system received only grass silage plus minerals and vitamins. Cattle were turned out to pasture in spring and the *Conventional* and *Forage-only* systems spent ~200 days grazing, whereas the *Intensive* system animals were housed in mid-July after ~120 days grazing. Following re-housing animals on the *Intensive* system were gradually introduced to an *ad libitum* concentrate diet (plus 1 kg of high DMD grass silage DM/head/day) until slaughter at 21 months of age. At the end of the grazing season the *Conventional* system animals were offered high-digestibility grass silage *ad libitum* supplemented with 3.5 kg DM/head/day concentrates (~4 kg fresh weight) and slaughtered at the end of winter at 24 months of age. The *Forage-only* system were offered only high-

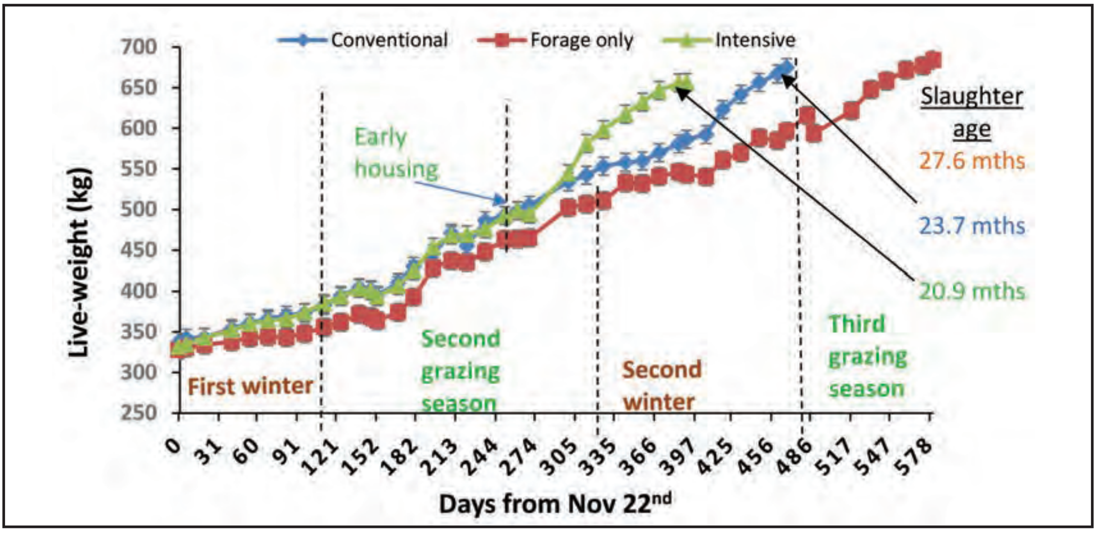


Figure 1. Animal growth paths for three contrasting spring-born weanling-to-beef production systems

digestibility silage plus minerals and vitamins for the second winter, and then turned out to pasture for four months grazing prior to slaughter at 28 months of age. All systems aimed to produce a 'finished' animal at ~390 kg carcass weight. The *Conventiona*l system diet was comprised of ~82% forage (43% grass silage and 39% grazed pasture) and 18% concentrate. The *Intensive* system comprised of 59% forage (~30% each of grass silage and grazed pasture) and ~41% concentrates. The *Forage-only* system, was 100% forage (55% grazed pasture and 45% grass silage). Animal growth performance results are presented in Figure 1. The *Intensive Conventional*, and *Forage-only* systems had carcass weights of 390, 386 and 395 kg, respectively. Corresponding carcass conformation scores were 9.8, 8.7 and 9.1 (scale 1-15), fat scores were 7.2, 7.3 and 6.6 (scale 1-15), while kill-out proportions were 600, 570 and 580 g/kg respectively, thus, showing the better kill-out proportion, conformation and fat scores associated with increased concentrate feeding.

Early-and late-maturing suckler-bred steers on contrasting production systems

In a further study at Teagasc Grange, spring-born early-maturing (EM, Aberdeen Angus and Hereford-sired) and late-maturing (LM, Charolais and Limousin-sired), weaned suckler steers were compared in four contrasting production systems with slaughter prior to a second winter period at approximately 19.5 months of age. All animals had a common 123-day first winter indoors (store period), during which they were offered grass silage *ad libitum* (DMD 693 g/kg) plus 3 kg concentrates fresh weight daily. At the end of the winter steers were assigned to one of four systems: (1) 175 days grazing pasture-only (GO), (2) 100 days grazing pasture-only, followed by 75 days grazing plus 4.2 kg DM concentrate daily (GGC), (3) 100 days grazing pasture-only, followed by 75 days *ad libitum* concentrate and grass silage (GAD), and (4) 175 days *ad libitum* concentrates and grass silage (ADLIB). Animals were slaughtered after 175 days. Mean age at slaughter was 580 and 594 days for EM and LM, respectively.

Table 1. Effect of sire breed maturity (early-, EM and late-, LM) and production system on growth and carcass traits in steers

	Breed		**Sig.**	**Production system**				**Sig.**[1]
	EM	**LM**		**GO**	**GGC**	**GAD**	**ADLIB**	
Slaughter weight (kg)	595	624	**	547	569	635	662	***
Kill-out proportion (g/kg)	534	551	***	532	541	547	550	***
Carcass weight (kg)	318	345	***	291	323	347	364	***
Conformation score (1-15)	6.9	8.3	***	6.3	7.6	8.1	8.5	***
Fat score (1-15)	8.7	7.0	***	6.2	7.4	8.4	9.5	***
Live weight gain (75 day finishing phase) (kg/day)	0.82	1.00	**	0.34	1.04	1.44	0.81	***

[1] Sig. = Significance; ** = P < 0.01; *** = P < 0.001

During both the 'growing' (first 100-days) and 'finishing' (final 75-days) phases LM had a higher daily live weight gain compared to EM (Table 1). At a similar slaughter age, LM had a higher slaughter weight, kill-out proportion, carcass weight and carcass conformation score, and lower carcass fat score than EM. During the 'finishing' phase, animal live weight gain at pasture-only (GO) was poor, and adding concentrates (4.2 kg DM/head/day) increased daily gain from 0.34 to 1.04 kg/day. Further increasing supplementary feeding to *ad libitum* concentrates for the final 75 days increased live weight further to 1.44 kg/day. When slaughtered at pasture, fat scores were, on average, 2+, implying approximately half of the carcasses had insufficient fat cover. Increasing concentrate inclusion in the diet during the 75-day finishing phase increased slaughter and carcass weight, kill-out proportion, and carcass conformation and fat score.

Suckler heifer beef production systems

'Blueprint' heifer systems at Teagasc Grange (e.g. Derrypatrick Herd) produce carcasses in excess of 315 kg when slaughtered at 20-months of age. In their finishing phase, heifers typically receive 3-4 kg concentrates/head/day for their final two months at pasture, or alternatively are housed in September and offered high-digestibility grass silage plus the same concentrate allowance. However, nationally, many suckler-bred heifers do not reach these target live weights, necessitating a second winter, and in some cases, return to pasture for part of a third grazing season before they are slaughtered.

A recent Teagasc Grange study examined the performance of suckler heifers offered grass silage-only (dry matter digestibility (>750 g/kg), or grass silage supplemented with 4 kg concentrates daily during the second winter (20 months of age at housing). Supplemented heifers were slaughtered after 139 days at a mean age of 24.5 months. Unsupplemented heifers returned to pasture (after their 126-day winter) for a 77-day grazing season and were slaughtered at a mean age of 27 months (Figure 2). During the second winter, supplemented animals gained 1.0 kg live weight/day and reached a carcass weight of 325 kg with a fat score of 4-. Unsupplemented heifers gained 0.52 kg live weight/day during the winter, and following turnout to pasture (March 16) gained in excess of 1.3 kg live weight/day until slaughter. They achieved a carcass weight of 325 kg with a mean fat score of 4-.

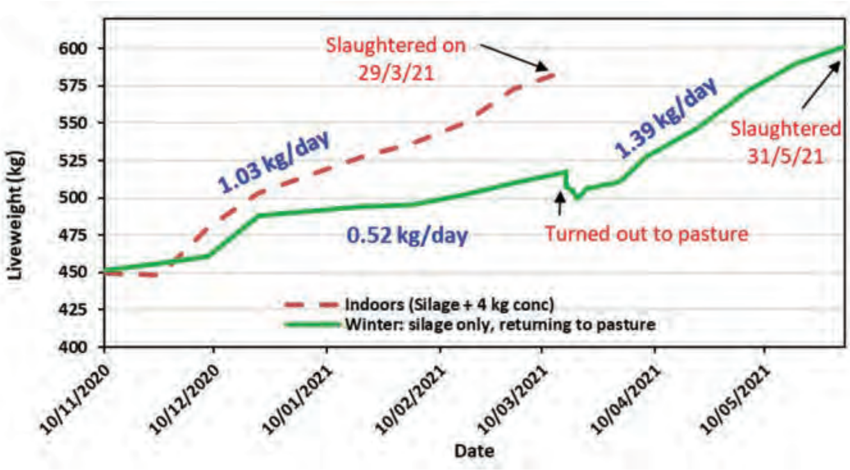


Figure 2. Mean growth performance of suckler heifers offered grass silage supplemented with 4 kg concentrates daily during the 'second' winter (**brown dotted line**) or offered grass silage-only during the winter and subsequently turned out to pasture for a 'third' grazing season (**green solid line**)

Suckler bull beef production systems

Edward O'Riordan, Aidan Moloney, Paul Crosson and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath.

Summary

- Bulls had greater growth rate, a heavier slaughter weight, better kill-out proportion, a heavier carcass, better carcass conformation and a lower carcass fat score than steers, when reared similarly in 'finishing' systems ranging from grazed grass-only to ad libitum concentrates.
- Pasture-based bull systems had greater profit, lower green-house (GHG) emissions intensity, and superior human-edible protein (HEP) efficiency than comparable steer systems.
- A key limitation of grass-based systems for suckler bulls is achieving adequate carcass fatness; therefore concentrates, offered as a supplement at pasture or as a high-concentrate diet indoors, is generally required for 'finishing', especially with late-maturing genotypes.

Introduction

'Young' bull beef has accounted for between 16% and 31% of the 'prime' male cattle slaughtered in Ireland annually, over the last decade. For any beef production system, knowledge of the market requirements must be known at the outset and this is particularly applicable to bulls. In this respect, factors such as age at slaughter, carcass weight, carcass fat 'cover' and meat quality characteristics are critical issues. Furthermore, there is a relatively wide range in carcass specifications depending on the market. Consequently, an important caveat with bull beef production is that producers should always discuss market options in advance with their meat processor. Even more importantly, matters concerning human safety must be carefully considered vis-à-vis behaviour of bulls.

Bulls vs. steers: performance, efficiency and environmental footprint

On reaching 'maturity', bulls are inherently more efficient for beef production than steers, due to naturally occurring male steroid hormones. A review of national and international literature carried out at Teagasc Grange comparing bulls and steers of similar breed, reared under similar management on the same diet and slaughtered at the same age showed that the proportional superiority of bulls over comparable steers for live weight gain, carcass weight and lean meat yield was 0.08-0.20, 0.09-0.14 and circa. 0.20, respectively, and, they produce carcasses with better conformation, and 0.27-0.35 less fat. In terms of converting feed to live weight gain, the feed conversion efficiency of bulls was 0.13-0.17 better than steers. Differences in favour of bulls are generally more pronounced at higher feed energy levels and with increasing slaughter weight.

Unsurprisingly, most published information for bull beef production derives from confined/indoor systems, often with high-concentrate inputs. In practice, bulls and steers are generally reared in different production systems ('intensive' vs. 'extensive') with differences in levels of feeding, lifetime ratios of grazing to indoor feeding, and ages and weights at slaughter. How bulls and steers compare, when reared and managed similarly on lower-cost grass-based production and finishing systems was relatively unknown.

In this regard, growth and carcass traits of late-maturing, suckler-bred yearling steers and bulls, previously offered grass silage plus supplementary concentrates over the 'first' winter, was determined in two experiments at Teagasc Grange (Table 1). In the first experiment, animals were offered either a high-concentrate diet or were grazed for 98 days followed by high-concentrate diet and slaughtered at a mean age of 19 months. In the second experiment they were offered pasture-only for a complete 192-day grazing season or pasture-only for the first half of the grazing season followed by pasture + 4 kg concentrate supplementation daily in autumn (95 days) and slaughtered at a mean age of 19 months. Overall, when reared similarly, bulls had greater growth rate, a heavier slaughter weight, better kill-out proportion, a heavier carcass, better carcass conformation score and a lower carcass fat score than steers. Of note in Experiment 2 is that, compared to late-maturing breed steers, carcasses from late-maturing breed bulls were only adequately finished at 19 months of age when supplemented with concentrates (Table 1; Figure 1). Additionally, in Experiment 2, bull systems had greater profit, lower greenhouse gas (GHG) emissions intensity, and superior human-edible protein (HEP) efficiency than steers. The effect of gender on meat eating quality traits is presented elsewhere (page 234).

Table 1. Growth and carcass traits of late-maturing breed suckler bulls and steers in different production/finishing systems and slaughtered at a mean age of 19 months

	Experiment 1					**Experiment 2**				
	High-conc.		**Grass → high-conc.**			**Grass-only**		**Grass + conc. (95 days)**		
	Steer	Bull	Steer	Bull	Sig.[1]	Steer	Bull	Steer	Bull	Sig.[1]
Live weight (kg/day)										
Phase 1 ('growing')	1.64	1.82	1.28	1.49	**	0.81	1.13	1.14	1.52	***
Phase 2 ('finishing')	0.87	1.33	1.51	1.79	***	0.98	1.24	1.28	1.48	***
Slaughter weight (kg)	683	728	651	711	***	604	678	667	715	***
Kill-out (g/kg)	560	575	559	571	**	554	570	568	580	**
Carcass weight (kg)	382	419	364	406	***	334	386	379	415	***
Conformation score (1-15)	9.1	10.2	8.9	9.9	*	7.5	9.2	8.8	10.1	***
Fat score (1-15)	8.6	7.9	7.6	6.7	**	7.5	5.0	8.3	6.2	***

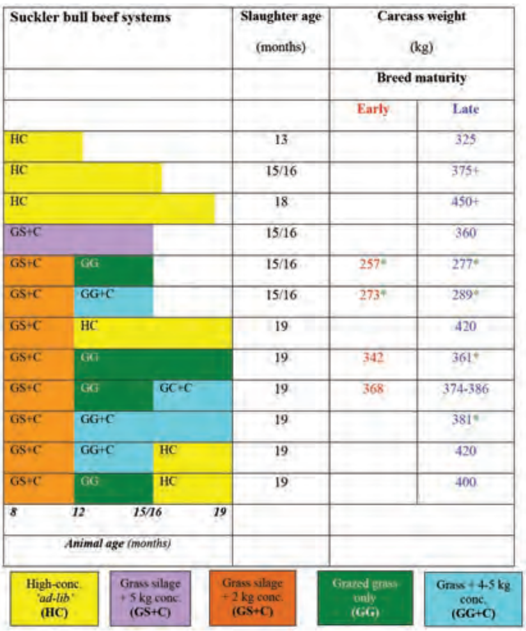
[1]Sig = significance, * = P < 0.05, ** = P < 0.01, ***= P<0.001

Suckler bull systems

Most traditional production systems for spring-born suckler-bred bulls involved male calves spending the first 7-9 months at pasture, suckling its mother, being weaned before housing at the end of the grazing season, and, finished indoors without a return to pasture. The finishing regime can vary from *ad libitum* concentrates plus limited forage/roughage to high-digestibility forage (grass silage) plus moderate levels of supplementary concentrates with slaughter usually between 12 and 16 months of age (Figure 1), but often older in practice. On high-energy diets, suckler bulls can always be adequately 'finished' (carcass fat score of

≥2+ or ≥6.0, 1-15 scale) and, because achieving an adequate carcass fat score is a primary market requirement, this is important.

A feature of traditional suckler bull systems, unlike steer and heifer production, is that they do not generally have a prolonged store or restricted growth period or did not utilise grass during a second, or part of, a second grazing season. Improved profitability of bull systems could derive from further increasing the proportion of grazed grass in the diet and exploitation of compensatory growth potential to reduce costs, analogous to steer beef systems. In this context, a wide range of suckler bull systems incorporating grazing, was evaluated at Teagasc Grange (Figure 1). A key limitation of grass-based systems for suckler bulls is achieving adequate carcass fatness, and concentrates in the form of supplementation at pasture or a high-concentrate indoor 'finishing' period is generally required (Figure 1).



***Inadequately 'finished': Mean fat score <2+ (<6.0, 1-15 scale) Source:** McGee *et al*. 2022, Teagasc Grange

Figure 1. Summary of recent Teagasc Grange suckler bull weanling-to-beef production systems - ranging from high-concentrate-based to grass forage-based.

Effect of suckler bull weanling winter growth rates on subsequent performance

Animal performance at all stages in the production cycle is important if bulls are to be finished at the desired age and weight. The effect of 'first-winter' weanling performance on the subsequent growth and carcass characteristics of suckler bulls was evaluated in two studies at Teagasc Grange. In the first experiment, spring-born (8 March) late-maturing breed weaned bulls, (~9 months old, 370 kg live weight) were offered: (1) grass silage (dry matter digestibility, DMD 731 g/kg) supplemented with either 2, 4 or 6 kg of concentrates fresh weight daily over a 123-day winter. They were turned out to pasture in spring for 99 days, re-housed on 9 July and adapted to an *ad libitum* concentrate plus grass silage diet. Animals were slaughtered when the group reached a mean live weight to achieve a mean target carcass weight of 400 kg. Feeding concentrates reduced silage intake during the first-winter; daily silage DM intake was 4.8, 4.0 and 3.6 kg, for the 2, 4 and 6 kg concentrate-supplemented groups, respectively. At the end of the first-winter bulls supplemented with 4 and 6 kg concentrates were 26 and 65 kg heavier, respectively, than those supplemented with 2 kg concentrates. After 99 days grazing, there was no difference in live weight between the 2 and 4 kg concentrates supplemented groups due to compensatory growth

(Table 2); however, the 6 kg supplemented group were still 32 kg heavier. At slaughter, there was no significant difference in live weight, carcass weight, kill-out proportion, carcass fat or conformation score between the three concentrate supplemented groups.

Table 2. Effect of first-winter concentrate feeding level on daily live weight gain, slaughter weight and carcass weight of suckler bulls in two experiments

	Experiment 1			Sig.[1]	Experiment 2		Sig.[1]
Concentrate level (kg/day)	2	4	6		3	6	
Live weight gain (kg/day)							
Indoor first-winter	0.67[a]	0.91[b]	1.18[c]	***	0.74	1.05	***
Pasture	1.17[a]	0.88[b]	0.87[b]	***	1.57	1.24	***
Indoor finishing	1.81	1.99	1.85	P=0.10	1.57	1.80	*
Slaughter weight (kg)	709	715	703	NS	713	743	**
Carcass weight (kg)	401	403	395	NS	411	431	**

[1]Sig = significance, NS= not significant, * = $P < 0.05$, ** = $P < 0.01$, ***= $P<0.001$

Similarly, in the second experiment, suckler bull weanlings (~9 months old, 369 kg) were fed either 3 or 6 kg concentrates daily as a supplement to grass silage (DMD 688 g/kg) over a 127-day indoor winter. Animals were turned out to pasture in spring for 98 days and then rehoused for a 76-day 'finishing' period on *ad libitum* concentrates. At the end of the first-winter, bulls receiving 6 kg concentrates were 50 kg heavier than those receiving 3 kg concentrates. After 98 days at pasture the live weight difference was reduced to zero due to compensatory growth (Table 2); however, in this study it was found that bulls offered 6 kg concentrates during their first-winter were 30 kg heavier at slaughter (due to compensatory growth during finishing, Table 2), resulting in a 20 kg heavier carcass, than bulls offered 3 kg concentrates for the first-winter. Inconsistency across studies was likely attributed to inclement, weather-related, grazing conditions having an adverse effect on intake and performance at pasture.

Pasture-based 'finishing' of suckler bulls

The early-finishing of spring-born, suckler-bred bulls from pasture, prior to housing for a second winter, eliminates the need for an expensive indoor finishing period, as well as 'freeing up' winter accommodation. However, a key challenge is meeting specifications for carcass fat score (≥2+ or ≥6.0, 1-15 scale), particularly for late-maturing breeds. As breeds differ greatly in their propensity for fat deposition, early-maturing beef breeds (e.g. Angus, Hereford) may be more suitable for grass-based finishing systems compared to late-maturing beef breeds (e.g. Limousin, Charolais). Additionally, there may be a role for strategic concentrate supplementation at pasture to enhance feed nutrient intake and thus, subcutaneous fat deposition. In this context, a series of grazing-based experiments carried out at Teagasc Grange using spring-born, suckler-bred bulls has established that: (i) carcasses of both early- and late-maturing breed suckler bulls were inadequately finished from pasture, with or without concentrate supplementation at 15 months of age, and (ii) carcasses of early-maturing breed bulls slaughtered at 19 months of age from pasture were lighter but adequately finished, with or without concentrate supplementation during the latter half of the second grazing season (i.e. ~4.0 kg daily for 95 days), whereas the heavier, late-maturing breed bull carcasses were only adequately finished when supplemented (Figure 1).

Beef from an all-grass forage diet: production system comparison

Edward O'Riordan, Peter Doyle, Aidan Moloney, Paul Crosson and Mark McGee

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath.

Summary

- Most beef cattle receive concentrates at some stage of their lifetime.
- There is increasing interest in grass-forage-only beef production systems.
- Achieving live weight, and especially carcass fat score, targets without strategic supplementary concentrate is challenging, and requires forage - grazed grass and grass silage - with consistently-high 'quality'.
- When slaughtered at a relatively young age, early-maturing suckler-bred steers may be more suited to grass-forage-only systems due to their inherently fatter carcasses; however, their carcass weight and conformation score is lower when compared to late-maturing breeds.

Introduction

The majority of beef cattle are supplemented with concentrates during the production cycle as an aid to achieving sufficient weight gain and especially to attain an adequate carcass fat cover at slaughter. However, the rising price of 'grain', the desire not to use a potential source of human food in animal feed, and an interest in developing niche markets for 'grass-fed' beef, has increased the interest in 'forage-only' systems. Pasture-only production systems allow beef to be marketed as 'grass-fed' which can command a price premium, and thus provide further high-value market opportunities for Irish beef. In the context of the 'feed-food debate', such forage-only diets can further enhance the sustainability of beef production as only feedstuffs that are not directly edible by humans are consumed by the livestock (i.e. grazed pasture and grass silage) and these are converted into high-quality human food.

In Irish suckler calf-to-beef systems where animals spend up to eight months or more annually at pasture, grazed pasture and grass silage accounts for around 90% of feed consumed. Completely omitting relatively expensive concentrates from the diet of beef cattle has the potential to enhance farm profitability and sustainability, but animal performance from pasture, both grazed and conserved, has to be increased if animals are to produce a commercially-saleable product. The success of such systems is dependent on excellent grassland management, where individual animal growth rates are maximised, and on the ability to produce high-quality silage for the winter where optimum indoor performance for both growing and finishing animals is required. Grass forage-only beef production systems poses a number of challenges at farm level. These include achieving live weight targets at critical points in the animal's lifetime, as well as attaining a minimum carcass fat cover (currently 2+, 6 on a scale 1-15) especially at younger slaughter ages, which can be more difficult to achieve without strategic concentrate supplementation. In this regard, early-maturing suckler-bred genotypes may be more suited to grass-only systems as their carcasses tend to be fatter than late-maturing breeds types. Failing to achieve growth targets and minimum carcass fat scores leads to older animals at slaughter, which can be a source of inefficiency, as well as potentially increasing the environmental footprint of such a production system.

Grass-based suckler steer weanling-to-beef production systems: effect of breed and slaughter age

To address these factors, a study was carried out at Teagasc Grange to compare the performance of purchased early- (Angus/ Hereford) and late-maturing (Limousin/ Charolais) sired suckler weanling steers, slaughtered at a mean of one of three ages – 20, 24, 28 months. The mean slaughter ages reflect, respectively, animals slaughtered at the end of their second grazing season (GO20), at the end of their second indoor winter (GO24 or GC24) or after a short duration at pasture during their third grazing season (GO28). Animals were offered either a grass-forage-only diet (GO) (i.e. no concentrate supplementation from post-weaning to slaughter – grass silage-only during the 'first' and/or 'second' winter, and grazed grass-only during the 'second' and/or 'third' grazing season, as applicable) or, alternatively, grazed grass-only during the grazing season but grass silage + concentrate supplementation during the winter and slaughtered at 24 months of age (GC24, standard/ 'control' system). Key findings from this study showed that early-maturing steers tended to be heavier at slaughter, but late-maturing steers had a heavier carcass (reflecting their higher kill-out proportion), with superior conformation, and a lower fat score (Table 1). When slaughtered directly off pasture at a mean slaughter age of 20-months, only the early-maturing breed steers achieved the minimum carcass fat score, whereas mean carcass fat score was acceptable for all breed types when slaughtered at older ages.

Table 1. Effect of sire breed maturity (B) and production system (PS) on average slaughter weight and carcass traits of suckler steers

Breed (B)	Early-maturing				Late-maturing				Sig[1.]	
Production System (PS)	**G0-20**	**G0-24**	**GC-24**	**G0-28**	**G0-20**	**G0-24**	**GC-24**	**G0-28**	**B**	**PS**
Slaughter weight (kg)	528[a]	596[b]	663[c]	708[d]	527[a]	558[b]	649[c]	690[d]	NS	***
Kill-out (g/kg)	531[a]	527[a]	543[b]	538[b]	560[a]	569[a]	576[b]	576[b]	***	**
Carcass weight (kg)	280[a]	314[b]	361[c]	381[d]	295[a]	319[b]	375[c]	397[d]	*	***
Conformation (1-15)	5.8[a]	5.7[a]	6.9[b]	7.8[b]	7.5[a]	8.1[a]	8.9[b]	9.1[b]	***	***
Fat (1-15)	6.1[a]	8.5[b]	9.9[c]	10.1[c]	4.1[a]	6.1[b]	8.0[c]	7.9[c]	***	***

[1]NS= not significant, * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

A further study at Teagasc Grange examined the effects of sire breed maturity (early-or late-maturing) on suckler steer progeny performance in a weanling-to-beef grass-forage-only production system. Spring-born weanlings were purchased in the autumn and managed similarly during their first winter (offered high-digestibility grass silage only), second season at pasture (grazed grass only) and during the indoor finishing period (silage only) until slaughter at a mean age of ~24 months. While early-maturing animals attained a higher live weight at slaughter than late-maturing animals, carcass weight was, however, higher for the late-maturing animals, reflecting the higher kill-out proportions of the late-maturing animals (Table 2). As observed in other studies, the late-maturing breed type had higher carcass conformation and lower carcass fat scores than the early-maturing breed type.

Table 2. Effect of sire breed maturity on carcass traits of spring-born suckler steers reared on a grass-forage-only system and slaughtered at a mean age of ~24 months

	Early-maturing	Late-maturing
Slaughter weight (kg)	670	653
Carcass weight (kg)	367	376
Kill-out proportion (g/kg)	548	577
Carcass conformation score (1-15)	7.1	8.6
Carcass fat score (1-15)	8.5	6.8

Omitting concentrates during winter finishing

Beef production from a grass-forage-only diet, introduces the challenge of finishing animals without concentrate supplementary. Studies at Teagasc Grange over three years comparing the indoor finishing phase (i.e. 'second' winter) of suckler-bred steers reared on a grass-forage-only (i.e. offered grass silage-only) versus a 'conventional' grass-based (i.e. grass silage + supplementary concentrate) weanling-to-beef production system with mean slaughter age at 24 months. Grass silage dry matter digestibility was invariably in excess of 740 g/kg. Results showed that live weight gain during the second winter (133-day duration) was 0.4 kg/day greater for animals offered silage plus concentrates compared to silage-only (Table 3). This superior growth resulted in a 43 kg heavier carcass for the supplemented animals. Supplementing with concentrates increased animal kill-out proportion (+19 g/kg), carcass conformation score (+1.30 units, 1-15 scale) and carcass fat score (+1.92 units, 1-15 scale). A proportion (~30%) of the forage-only animals were still 'under-finished' (fat score of 6 or less, scale 1-15) at the mean slaughter age of 24 months.

Table 3. Effect of grass silage-only vs. concentrate supplementation during the indoor winter 'finishing' phase on suckler steer performance and carcass traits (3-year average)

	Grass silage only	Grass silage + concentrates (4 kg fresh weight/head/day)
Live weight gain (kg/day)	0.57	0.97
Winter live weight gain (kg)	77	130
Slaughter weight (kg)	620	661
Carcass weight (kg)	347	390
Kill-out proportion (g/kg)	558	577
Carcass conformation score (1-15)	7.5	8.8
Carcass fat score (1-15)	6.5	8.4

'Third' season at pasture: animal performance

As a proportion of animals slaughtered at 24-months of age failed to attain the minimum carcass fatness at slaughter when offered a grass-silage-only finishing diet, the option of returning beef cattle to pasture for a short 'third' grazing season was explored. In one study, early- and late-maturing sired suckler steers, reared similarly from weaning at ~8 months of age until ~24 months of age on a grass-forage-only system, were turned out to pasture and rotationally grazed for a 110-day 'third' grazing season, before slaughter directly off pasture at a mean age of 28-months. A live weight gain in excess of 1.5 kg/day was achieved during the 110-day grazing season for both breed types and, as observed in other studies, the early-maturing animals were heavier (+18 kg) at slaughter (Table 4). However, the higher kill-out proportion (+0.38 g/kg) of the late-maturing animals resulted in a heavier carcass weight (+16 kg) compared to the early -maturing animals. The late-maturing animals had a higher carcass conformation score (+1.28 units; 1-15 point scale), but a lower carcass fat score (-2.23 units; 1-15 point scale) compared to the early-maturing animals. Both breed types exceeded the minimum carcass fat score of six (on 15-point scale), suggesting that they could, potentially, have been slaughtered earlier. This especially applied to the early-maturing breed type that were the fattest (average fat score of >10 (4-).

Table 4. Effect of sire breed maturity on suckler steers live weight gain at pasture and carcass traits of suckler steers when grazed for a 110-day 'third' grazing season

	Early-maturing	Late-maturing
Live weight gain (kg/day)	1.57	1.57
Slaughter weight (kg)	708	690
Carcass weight (kg)	381	397
Kill-out proportion (g/kg)	538	576
Carcass conformation score (1-15)	7.8	9.1
Carcass fat score (1-15)	10.1	7.9

Similarly, in another study, spring-born late-maturing suckler-bred steers, weighing 560 kg live weight, were returned to pasture on 5 April for an 80-day 'third' grazing season. They achieved a live weight gain at pasture of 1.69 kg/day, a mean carcass weight of 392 kg and attained a mean carcass fat score of 7.5 (15-point scale) when slaughtered at an average age of 27-months. In terms of carcass fatness, however, a proportion (16%) attained a carcass fat score of under six (15-point scale), whereas 22% had a carcass fat score of greater than nine. On an individual animal basis, this implies that there was scope to draft some animals earlier for slaughter, with its associated cost savings.

Effect of space allowance and floor type on the performance and welfare of cattle

Bernadette Earley[1], Michael Keane[1,2], Mark McGee[1], Edward O'Riordan[1] and Alan Kelly[2]

[1] Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath
[2] School of Agriculture and Food Science, University College Dublin, Dublin 4

Summary

- Increasing space allowance for finishing beef cattle above 3.0 m2 on concrete slatted floors (CSF) did not affect animal welfare.
- A space allowance of 3.0 m2 is sufficient for finishing beef cattle on CSF in terms of performance.
- When housed at the same space allowance, accommodating finishing beef heifers on straw as opposed to CSF improved daily live weight gain, but not carcass weight.
- Behavioural results indicated that the provision of straw increased lying time.
- It is necessary to account for the weight and potential growth rate of finishing cattle when deciding what space allowance they should receive.

Introduction

Space allowance and floor type are identified as critical factors affecting the welfare of cattle housed indoors. Studies comparing the welfare and performance of finishing beef cattle accommodated on straw and concrete slatted floors (CSF) are often confounded by the fact that straw-bedded systems normally have a larger floor area than CSF. One way of possibly determining the space requirements for finishing cattle, irrespective of their weight, is through the use of dynamic (allometric) equations. Instead of allocating a fixed space allowance per animal, allometric equations use the progressing weight of an animal to estimate the space that they require during housing. International research has concluded that beef cattle should be housed at a space allowance defined by the formula $y = 0.033w^{0.667}$, where $y = m^2$ per animal and w is bodyweight (Petherick and Phillips, 2009). The Scientific Committee for Animal Health and animal Welfare (SCAHAW, 2001) recommended that beef cattle expected to reach 500 kg should be provided with 3.0 m^2 per animal, ± 0.5 m^2 for every 100 kg above or below this level. In allometric terms, the Scientific Committee of Animal Health and Welfare (SCAHAW, 2001) recommendation equates to a space allowance defined by the formula $y = 0.048w^{0.667}$. Two studies were carried out to address space allowance and floor types for indoor finishing cattle.

Study 1: The effect of space allowance and floor type on performance and welfare of finishing beef heifers

The first study evaluated the effects on animal performance and welfare of housing finishing beef heifers at a range of space allowances on CSF. The lowest and intermediate space allowances (3.0 m^2 and 4.5 m^2 /animal) were based on the recommendations in a report by SCAHAW (2001).

Continental crossbred heifers (n = 240: mean initial live weight, 504 kg) were assigned to one of four treatments; i) 3.0 m^2, ii) 4.5 m^2 and iii) 6.0 m^2 space allowance per animal on a concrete slatted floor (CSF) and, iv) 6.0 m^2 space allowance per animal on a straw-bedded floor, for 105 days. To permit direct treatment comparisons within the same shed, the straw-bedded floors were created by placing a polypropylene geotextile membrane (Synthetic Packaging, Clara, Co. Offaly, Ireland) over the CSF and the straw was placed on top of this free-draining membrane. The straw-bedded pens were replenished with unchopped barley straw at a rate of 150 kg per pen every three days and this was fully removed and replaced with fresh straw, every two weeks. Soiled bedding in the straw-bedded pens was never higher than 25 cm in depth. Heifers had free access to clean, fresh drinking water. Heifers were offered a total mixed ration *ad libitum*. Dry matter intake was recorded on a pen basis. Heifers were weighed, dirt scored and blood sampled every three weeks. Whole blood was analysed for complete cell counts and serum samples were assayed for metabolite concentrations. Behaviour was recorded continuously using infrared cameras from day (d) 70 to 87. Heifers' hooves were inspected for lesions at the start of the study and again after slaughter. Post-slaughter, carcass weight, conformation and fat scores, and hide weight were recorded.

Table 1. Effect of space allowance and floor type (concrete slatted floor, CSF vs. straw) on feed dry matter (DM) intake, growth, carcass characteristics and number of hoof lesions in beef heifers during a 105-day finishing period.

	Space allowance (m^2/head)			Floor type (6 m^2/head)		Sig.[1]	
	3	4.5	6	CSF	Straw	Space allowance	Floor type
Feed DM intake (kg/day)	11.1	11.1	11.1	11.1	11.1	NS	NS
Slaughter weight (kg)	631	642	633	633^a	648^b	NS	*
Daily live weight gain (kg)	1.18^a	1.28^b	1.19^a	1.19^a	1.34^b	*	*
Feed conversion ratio2	9.43^a	8.74^b	9.45^a	9.45^a	8.42^b	*	*
Carcass weight (kg)	343	344	341	341	347	NS	NS
Kill-out proportion (g/kg)	544	536	539	539	537	NS	NS
Carcass conformation (1-15)	8.5	8.5	8.2	8.2	8.6	NS	NS
Carcass fat (1-15)	10.1	10.2	10.1	10.1	10.4	NS	NS
Hide weight (kg)	38.5	38.5	37.6	37.6^a	39.5^b	NS	*
Hoof lesions obtained (number)	3	3.3	3	3	3	NS	NS

[1]NS = not significant; * = P<0.05; [2]Kilograms of dry matter intake divided by kilograms of live weight gained. [a,b], Least squares means within a row without a common superscript letter differ (P <0.05);

Heifers housed at 4.5 m^2 had a greater average daily live weight gain (ADG) than those on both of the other CSF treatments; however, space allowance had no effect on carcass weight (Table 1). Heifers accommodated on straw had a greater ADG (0.15 kg), hide weight, better feed conversion ratio and had greater dirt scores at slaughter than heifers accommodated on CSF at 6.0 m^2. The number of heifers lying at any one time was greater on straw than on CSF. Space allowance and floor type had no effect on the number of hoof lesions gained or on any of the haematological or metabolic variables measured.

It was concluded that increasing space allowance above 3.0 m^2 per animal on CSF was of no benefit to animal carcass performance but it did improve animal cleanliness. Housing heifers on straw instead of CSF improved ADG and increased lying time; however carcass weight was not affected.

Petherick, J.C. and Phillips, C.J.C. 2009. Space allowances for confined livestock and their determination from allometric principles. *Applied Animal Behaviour Science,* 117**,** 1-12.

SCAHAW (Scientific Committee on Animal Health and Animal Welfare), 2001. The welfare of cattle kept for beef production. SANCO.C.2/AH/R22/2000.

Study 2: Are allometric equations suitable for estimating the space requirements of finishing beef cattle housed on concrete slatted floors?

The objective of this study was to compare the performance and welfare of beef cattle housed on CSF at two different dynamic space allowances, defined by Petherick and Phillips (2009) and SCAHAW (2001), to that of cattle housed at three different fixed space allowances. Continental crossbred steers (n=120: mean initial live weight, 590 kg) were assigned to one of five space allowance treatments (three fixed and two dynamic) on CSF: i) 2.0 m^2 per animal, ii) 2.5 m^2 per animal, iii) 3.0 m^2 per animal, iv) Equation 1 (E1); $y=0.033w^{0.667}$, where y = m^2 per animal and w = body weight, and v) Equation 2 (E2); $y=0.048w^{0.667}$ for 105 days. Each treatment consisted of 6 pens, with each pen containing four steers. All pens were located in the same housing facility. Steers were offered grass silage and concentrates *ad libitum*. Dry matter intake was recorded weekly on a pen basis. Steers were weighed and dirt scored every 14 days. Blood samples were collected every 28 days, and analysed for complete cell counts. Behaviour was recorded using closed-circuit infrared cameras. Steers' hooves were inspected for lesions at the beginning of the study and post-slaughter.

Slaughter weight and ADG were lowest, and feed conversion ratio (FCR) was poorest, for steers accommodated at 2.0 m^2, and slaughter weight and ADG were greatest, and FCR was the best, for steers accommodated at E2; steers accommodated at 2.5 m^2 were intermediate to those accommodated at 2.0 m^2 and both 3.0 m^2 and E1, whereas steers accommodated at 3.0 m^2 and E1 were intermediate to 2.5 m^2 and E2 (Table 2). Carcass weight of steers housed at 2.0 m^2 was lower than all other treatments. Steers housed at 2.5 m^2 had lower carcass weights than those with accommodated at E1 and E2, whereas the carcass weight of steers accommodated at 3.0 m^2 was intermediate. Carcass fat scores and hide weights were lower in steers accommodated at 2.0 m^2 than those housed at E2 with other treatments being intermediate. The number of steers lying at any one time and the number of steers observed grooming themselves was lower at 2.0 m^2 than on any other treatment. Dirt scores, hoof lesion number and haematological measurements were not affected by treatment.

Table 2. Effect of space allowance on dry matter intake (DMI), performance characteristics and number of hoof lesions of finishing beef steers during a 105-day finishing period.

	Space allowance (m^2/animal)			Equations		Sig.[3]
	2	2.5	3	E1[1]	E2[2]	
Grass silage DMI (kg/day)	1.2	1.2	1.2	1.2	1.1	NS
Concentrate DMI (kg/day)	8.8	9.2	9.6	9.4	9.8	NS
Total DMI (kg/day)	10.0	10.4	10.8	10.6	10.9	NS
Slaughter weight (kg)	665^{a}	688^{ab}	705^{bc}	701^{bc}	713^{c}	*
Daily live weight gain (kg)	0.76^{a}	0.88ab	1.05^{bc}	1.09^{bc}	1.14^{c}	*
Feed conversion ratio4	13.7^{a}	12.0^{ab}	10.3^{bc}	10.1^{bc}	9.4^{c}	*
Carcass weight (kg)	389^{a}	401^{b}	409b^{c}	411^{c}	417^{c}	*
Kill-out proportion (g/kg)	586	581	583	588	583	NS
Carcass conformation (1-15)	9.2	9.4	9.8	9.8	9.8	NS
Carcass fat (1-15)	7.9^{a}	8.7^{ab}	8.9^{ab}	8.9^{ab}	9.3^{b}	*
Hide weight (kg)	49.1^{a}	50.2^{ab}	52.1^{ab}	50.5^{ab}	54.7^{b}	*
Hoof lesions (number/animal)	3.1	2.5	3.5	2.9	3.6	NS

[1]E1 = space allowance per animal (m^2) = 0.033 bodyweight$^{0.667}$; [2]E2 = space allowance per animal (m^2) = 0.048 bodyweight$^{0.667}$; [3]NS = not significant; * = $P<0.05$; [4]kilograms of dry matter intake divided by kilograms of live weight gained; [a,b]Least squares means within a row without a common superscript letter differ ($P < 0.05$)

Conclusions

It was concluded that 2.0 m^2 per animal was an insufficient space allowance for finishing steers housed on CSF. There was no difference in ADG or carcass weight between steers accommodated at 2.5 and 3.0 m^2 per animal. There was no difference in ADG or carcass weight between steers housed at 3.0 m^2, E1 (k = 0.033) or E2 (k = 0.048). A k-value of 0.033 (equation E1) is sufficient for estimating the space allowance for finishing steers housed on CSF.

Controlling parasitic infection and pneumonia in growing and finishing beef cattle

Orla Keane, Bernadette Earley and Edward O'Riordan

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- An optimal herd health programme should be designed to prevent major disease and it is important to consult with a veterinary practitioner in this regard.
- Parasite control programmes, encompassing internal parasites and ecto-parasites should be developed.
- Anthelmintics from different classes have different modes of action but within a class products share the same mode of action.
- When resistance develops to one product within a class all the products in the same class are often affected.
- Bovine respiratory disease (BRD) is a multifactorial disease and involves a wide variety of infectious agents.
- The key to preventing respiratory disease is to reduce stress and to vaccinate against viruses and bacteria that cause disease.

Introduction

In suckler herds, calves generally remain with the cows at pasture until they are weaned between six and nine months old. In addition to removal from the cow, the weaning procedure may be compounded by other stressors occurring around the same time, e.g. change of diet (grass and milk to conserved feed with or without concentrates), change of environment (outdoors to indoors), and transport/marketing. Weaning therefore can be a multi-factorial stressor, in which, nutritional, social, physical, and psychological stress are combined. Psychological stress is present in the form of maternal separation and social disruption, whereas nutritional and physical stressors are often present through the introduction and adaptation to a novel diet and environment. Research at Teagasc, Grange has shown that reducing the cumulative effect of multiple stressors around weaning time results in a less marked stress response in the calf.

Dairy calves, in contrast to suckler calves, are commonly separated from their dam a few hours after birth. In grass-based dairy-beef steer production systems, spring-born calves are typically offered milk replacer plus concentrates over an indoor rearing period of 8 weeks, turned out to pasture in May, and housed at the end of the grazing season (October/November).

During the ‘first’ indoor winter (‘store’) feeding period, both suckler-bred and dairy-bred animals consume a restricted-energy diet based on grass silage and supplementary concentrates, followed by a ‘second’ grazing season (February/March to October/November) where they can exploit compensatory growth. Some animals, primarily heifers and earlier maturing breed types, are finished towards the end of this second grazing season. During the ‘second’ indoor winter period animals are offered grass silage and concentrates, and some animals are finished at approximately 24 months of age. Animals not finished at the end of the second grazing season or during the second winter are returned to pasture from where they are finished at approximately 28 months of age.

An optimal herd health programme should be designed to prevent major disease and it is important to consult with a veterinary practitioner prior to weaning and/or purchase of finishing cattle to discuss the prevalent diseases and associated risks specific to the farm. Respiratory disease (pneumonia) and internal parasites (stomach worms, lungworm (hoose) and fluke) are among the main health concerns affecting weanlings and older cattle.

Control of stomach worms, lungworm and fluke

Parasite control programmes, encompassing internal parasites such as gutworms, lungworm and fluke along with ectoparasites such as lice and mange mites, should be developed in consultation with a veterinary practitioner. The programme should consider all parasite challenges and be designed for holistic and sustainable parasite control on the farm.

During the winter housing period the major parasites of concern are often ectoparasites such as lice and mites. These parasites increase during the winter months due to higher stocking densities, longer coats and the low amount of UV light. Signs of infestation include itching, hair loss, skin lesions and poor thrive. These ectoparasites are usually controlled by the administration of synthetic pyrethroids or injectable or pour-on macrocyclic lactones (clear wormers). While all products (injectable and spot or pour-on) are effective against mites and sucking lice, only topical products are effective against biting lice.

When turned out to grass the following spring, the major parasites of concern for the second grazing season include roundworms, i.e. gutworms and lungworm, and fluke, including rumen and liver fluke. Cattle develop immunity to roundworms over time, relatively quickly in the case of lungworm and over 1-2 grazing seasons in the case of gutworms. In contrast, there is little evidence that cattle develop immunity to fluke infection and these remain a threat throughout the animal’s life. Therefore, in their second grazing season yearlings should have some immunity to roundworms. Immunity may be stronger in the case of dairy calves than in suckler calves as a higher proportion of their diet in the first grazing season came from grass, resulting in higher exposure to these worms. Indeed, if roundworms are well managed in dairy calves in the first grazing season, allowing sufficient exposure for immunity to develop, then they are unlikely to be a major issue in the second grazing season. In contrast, suckler progeny may be at greater risk of disease or ill-thrift due to roundworms in their second grazing season because of their relatively limited exposure to worms in their first year of grazing. Such animals should be monitored for signs of lungworm (hoose) such as coughing and gutworms (scour and poor thrive). Due to the build-up of at least some immunity, second season grazers are more likely to experience sub-clinical disease due to gutworms than clinical disease. Monitoring animal performance will help identify any issues. This can also be combined with laboratory testing, such as examination of faecal samples for gutworm eggs, to determine if and when animals need to be treated. Chemotherapeutic control of roundworms is dependent on the availability of broad-spectrum anthelmintics or 'wormers.' However, in recent years anthelmintic resistance has been detected on cattle farms in Ireland. Anthelmintic resistance refers to the ability of a worm to survive a dose that should kill it. Resistance has been detected in Ireland among gutworms to all three classes of anthelmintics available, the benzimidazoles (white wormers), levamisole (yellow wormers) and macrocyclic lactones (clear wormers). Therefore, it is important to know what wormers work on the farm before choosing which product to use.

The flukes, liver fluke and rumen fluke, can also cause disease in grazing cattle. In the case of rumen fluke, they appear to be usually well-tolerated, although large numbers of larvae in the intestine has been associated with clinical disease which can manifest as rapid weight loss and severe scour. If untreated it can be fatal. However, of far greater concern is the liver fluke. Liver fluke disease, caused by *Fasciola hepatica* can result in anaemia, poor thrive or loss of weight/condition. Liver fluke has a seasonal, indirect lifecycle with both animal and snail hosts. Eggs passed out onto pasture in late spring by infected animals hatch into miracidia, which infect mud snails where they multiply. After about 6 weeks, cercariae are released from the snail host and encyst on the grass as metacercariae. Therefore, the major risk period for fluke is from late summer/autumn onwards. When infective metacercariae are eaten by grazing cattle the newly excysted juvenile fluke burrow through the gut wall and migrate to the liver, a process that takes about two weeks. Over the following eight to 10 weeks the immature fluke migrate through the liver where they can cause extensive damage, ending up in the bile ducts where the mature fluke lay eggs that are passed out with the dung. The effect of weather and ground conditions on disease prevalence is well known with warm, wet weather providing ideal conditions for the intermediate mud snail host. This enables the Department of Agriculture Food and the Marine (DAFM), in conjunction with Met Éireann, to produce a liver fluke forecast each autumn predicting the risk of disease. Avoiding grazing particularly wet areas of the farm in autumn will help reduce exposure to liver fluke. In addition, the DAFM fluke forecast, farm history and liver report information, such as from the Animal Health Ireland Beef Health Check Programme, can help to ascertain liver fluke exposure. Housing represents a good opportunity to control fluke. However, there are different products on the market, which kill fluke of different ages. It is important to target the treatment to the appropriate stage of the parasite. Products that target early immature and immature fluke can be used in the weeks after housing while products that target adult fluke are more suitable for use in spring, before turn-out.

Prevention of pneumonia/bovine respiratory disease

The sourcing of cattle from multiple sources and housing them together within the same airspace almost invariably leads to respiratory disease. Take steps to protect your animals and your profits by "conditioning" animals prior to housing, controlling the animals' environment, vaccinating your animals against respiratory pathogens and taking steps to exclude pathogens from your farm.

The primary cause of pneumonia (respiratory disease) in weanlings is initially attributable to viruses such as bovine herpes virus-1 (BoHV-1/infectious bovine rhinotracheitis (IBR)), bovine respiratory syncytial virus (BRSV), bovine parainfluenza-3 virus (BPI-3 virus), and in many cases is followed by secondary bacterial infections usually caused by *Mannheimia (Pasteurella) haemolytica* and *Mycoplasma bovis*. Bovine virus diarrhoea/mucosal disease (BVD/MD virus) was previously an important component of respiratory disease in weanlings, but its contribution now is minimal as a result of the national eradication programme.

To ensure a healthy weanling, the aim is to minimise their exposure to disease, and maximise their defence against disease

Minimising an animal's exposure to disease, may be achieved through the use of a closed herd, screened replacements and positive herd immunity. Good housing conditions (e.g. adequate ventilation and space) also play a key role in preventing respiratory disease. Ventilation is important in ensuring the health of housed cattle. The rate of air movement into and out of an animal house will determine the quality, humidity and temperature of the air within, and ultimately the ease with which infectious agents may be transmitted between animals in that airspace. Natural ventilation in well-designed animal houses relies on the 'stack effect' – produced when warm air from animals rises and escapes through the outlet at the top of the house, being replaced by fresh air entering through the inlet. Air movement in excess of 0.5 m/s represents a draught, which can lead to chilling of the animal while insufficient air movement can lead to moisture and gas build-up.

Outbreaks of pneumonia amongst weanlings are highly associated with situations where the immune system is compromised. These risk factors include the stresses associated with weaning, as described above, and should be minimised as much as possible. Nutrient deficiency can significantly suppress the immune system, resulting in a poor response to vaccination, as well as resulting in calves that are unable to fight off infections. Furthermore, adequate nutrition minimises the long-term negative effects of disease and permits a more rapid recovery. Stressors associated with castration can also compromise immunity and result in greater susceptibility to pneumonias.

The role of vaccination in prevention or control of bovine respiratory disease

Commercially available vaccines against many of the agents responsible for respiratory disease can help prevent respiratory disease and/or manage an outbreak on farms. However, vaccines are not 100% effective and their efficacy is determined by many factors including the level of challenge presented to the animal, the proper functioning of the animals' immune system and the timing of vaccination relative to infection.

A disease prevention programme for pneumonia usually involves vaccination. Viral specific vaccines are available but their effectiveness is dependent on management procedures and timing of administration. Depending on the causative agent (virus) and product, the vaccine should be administered prior to weaning, bearing in mind that some products require a booster dose. Where possible, do not mix animals from different sources until after the vaccinations have had time to produce immunity (2 to 3 weeks). It is vital, irrespective of the programme, that vaccines are stored and administered as per manufacturers' instructions including being given at the right time, at the right dose and route of administration and right interval between primary and booster (if required).

It is also important to work in close association with a veterinary practitioner. Collection of nasal mucous samples or swabs for laboratory diagnosis will direct the selection of the appropriate vaccine and/or antibiotic treatment.

Changes in steer, heifer and young bull slaughter age and carcass traits in the last eleven years

Edward O'Riordan, Mark McGee, Peter Doyle, Aidan Moloney, Paul Crosson and Paul Cormican

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- From 2011 to 2021 the proportion of carcasses derived from dairy-bred steers increased from 52% to 62%, and dairy-bred 'beef' heifers from 31% to 47%.
- Age at slaughter over this time has decreased by approximately one week per year for steers and 1.25 days per year for heifers.
- Carcass weight of dairy-bred steers decreased by about 0.5 kg per year, and suckler steers increased by about 1.0 kg per year.
- Carcass conformation score decreased by approximately 0.04 units per year for dairy-bred steers, whereas it increased slightly (0.01-0.04 units per year) for suckler-bred steers (15-point scale).
- Overall, heifer carcass weight has shown a gradual increase of 1.25 kg per year. Correspondingly, carcass fat score has increased by about 0.04 units and carcass conformation has decreased by a similar amount, annually (15-point scale).
- Age at slaughter for young suckler bulls has decreased from ~19 to 17.5 months, whereas dairy bulls have remained constant (~20 months).

Introduction

Reducing age at slaughter by three months is one of the proposed strategies to reduce the environmental footprint of beef production systems. The national steer, heifer and young bull slaughter data from 2011 to 2021 was examined to assess changes in animal slaughter age, carcass weight, and conformation and fat scores for different breed types and genders to explore options to reduce slaughter age. In 2011, steers of dairy origin accounted for approximately 52% of total steer carcasses, and suckler-bred steers made up the balance (~48%). This proportion had changed to 62 % dairy and 38% suckler origin in 2021, reflecting the expansion in the national dairy herd. In 2011, suckler-bred heifers accounted for 69%, and dairy-bred 'beef' heifers accounted for 31% of the total carcasses, whereas in 2021 the corresponding numbers were 53% and 47%. In terms of sire breed use, in 2011, late-maturing beef breeds, early-maturing beef breeds and dairy breeds accounted for 50%, 26% and 24%, respectively, of the total steer carcasses. Corresponding values for 2021 were 40%, 35% and 25%.

Change in steer slaughter age and carcass traits

The temporal changes in steer numbers and age at slaughter over the eleven-year period (2011–2021) are shown in Figure 1. Total numbers slaughtered increased from approximately 500,000 in 2011 to approximately 650,000 in 2021. During the same time frame, overall age at slaughter has decreased from approximately 29.5 months to 26.5 months, corresponding to a decrease of approximately one week (7.8 days) per year.

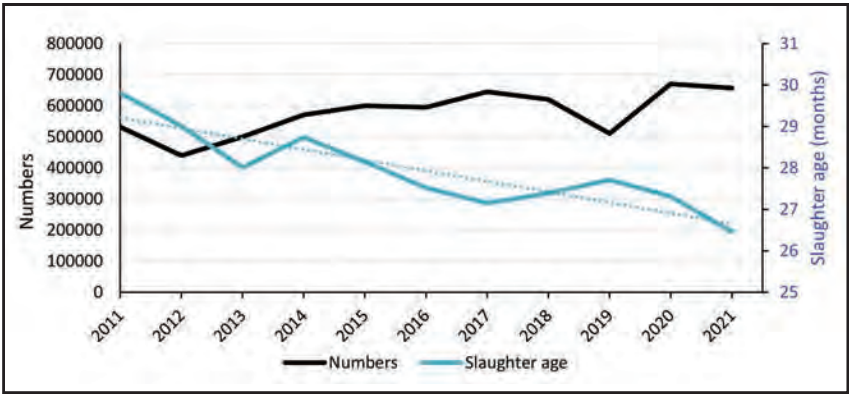


Figure 1. Change in overall steer numbers and slaughter age from 2011-2021

In the same time period, carcass weight has, on average, decreased by approximately 0.5 kg per annum, but in absolute terms showed relatively large annual variation of 10-12 kg (Figure 2). Both carcass conformation and fat score have shown a negative trend over the eleven years, with carcass fatness decreasing by approximately 0.012 units (15-point scale) and carcass conformation score decreasing by 0.04 units (15-point scale) per year.

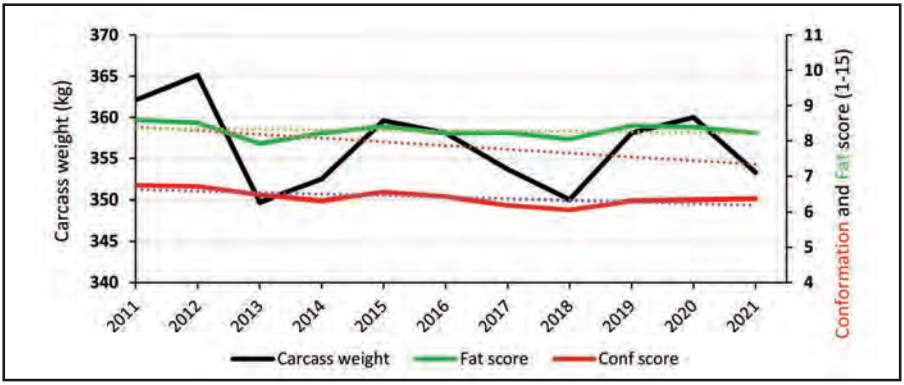


Figure 2. Change in overall steer carcass weight, carcass conformation and fat score from 2011-2021

Carcass weight of dairy × dairy steers decreased by ~0.8 kg/year and beef × dairy steers decreased by ~0.2 kg/year. Overall, carcass conformation score of dairy-bred beef steers (i.e. Holstein/Friesian × Holstein/Friesian, early-maturing × dairy breed and late-maturing × dairy breed) decreased by on average 0.04 units (15-point scale) per year, while carcass fat score (15-point scale) also decreased, but the rate of change was smaller

In terms of the suckler herd, carcass weight of steer progeny from late-maturing and early-maturing breed suckler cows increased, on average by 1.1 kg and 0.85 kg per annum, respectively, over the 11 years. During the same time period, carcass fatness decreased by approximately 0.04 units per year, and carcass conformation increased by 0.01 and 0.04 units per year for steer progeny from early- and late-maturing sire breeds, respectively. Steer carcasses from early-maturing breed suckler dams bred to early-maturing sire breeds were typically one-unit fatter (fat score 3+ (9) on 1-15 scale) and had a one-unit poorer conformation than the steer progeny from these cows bred to late-maturing sire breeds. Similarly, steer carcasses from late-maturing breed suckler dams bred to late-maturing sires were invariably leaner (~0.5 units; 15-point scale) and better conformed (~1.0-1.5 units; 15-point scale) than those sired by early-maturing breeds.

Change in heifer slaughter age and carcass traits

Between 2011 and 2021, the number of heifer carcasses increased from approximately 350,000 to 450,000, and age at slaughter, while showing large annual variation, decreased by, on average, of 1.25 days per year giving a mean age at slaughter of approximately 25 months in 2021 (Figure 3).

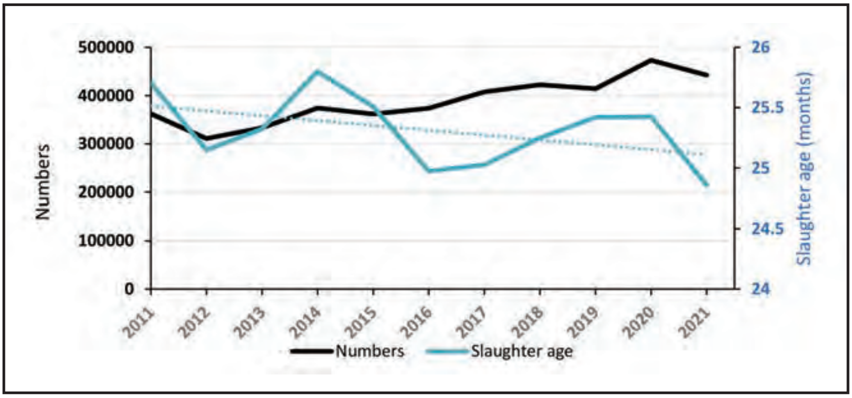


Figure 3. Change in overall heifer numbers and slaughter age from 2011-2021

Changes in heifer carcass weight, and carcass conformation and fat scores is summarised in Figure 4. Overall, heifer carcass weight has, on average, shown a gradual increase at a rate of 1.25 kg per year. In the same time frame, carcass fatness has increased slightly (0.036 fat units per year), while carcass conformation has decreased by a similar rate (15-point scale). For dairy-bred 'beef' heifers, carcass weight (~1 kg per annum) and carcass fatness (~0.02-0.03 units per annum) has increased, while carcass conformation has decreased (0.01-0.02 units per annum) over the eleven years. For suckler heifers out of early-maturing dams, carcass weight has increased for progeny from both early- (2.0 kg per annum) and late-maturing (2.5 kg per annum) sires. Correspondingly, carcass fat (0.02-0.04 units/annum) and conformation (~0.01 unit/annum) scores also increased for these genotypes over the eleven years. Carcass weight of heifers from late-maturing breed suckler cows increased by 2.5 kg and 3.3 kg per annum for progeny of early- and late-maturing sire breeds, respectively. Correspondingly, carcass fat score increased by 0.01 and 0.05 units, and carcass conformation score increased by 0.03 and 0.05 units per annum (15-point scale).

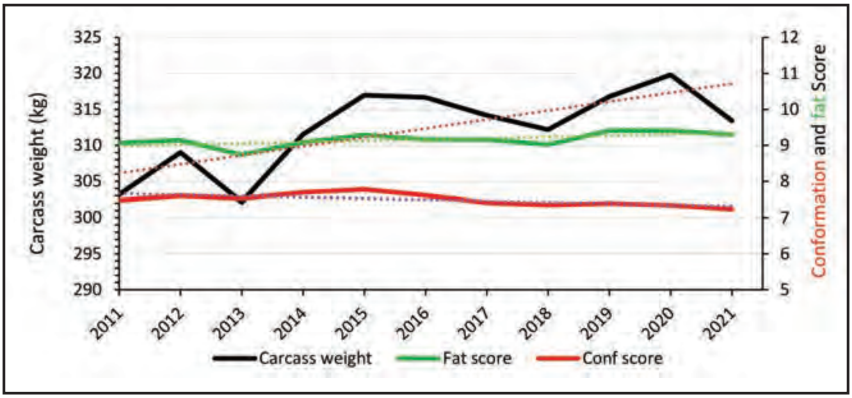


Figure 4. Change in overall heifer carcass weight, carcass conformation and fat scores from 2011-2021

Change in bull slaughter age and carcass traits

Over the past eleven years (2011-2021) age at slaughter for young suckler bulls has decreased from ~19 months to 17.5 months (equivalent to a mean reduction of ~5 days/year), and mean carcass weight has increased at an average rate of 1.3 kg/annum, (currently ~400 kg) (Figure 5). In the same time period, slaughter age of young dairy bulls has remained relatively constant (~20 months), while carcass weight has increased by an average rate of 1.2 kg/annum (currently ~330 kg).

Carcass conformation score has declined (currently 5.6 (on 1-15 scale)) and fat score has increased (currently 6.5 (on 1-15 scale))) for dairy bulls, whereas both have remained relatively constant (10.1 and 6.7 units, respectively) for suckler bulls.

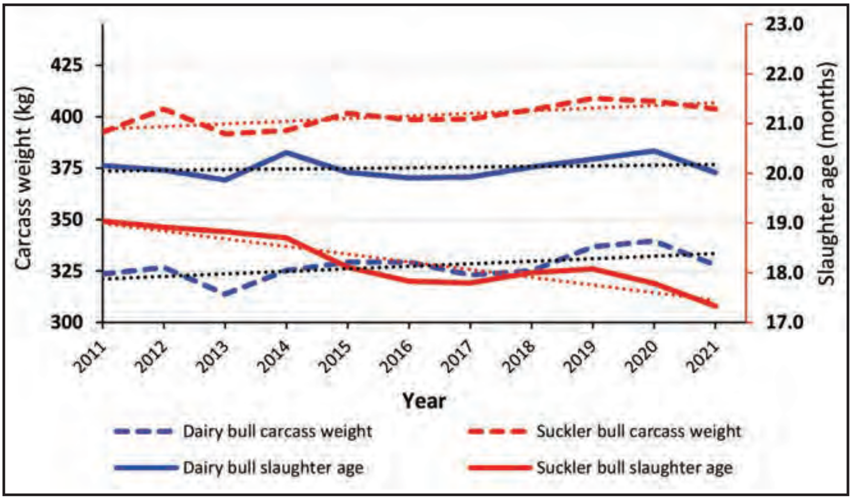


Figure 5. Changes in carcass weight and age at slaughter for 'young' suckler and dairy bulls


0833
1082
1052

Technology Village

MEAT QUALITY

The influence of on-farm factors on the eating quality of beef

Aidan Moloney, Mark McGee and Edward O'Riordan

Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

Summary

- Eating quality (particularly tenderness and flavour) has a critical influence on the decision of the consumer to purchase beef again.
- When slaughtered at a similar fatness, there is little difference between beef breeds in tenderness or overall consumer acceptability of meat.
- On current evidence, increasing age at slaughter (up to 22 months) does not negatively influence the tenderness of suckler or dairy bull beef.
- Within a defined production system, finishing cattle at grass rather than on concentrates has only a minor effect on beef eating quality.
- Producers can choose the most cost-effective ingredients for cattle rations without a commercially-important effect on beef eating quality.

Introduction

As more than 85% of Irish beef is exported there are a myriad of markets and consumers whose preferences must be satisfied to ensure repeat purchase. Each consumer group may have a different definition and expectation of beef meat quality. Within the broad definition of beef meat quality, which includes safety, appearance, shelf-life and nutritional composition, the satisfaction which consumers derive from eating beef is particularly important. Beef eating satisfaction is determined by its intrinsic characteristics (eating quality) and how it meets the expectations of the consumer. An objective of the Teagasc beef quality research programme is to understand how production factors affect beef eating quality, and thereby provide beef farmers with the information to allow them to produce beef that is suitable for specific markets. Eating quality can be affected by animal genetics, animal management on-farm, during transport and slaughter, management of its carcass during the early post-slaughter period, and management of its meat during maturation and cooking. This paper considers "on-farm" influences on eating quality with a focus on the type of animal and ration composition, while recognising that both factors frequently interact within a beef production system.

Animal effects in the eating quality of beef

Tenderness is considered to have a major influence on the enjoyment that comes from eating beef. When tenderness is "satisfactory", then other characteristics such as flavour and juiciness become more important. Eating quality of meat can be assessed by everyday consumers, but this requires a large number of individuals to generate reliable data, and consequently is costly. Eating quality can also be measured by assessors trained to detect relatively small differences between meat samples that often would not be readily determined by everyday consumers. The data summarised in this paper was generated using this approach - a trained taste panel.

Breed: The marbling in muscle (intramuscular fat) contributes to the eating quality of beef. When slaughtered at a constant age, beef from early-maturing breeds such as Angus and Hereford is generally more tender than beef from late-maturing breeds. However when slaughtered at a constant carcass fatness, as a proxy for intramuscular fat, there is generally little difference between breeds in tenderness. For example, striploin from Belgian Blue × dairy heifers, slaughtered at a carcass weight of 327 kg, had similar intramuscular fatness and overall acceptability, (an amalgamation of the various individual sensory characteristics) to striploin from Angus × dairy heifers slaughtered at a carcass weight of 237 kg. In a recent study at Teagasc Grange, suckler bulls from early- or late-maturing breed sires were slaughtered at 380 kg carcass after long-term finishing on an *ad libitum* concentrate-based diet or grazed prior to finishing on an *ad libitum* concentrate-based diet. The intramuscular fat content of striploins was similar for bulls from the early-maturing breed sires in the grass-based system and the late-maturing breed sires in the long-term concentrate system. Consequently, the tenderness of the striploin was also similar.

Gender: In a recent study, continental breed-sired bulls and steers were compared within 2 production systems, either *ad libitum* concentrates indoors or finished on *ad libitum* concentrates after 100 days at pasture. The results are summarised in Table 1. In both production systems, the striploin from steers was fatter and rated more highly for tenderness and acceptability than the striploin from bulls. The absolute differences in eating quality were however, small.

Table 1. Eating quality of *longissimus thoracis* (striploin) muscle from young bulls and steers finished on *ad libitum* concentrates with (GC) or without (CC) a pre-finishing period at pasture (Diet)

Variable	CC		GC		Significance[1]	
	Bull	Steer	Bull	Steer	Diet	Bull vs. steer
Carcass weight (kg)	419	382	406	364	NS	***
Carcass fat score (1-15)	7.9	8.6	6.7	7.6	**	*
Intramuscular fat (g/kg)	21.4	37.2	12.0	19.2	**	*
Tenderness[3]	4.2	5.0	4.2	4.5	NS	*
Beefy flavour[3]	5.0	5.2	5.0	5.1	NS	NS
Firmness[3]	5.6	5.1	5.6	5.3	NS	*
Texture[3]	4.7	5.2	4.6	4.8	*	*
Acceptability[3]	4.8	5.3	4.8	5.0	*	*

[1]NS= not significant, * = $P < 0.05$, *** = $P < 0.001$; [3]Scale: 1=least, 8 = most

Age: The age at which an animal, particularly a bull, is slaughtered, is of current interest due to an age specification in some markets. The dislike of bulls older than 16 months is based to some extent on perceptions of inferior beef tenderness and overall acceptability when compared to younger animals. Recent Teagasc studies indicate that there is little commercially-important difference in tenderness or overall liking of striploins from continental breed-sired suckler bulls slaughtered between 15 and 22 months of age, or from dairy bulls slaughtered at 16, 19 or 21 months of age. Indeed, in the dairy-beef heifer study mentioned earlier, there was an improvement in overall acceptability of the striploin as the animals became older. There is some evidence that production system *per se* may have a small negative effect on eating quality. For example, when suckler bulls from late-maturing breed sires were slaughtered at a range of carcass weights after long-term finishing on an *ad libitum* concentrate-based diet or grazed prior to finishing on an *ad libitum* concentrate-based diet, the tenderness rating by trained assessors was lower for the grass-based system. However, the scale of this decrease is unlikely to be detected by untrained consumers.

Ration composition effects on the eating quality of beef

Energy supply: The effects of the diet of cattle on beef quality may be direct, i.e., other carcass traits have not changed, or indirect, i.e., factors such as carcass weight, age or fatness may change as a result of a change in diet and these may then influence beef quality. An increase in energy consumption by cattle will increase growth and carcass fatness. If slaughtered at the same age, carcasses and muscle from cattle fed the higher-energy ration will likely be fatter and, due to the small positive influence of intramuscular fat on tenderness, an improvement in meat 'quality' may be seen. Generally, however, growth rate before slaughter does not greatly influence beef tenderness. Although, there is some evidence that on a common ration, rapid growth following a period of restricted growth decreases tenderness compared to meat from cattle that grow at a more even rate throughout the finishing period.

Pasture: Grazed grass is an important component of the majority of beef production systems used in Ireland. Compared to concentrate-fed beef, "grass-fed" beef can command a premium in some markets based on perceived differences in appearance and sensory characteristics. The influence of grazed grass *per se*, supplementation of grazing cattle with concentrates and the duration of grazing, on selected sensory characteristics of beef has been examined in Grange. In general, subcutaneous fat from grass-fed cattle was more yellow than from similar cattle fed concentrates. Beef from grass-finished cattle is sometimes darker in colour but this is not a result of a high ultimate pH, which is generally in the range considered as normal. The duration of grazing appears to influence this effect because the colour of muscle from cattle that grazed grass for approximately 85 days (compared to a full grazing season) was similar to muscle from concentrate-fed cattle. The darker colour of grass-fed beef can contribute to its "unique selling point" in some markets. In the most recent study evaluating this, weaned Angus-sired suckler-bred heifers were fed concentrates *ad libitum* from weaning or grazed grass/grass silage throughout life, until slaughtered at a similar carcass weight (Table 2).

While muscle from the concentrate-fed heifers was fatter than muscle from the grass-fed heifers, both were rated similarly for tenderness and a range of flavours by a trained sensory

Table 2. Eating quality of *longissimus thoracis* (striploin) muscle from heifers raised on either a concentrate or "all" grass-based system (Grass)

Variable	Concentrate	Grass	Significance[1]
Carcass weight (kg)	258	264	NS
Carcass fat score (1-15)	10.1	10.6	NS
Intramuscular fat (g/kg)	61.9	44.8	*
Tenderness[2]	43.7	46.0	NS
Juiciness[2]	46.4	47.8	NS
Beefy flavour[2]	54.8	51.7	NS
Abnormal flavour[2]	9.3	10.9	NS
Vegetable/grass[2]	3.4	4.9	*
Overall liking[2]	47.4	46.0	NS

[1]NS= not significant, * = $P < 0.05$; [2]Scale: 1 = least, 100 = most.

panel (Table 2). It would appear that within the range of Irish production systems, the sensory characteristics of grass-fed beef do not differ greatly from concentrate-fed beef.

Concentrate ingredients: There is an array of feed ingredients available to beef farmers which may be included in rations and offered to cattle in varying amounts. Table 3 summarises the results from an experiment in which the barley in a 'standard' barley/soyabean ration was replaced with different feed ingredients, namely; corn gluten feed, citrus pulp, maize dried distillers grains, wheat dried distillers grains and oats. The rations were fed as a supplement (4 kg/day) to finishing steers offered grass silage *ad libitum*. Striploin from steers offered the oats-based ration was leaner than striploin from steers fed the other ingredients but eating quality was generally similar across the ingredients tested. There were some differences in "fishy flavour" but the values were very low for all ingredients. In general therefore, if slaughtered at the same carcass weight/fatness, the composition of the concentrate does not greatly influence beef eating quality. Farmers therefore can choose the most cost-effective ingredients without compromising meat eating quality when compared to a barley/soyabean ration offered as a supplement to grass silage.

Table 3. Eating quality of *longissimus thoracis* (striploin) muscle from steers fed different ingredient-based supplements in a grass silage-based finishing ration

Variable	Barley	Corn Gluten	Citrus Pulp	Maize Distillers	Wheat Distillers	Oats	Sig.[1]
Carcass weight (kg)	331	326	322	326	327	323	NS
Carcass fat score (1-15)	7.7	7.1	7.2	7.6	7.5	7.2	NS
Intramuscular fat (g/kg)	25.7[a]	22.6[a,b]	23.1[a,b]	27.6[a]	27.6[a]	20.5[b]	**
Tenderness[2]	62.0	58.2	61.4	60.8	59.6	63.2	NS
Juiciness[2]	38.7	37.1	39.7	40.1	37.6	38.6	NS
Beefy flavour[2]	42.6	45.3	42.9	43.1	42.2	40.9	NS
Chewiness[2]	18.3	22.1	18.3	18.5	19.9	16.8	NS
Fishy flavour[2]	1.9[a]	0.9[b]	1.9[a]	0.8[b]	2.2[a]	1.1[b]	*

[1]NS= not significant, * = $P < 0.05$; ** = $P < 0.01$; [2]Scale: 1 = least, 100 = most.

Conclusions

The expectations of beef meat consumers must be satisfied to ensure continued purchase of the product, and to sustain the industry. This requires clear market signals on the requirements and/or preferences of each consumer group in the production/supply chain and information on the farm practises required to meet those preferences. Information is now available on the influences of several farm factors on the eating quality of beef. This information will assist farmers and processors to more consistently meet consumer expectations of the beef eating experience.

Acknowledgements

The information summarised here has been generated within projects supported by Teagasc and the Department of Agriculture, Food and the Marine Competitive Research Programmes (11/SF/322, BullBeef), (13/F/514, GrassBeef), (11/S/122, FEFAN). The assistance of Kepak Group and Dawn Meats in the studies mentioned above is gratefully acknowledged.

Advances in technology and innovation for meat quality monitoring and improvement

Mohammed Gagaoua, Carlos Álvarez, Ruth Hamill, Alessandro Ferragina, Anne Maria Mullen and Declan Troy

Teagasc Food Research Centre, Ashtown, Dublin 15

Summary

- Red meat quality is a complex characteristic that is influenced by many factors including production system, animal type/gender and muscle type.
- Our research focuses on emerging and innovative methods to predict, and manage, the variation in meat quality.
- We develop tools to predict the quality of meat using omics methods, such as genomics/ transcriptomics, proteomics and metabolomics.
- We develop non-invasive technologies for meat quality analysis, including near infrared spectroscopy, hyperspectral imaging and Raman spectroscopy.
- Post-mortem interventions focused on improving meat tenderness, such as dry-aging, are described.

Introduction

Meat quality can be affected by many different factors, including farming practices, early pre- and post-mortem events, carcass interventions, technological treatments and, finally, packaging and storage conditions. Definition of meat quality includes many aspects e.g. technological traits such as drip loss; however, from a consumer's point of view, sensory and safety are the main criteria for purchasing decisions. In order to satisfy consumer's demands, a number of innovative methodologies and technologies have been implemented to ensure consistently-high eating quality. Furthermore, such approaches aim to predict and to improve all aspects related to red meat quality from farm-to-fork. The introduction of animal breeding programs, new farming and production practices at the animal level and processing systems have led to a tangible positive impact on the quality but a certain amount of variability on the final product is remaining. Thus, developing prediction tools for meat quality is of high relevance for the whole meat industry.

From a post-slaughter perspective we summarize the recent advances in three key areas of interest: i) management and prediction tools of technological traits of fresh red meat; ii) non-destructive technologies to measure meat quality, and iii) emerging carcass interventions.

Prediction of meat quality traits – an omics approach

Huge advances have been made in the prediction of meat quality, with the development of new tools generally termed "foodomics". Such tools enable an unprecedented detailed molecular (genes, proteins, DNA, glycogen, enzymes etc.) exploration of factors underpinning the final meat quality. As very small quantities of sample are required, these foodomics tools are considered as non-destructive methods compared to more traditional lab-based methods requiring important amounts of samples (entire steak). These include, genomics and transcriptomics (related to genes and their expressed transcripts, and variation between and within populations); proteomics (focused on the different abundance of the proteins that can be detected and identified in the meat matrix); and metabolomics (very small molecules that are relevant for the animal/muscle metabolism).

Genomics and transcriptomics: Advanced DNA sequencing technology detects variations in the DNA sequences between individual animals and enables detection of DNA sequences that are associated with specific meat quality traits. The use of high throughput sequence and DNA chip technology have been of particular importance in the field of animal production and in their use to understand the variability in meat quality traits. Small detectable differences at the DNA level can lead to variations in the final meat quality. Once the genomic diversity and heritability has been analysed and related to meat quality, prediction of quality based on genetic merit is feasible and the accuracy of beef cattle breeding selection programs can be enhanced to improve meat quality in future generations.
Variants of specific genes have been identified as associated with, or influential on, meat sensory traits, and this variability has been investigated in order to understand their role in obtaining high-quality meat. Among them, several of the most relevant genes that have been associated with meat quality are those related to post-mortem tenderization, (i.e., the aging phase or maturation), specifically the enzymes responsible for degrading the muscle structure (*calpains*) and the structural proteins in the muscle that are degraded by these enzymes (*titin, actin, myosins, nebulin* or *desmin*).
In some cases, depending on the level of gene expression, there can be a differential outcome in terms of meat quality and the overall level of expression (or activity) of genes in a group of animals with divergent quality can be investigated gene-by-gene or globally by means of *transcriptomics* approaches including the next generation sequencing family of methods. How abundantly a particular gene is expressed will have an impact on associated physiological pathways and, therefore, can influence a range of meat quality traits, that are relevant to processors or consumers, such as colour, texture, flavour, water-holding capacity etc. For instance, it was observed that the expression of genes related to muscle growth and metabolism was different for animals producing meat of different quality.
Current research is mainly focused on developing a deeper understanding of the physiological processes underpinning variation in meat quality, and identifying specific genes and levels of expression that are indicative and strongly correlated with specific quality traits. In addition, to characterise the current genetic variation will be of help to plan more effective animal breeding programs.

Proteomics: Following gene expression the next step is the translation of genes into proteins. The totality of all proteins expressed in a tissue or a sample is termed the *proteome* and sophisticated analytical and characterisation proteomic tools have provided very detailed and robust insights to pathways and processes, which are involved in meat quality variation. Proteomics focuses both on understanding the phenomenon (trait) and in discovering potential biomarkers for that trait. This is achieved by sampling animals showing divergences for particular characteristics (e.g. colour, tenderness, or juiciness) to identify abundance differences in expressed proteins. Proteomics studies have already correlated the abundance of specific proteins with eating quality traits: colour, tenderness, shear force, marbling and pH decline. They have also provided pivotal insights into the changes during the tenderization phase in post-mortem muscle. We are following a defined pipeline (discovery, evaluation, qualification, research assay optimization, industrial validation and commercialisation of a tool) to work towards prediction of quality and ultimately the development of a routine analytical tool, for use in a quality management system that will enable rapid testing for quality.

Metabolomics: Once a gene is used to make proteins, these protein then perform a multitude of activities in the muscle cell: structure, communication, regulation, facilitation of biochemical reactions. The proteins in charge of mediating the biochemical reactions happening in the cell are known as enzymes. The role of the enzyme is very complex, but the activity of some of them are determined by measuring the substrates and the products of the reaction they are involved in: glucose, glycogen, lactic acid, amino acids, lipids, peptides, etc. In addition to enzymes many metabolites are also generated e.g. vitamins or polyphenols, the abundance of which can be influenced by diet and food-processing technologies. The analysis and characterisation of all these compounds or *metabolites* is the area of research called *metabolomics*. Similar to proteins, metabolites (likely free amino acids) can be correlated to sensory traits and used as biomarkers to predict aroma, flavour, or tenderness. For example, there is a strong correlation with the abundance of free amino acids (generated by calpains, and other enzymes) and the categorisation of samples as tender. On the other hand, other metabolites (such as glycerol-3-phosphate) have been shown to be highly correlated with meat classified as tough. In addition to quality prediction, a further application of this tool is for meat authentication to prevent origin fraud/adulteration, since some metabolites seems to have a particular fingerprint based on origin and production system.
Finally, we are integrating all the above-mentioned tools and technologies, in an innovative multi-omics approach which is helping to develop a better understanding of the mechanisms underpinning meat quality and its variation. Identifying and validating biomarkers for high-quality meat will pave the way for continued improvement in meat quality management systems; allowing producers and processor to take faster decisions and plan interventions to optimally deliver high-quality meat in a consistent way.

Non-destructive technologies to predict fresh meat quality

A new generation of totally non-destructive methods are under examination for prediction and monitoring of meat quality and for objective carcass assessment. These analyses are based on the interaction between a harmless radiation (light) and the sample (meat, carcass etc.). When radiation hits the sample an interaction takes place and the radiation can be transmitted, reflected or absorbed. These three phenomena happen at the same time and its occurrence is dependent on the sample chemical composition and physical properties. Therefore, the interaction is measured by means of statistical tools and the data, once processed and analysed, have shown potential to predict red meat quality traits. Several technologies are available, each one of them with their own pros and cons. These include, near infrared spectroscopy (NIRS), hyperspectral imaging (HSI) and Raman spectroscopy among others.
Along with the fact that the meat sample is not affected, another advantage is the speed of analysis and that, generally, no sample preparation is required. However, in order to develop the mathematical models used to make predictions, a large number of samples must be scanned and combined with analysis from traditional 'wet chemistry' analytical methods.
Promising applications have been demonstrated when predicting colour, pH, tenderness,

compositional analysis or water holding capacity. Also, they show good potential for identification and classification of meat of different origin. Currently, major efforts are being made to correlate spectral data with sensory traits, and other relevant properties such as intramuscular fat or shear force. Finally, the system required to be incorporated in an online application at factory level is being developed, where shorter scanning time and better accuracy is needed.

Interventions for improved meat tenderness after slaughtering

It is well-recognised that the cause of variability in beef tenderness are multifactorial, from farm-to-fork, but that the events taking place during the post-mortem period are pivotal in influencing final meat tenderness. For this reason, several carcass interventions have been under investigation with the goal of improving and standardising final meat eating quality, especially tenderness. Carcass interventions such as electrical stimulation, hanging method and chilling regime have received much attention and optimised practises are currently used commercially. As part of our recent research, we are paying special interest to both tenderization and flavour or aroma development.

Post-mortem aging methods are commonly classified in to wet- and dry-aging, with wet-ageing being the most common and the focus of previous research. However, dry-ageing has recently become a value-added product and is generating a lot of interest. Dry-ageing permits the evaporation of moisture entrapped in the muscle and the process leads to a distinctive flavour and aroma development. The market for dry-aged beef has increased with consumers willing to pay more for the particular quality traits. Due to the process employed, yields are lower and sometimes aging times are longer. Our research focuses on the application of this processing to beef from grass-based systems, examining the drying kinetics and also applying 'omic' approaches to better understand, and ultimately control, pathways contributing to the product quality.

Other interventions relate to emerging or novel technologies, namely high hydrostatic pressure (HPP), pulse electric fields (PEF) or ultrasound (US). The mechanisms of action for each one of them are different, but what they have in common is that they can effectively influence the muscle, cell or protein structure, or modify the enzymatic activity (proteolytic or metabolomic), which ultimately may lead to improved tenderness.

Conclusions

Rapid advances in a variety of analytical techniques are enabling meat researchers to explore in an unprecedented depth the mechanisms responsible for the fresh meat quality determination. Regardless of the type of approach (genomic, proteomics or metabolomics) the quest for biomarkers for meat quality is one of the main interests of our research group.

Non-invasive techniques are also being developed for rapid analysis and prediction of meat quality and carcass assessment. In tandem, we are also examining the potential of novel and existing technologies, which influence the factors affecting meat eating quality, to assist in generating higher-quality fresh meat more consistently, and satisfying consumer's expectations.

Meat Technology Ireland – Enterprise Ireland Technology Centre

John Colreavy

Teagasc Food Research Centre, Ashtown, Dublin 15

Summary

- Irish beef and lamb processors established the first collaborative, industry-led research programme with Enterprise Ireland in 2016.
- Meat Technology Ireland (MTI) has been in operation for five years and is still unique in the northern hemisphere.
- An independent review conducted by international consultants 'frontline' of the centre's first five-years' performance revealed important potential outputs from Phase I.
- Three case studies from the MTI published literature are presented here, describing key findings from the Genetic Improvement, Meat & Health, and New Opportunities Pillars in Phase I.

Introduction

In 2012 beef processors ABP, Ashbourne Meat Processors, Dawn Meats, Kepak, Slaney International, Liffey Meats, Irish Country Meats and Hilton Foods initiated a journey with Enterprise Ireland to form a collaborative research consortium. A number of years planning and consultation culminated in the launch of the centre on the 29 February 2017. Prior to the formation of Meat Technology Ireland (MTI), little collaborative interaction on the design and operation of Research & Innovation had occurred between sector industry members. Sectoral investment in Research & Innovation had been traditionally low, reflective of the low R&D spend in the food sector in general. In 2016, the formation of MTI represented a €2.5 million investment from industry members and was valued at over €8 million overall following public investment. The initiative represented a sizeable collaboration unique in the northern hemisphere. MTI Phase I (2016 to 2021) represented an opportunity for industry members to undertake projects of scale that they could not do individually, such as supporting the launch of the world's-first national genetic evaluation for meat quality through the Irish Cattle Breeding Federation (ICBF).

The Phase I programme consisted of research into genetic improvement, meat quality, shelf-life, meat grading, meat & health and new opportunities. The centre underwent an extensive, international mid-term review in 2020. The independent review from 'frontline' resulted in an automatic invitation from Enterprise Ireland to submit an application for a follow-on Phase II programme based on its excellent performance. The independent findings from the 'frontline' review revealed that anticipated MTI outputs from Phase I were,

- 288 new jobs created and a further 964 safeguarded.
- €106 million of net economic value add (EVA) to the Irish economy or €18.6 for every €1 invested.

The Phase I programme was completed on the 30 November 2021 with Phase II starting seamlessly on the 1 December 2021. The industry members' investment exceeded expectations by increasing the scale of their investment by 35% in Phase II, supported by Enterprise Ireland. The Phase II programme addresses two primary themes of sustainability and digitalisation, in addition to meat quality, meat & nutrition as well as the circular economy. The anticipated impact that Phase II can contribute to is expected to be,

- Reduction of annual emissions by ~0.5 Mt CO2eq. per year by 2030 representing between 17 and 24% of the annual methane reduction target for agriculture overall.
- Launch the world's first Beef Carbon Footprint breeding index with ICBF for beef animals on pasture-based systems.
- Contribute to a meaningful debate on the role of meat in a sustainable diet, thereby continuing to inform policy actors such as the Food Safety Authority of Ireland.
- Establish a Digitalisation roadmap for the Irish meat-processing sector.
- Broaden the relevance of the MTI platform to more industry members and stakeholders in the innovation chain.

Technology Centres – The model

The Technology Centre programme is a joint initiative between Enterprise Ireland and IDA Ireland. It allows Irish companies and multinationals to work together on market focused strategic R&D projects in collaboration with research institutions. The eight Technology Centres in the programme are resourced by highly-qualified researchers who provide a unique ecosystem for collaboration in areas identified by industry as being strategically important. Technology Centres are characterised as,

- *Collaborative entities* – Globally unique collaboration.
- *EI/IDA/Industry/Academia* – Collaboration across State and private sector.
- *Established and led by industry* – Industry draft the research questions for academics to address and are involved in the management of the programme.
- *Resourced by highly capable researchers* – Teagasc/ UCC etc.
- *Hosted with research institutions* – Teagasc Legal, HR, Finance and Commercialisation infrastructure.

Pillar 1 Genetic improvement

The objective of the genetic improvement pillar in Phase I was to achieve cumulative and permanent, sustainable genetic gain for improved meat quality and yield in cattle through a combination of genetic and genomic tools within the framework of an overall holistic breeding goal for profit. An important component of the pillar was the validation that genetic merit of animals for eating quality materialised into true differences detectable by consumers. To support this validation, a consumer study of 140 consumers was undertaken to determine if animals who were genetically divergent in meat tenderness actually produced more tender meat, as well as assessing the implications for other sensory attributes like flavour, juiciness and overall likeability. Individual animal parental average genetic merit for meat tenderness was used to locate 20 *Tough meat genotype* heifers and 17 *Tender meat genotype* heifers; striploin steaks from all heifers were subjected to sensory analysis using both specifically trained panellists and ordinary consumers separately. All sample steaks were treated identically throughout the process including being all finished on a single farm. The consumer study found that the Tender meat genotype scored higher for tenderness, juiciness, flavour and overall acceptability compared to the Tough meat genotype (Figure 1).

Similar results were generally found for the separate consumer age cohorts (18–64 years) with lower sensory acuity in the 65+ age cohort. This was consistent with the results from the experienced trained panellists who scored the Tender meat genotype better for tenderness, juiciness and flavour. The critical outcome from this study was that parental average genetic merit (i.e., genetic merit at birth) can be used to segregate groups of animals for tenderness, which, in turn, can be detected by consumers.

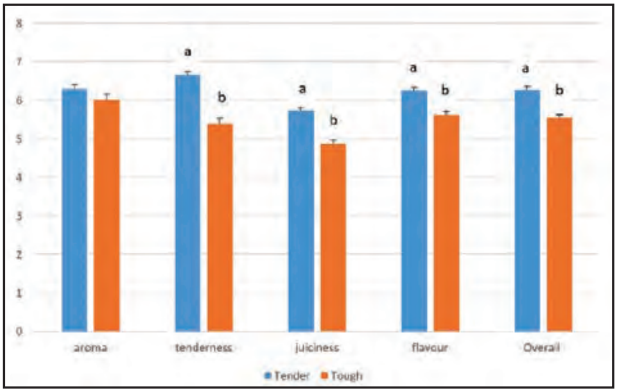


Figure 1. Consumer evaluation of Striploin Steak from 'Tough' and 'Tender' genotype cattle treatments. Mean data with SEM (Standard Error of the Mean). Lower case letters (a,b) denote differences (P<0.0001) between columns (*O'Sullivan et al., 2021. Sensory Consumer and Descriptive Analysis of Steaks from Beef Animals Selected from Tough and Tender Animal Genotypes: Genetic Meat Quality Traits Can Be Detected by Consumers. Foods 2021, 10, 1911. https://doi.org/10.3390/foods10081911*)

Pillar 5 Meat and health

The role of meat in the diet has come under scrutiny recently due to an increased public emphasis on providing healthy diets from sustainable food systems and due to health concerns relating to the consumption of red and processed meat. The MTI review aimed to summarise the scientific evidence relating to meat consumption, actual meat intakes and the contribution of meat to energy and nutrient intakes of children, teenagers and adults in Europe. The available literature has shown that food-based dietary guidelines for most countries recommend consuming lean meat in moderation and many recommend limiting red and processed meat consumption.
(Cocking et al., 2020. The role of meat in the European diet: current state of knowledge on dietary recommendations, intakes and contribution to energy and nutrient intakes and status, Nutrition Research Reviews, 33, 181–189).

- 'Unprocessed beef and lamb' is a nutrient dense food group which contributes significantly to the dietary intakes of a number of important macro- and micro- nutrients in Irish school-aged children, teenagers and adults (including young women and elderly) but contributes relatively small proportions of total fat, saturated fat and sodium. Higher consumption of unprocessed beef and lamb was not associated with increased coronary heart disease risk through raised blood pressure or increased cholesterol levels in Irish adults, including nutritionally vulnerable groups such as older adults and women of child-bearing age.
- Overall, fresh beef contributes nutritionally significant amounts of macro- and micro-nutrients to the diets of young children living in Ireland. The contribution of fresh beef versus processed meats to nutrient intakes varies considerably in young children.

Of note, among consumers, almost one-quarter of sodium was supplied by processed meats compared with less than 10% by fresh beef. Inappropriate reporting of meat as an aggregated food group, including all sources of meat under the same umbrella, obscures the relative benefits and risks from consuming fresh beef versus processed meats. Targeted messaging is warranted to emphasise the valuable, and often overlooked, contribution that fresh beef, eaten in moderate amounts, can make to nutrient intakes among young children.

(Lyons et al., 2020. Proceedings of the Nutrition Society, 79 (OCE2), E453)

- Irish beef contains four nutritionally relevant vitamin D-related compounds - vitamin D_3, vitamin D_2 and the associated 25-hydroxyvitamin D_3 and 25-hydroxyvitamin D_2 metabolites. Two of these compounds (vitamin D_2 and the 25-hydroxyvitamin D_2 metabolite) are not typically captured in food compositional databases to-date. Their inclusion in the calculation of total vitamin D content for beef is a truer reflection of its potential vitamin D supply.
- Seasonal variation in all four of these vitamin D-related compounds (lowest in late-winter/early-spring, highest in late-summer/early-autumn) was evident in Irish striploin beef steak. This emphasises the need for pragmatic strategies to maintain overall vitamin D content of beef at peak levels all year-round potentially enabling a 'source of vitamin D' nutrient claim in Europe.
- Overall, these new analytical data highlights how Irish beef is an important contributory food source of vitamin D in the diet. Irish beef together with other red meats likely contribute about a fifth to the daily vitamin D intake by Irish adults, a fact under-appreciated by many.

  (Cashman et al., 2020. Contribution of Vitamin D2 and D3 and Their Respective 25-Hydroxy Metabolites to the Total Vitamin D Content of Beef and Lamb. Curr Dev Nutr.;4 (7):nzaa112. doi: 10.1093/cdn/nzaa112).

Pillar 6 New Opportunities (Circular bio-economy)

Everyday operations in the red meat industry generate large quantities of offal and meat co-products. These traditionally were not valued as highly as prime cuts of meat, and can represent a threat to the environment if not disposed of or processed properly. In this way, they can represent a cost rather than a potential income stream. A requirement to sustainably feed a growing global population, and to find renewable bio-based alternatives to fossil-derived food, feed, materials and energy, provide new valorisation opportunities for such biomass. A systematic literature review was undertaken to identify such opportunities, considering edible and inedible offal and co-products as raw materials, with 23 review papers and 94 full research papers available for analysis. Results highlighted the large variety of potential products that can be produced from meat co-products and offal, including applications in food and human nutrition, pharmaceuticals, biomedical, oleo-chemical, animal feed, pet-food and fertilizer. Capitalising on these opportunities is likely to require demonstration and industrial-scale development, and changes to operational as well as current business practices within the industry. However, the creation of a circular bio-economy model with positive economic, environmental, and social impacts will increasingly be required to enable the industry to address challenges relating to sustainability.

(Shirsath and Henchion, 2021. Bovine and ovine meat co-products valorisation opportunities: A systematic literature review, Trends in Food Science Technology 118 (2021) 57-70).

Beef provenance: authentication of the dietary background and geographical origin of beef

Aidan Moloney[1], Olaf Schmidt[2] and Frank Monahan[2]

[1]Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath
[2]University College Dublin, School of Agriculture and Food Science, Dublin 4, Ireland

Summary

- Beef products may have a particular value associated with their geographical origin or the production system from which they derive.
- This value may be captured by the use of labels such as protected geographical indication (PGI), "(Irish) grass-fed" or "organic".
- Methods to authenticate and protect these labels based on the chemical composition of beef are being evaluated.
- Recent research shows that rapid, non-destructive spectroscopic methods have potential as authentication tools.
- For beef produced in geographically-close regions and/or from similar feedstuff rations, it is likely that a combination of methods will be required to produce a robust authentication signature.

Introduction

Pasture-based beef systems have come to be regarded by some consumers as more environmentally and animal welfare friendly alternatives to intensive/feedlot systems of production. There is also growing interest by consumers in the origin, safety, healthiness and quality of their food. Animal products labelled as "grass-based", can command a price premium but authentication methods are required to validate the system of production and make it less likely that counterfeit products are fraudulently sold under such labels. Traceability has been defined as "the ability to follow the movement of a food through specified stages of production, processing and distribution". Thus, traceability requires a record of the various steps in the journey of a food from its site of production to consumption and "each link requires keeping records of preceding and succeeding links". Because traceability systems depend on the maintenance of records, paper- or computer-based, they are open to error. Authentication, defined as "the process by which a food is verified as complying with its label description", is therefore necessary to support traceability systems and to prove beyond doubt that a particular food product is as is stated on the product label. This paper summarises recent and on-going research on authentication methodologies to underpin such an "authenticity based traceability system" for Irish beef from grass-based production systems.

Strategies to authenticate beef have focussed on the measurement of components that are directly influenced by the diet consumed by animals and therefore can provide information about their dietary background. Some of these "markers" can also be useful for assignment of geographical origin if, for example, specific feedstuffs are associated within a particular geographical region or are influenced by regional climatic conditions or underlying geology. A 'fingerprint' approach can also be used whereby spectroscopic techniques are used to determine differences in the optical properties of foods derived from different production systems. In either approach, statistical procedures, often termed 'chemometrics', must be applied to the data collected to allow discrimination or classification of beef samples.

Authentication based on the chemical composition of beef

Stable isotope ratio analysis: Stable isotope ratio analysis (SIRA) involves the measurement of ratios of stable isotopes of bioelements, frequently including carbon ($^{13}C/^{12}C$), nitrogen ($^{15}N/^{14}N$), hydrogen ($^{2}H/^{1}H$), oxygen ($^{18}O/^{16}O$) and sulphur ($^{34}S/^{32}S$). It is well established that the stable isotope composition of bioelements in animal tissue is influenced by the composition of the diet consumed. Therefore, stable isotope signatures obtained from an animals' tissues can provide useful information about the diet consumed by that animal. For example, beef from cattle consuming a predominantly C_3 (temperate grass silage) diet was clearly distinguishable from that of animals consuming a predominantly C_4 (maize silage) diet (Figure 1).

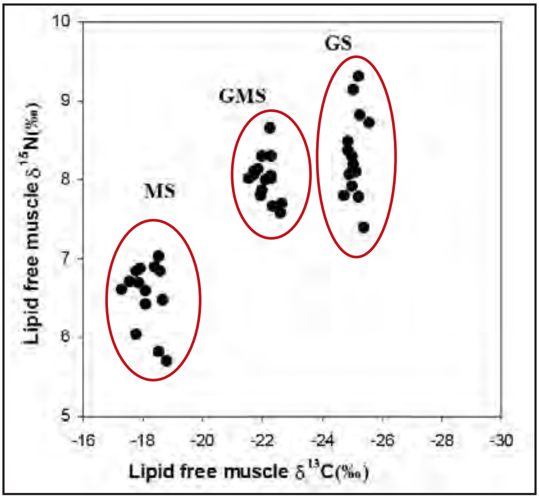


Figure 1. Discrimination of beef from cattle fed maize silage (MS), a blend of MS and grass silage (GMS) or grass silage (GS) based on carbon and nitrogen stable isotopes.

In addition, while not direct indicators of geographical origin, $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios can be useful in indirectly determining geographical provenance if a particular feedstuff is typically fed in a particular region or if analysed in combination with other stable isotopes such as hydrogen and oxygen isotopes. Using stable isotope data ($\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) we investigated the feasibility of discriminating Irish grass-fed beef from beef obtained from six other European countries, the US and Brazil. Beef from the US and Brazil formed one cluster, beef from central Europe another, and Irish and UK beef tended to cluster together reflecting the similar beef production practises in these two countries (Figure 2).

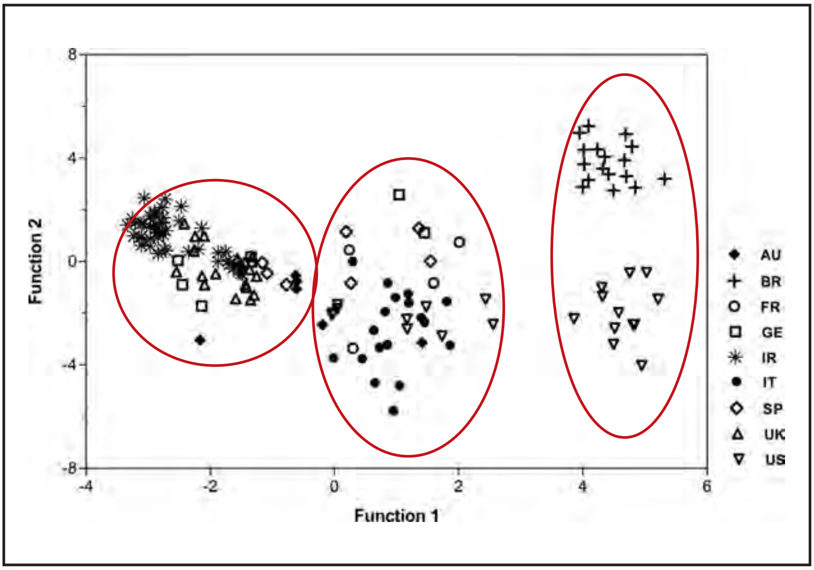


Figure 2. Discrimination of beef from cattle from different countries based on carbon, nitrogen, hydrogen and sulphur stable isotopes

.*Fatty acid profile:* There are clear differences in the fatty acid profile of beef from cattle that consumed a concentrate-based or grass-based diet. We sought to discriminate, using fatty acid analysis, between beef from animals raised on grass, grass silage followed by grass, a barley-based concentrate or on a grass/concentrate combination (Figure 3). The discrimination model we developed, permitted differentiation between the four dietary treatments with a correct classification of 92.6 %. The miss-classified samples related to beef from animals raised on pasture for 12 months prior to slaughter being classified as beef from animals fed grass silage for 6 months followed by grass at pasture for 6 months. Effectively, however, both groups could be considered grass-fed, since grass silage is ensiled grass; pooling these groups together gave 100 % correct classification of beef according to diet.

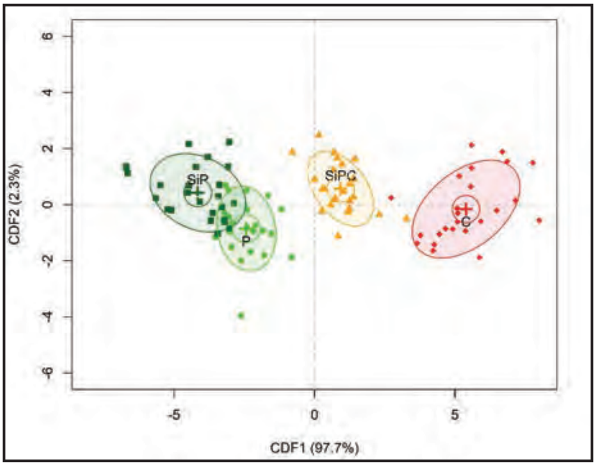


Figure 3. Discrimination of beef from cattle offered grass (P), grass silage followed by grass (SiP), grass silage followed by grass and concentrates (SiPC) or concentrates (C), based on the fatty acid profile.

Other chemical constituents: The relationship between the diet of animals and the concentration of other constituents such as carotenoids, vitamin E, trace elements and volatile compounds in beef, and their potential as authentication tools, is under investigation at present.

Rapid methods of authentication

Measurement of the chemical composition of beef is time-consuming and costly. The potential of spectroscopic methods which are rapid and non-destructive is being evaluated. Preliminary data using one method, near infrared spectroscopy (NIRS), is shown in Figure 4. Samples from grass forage-fed heifers were clearly separated from samples from heifers fed concentrate-based rations. There was some evidence that NIRS could distinguish between heifers fed grass-only or grass silage supplemented with concentrates before slaughter. Developments in NIRS and other spectral technologies such as Raman spectroscopy and hyperspectral imaging will likely result in additional authenticating tools in the future.

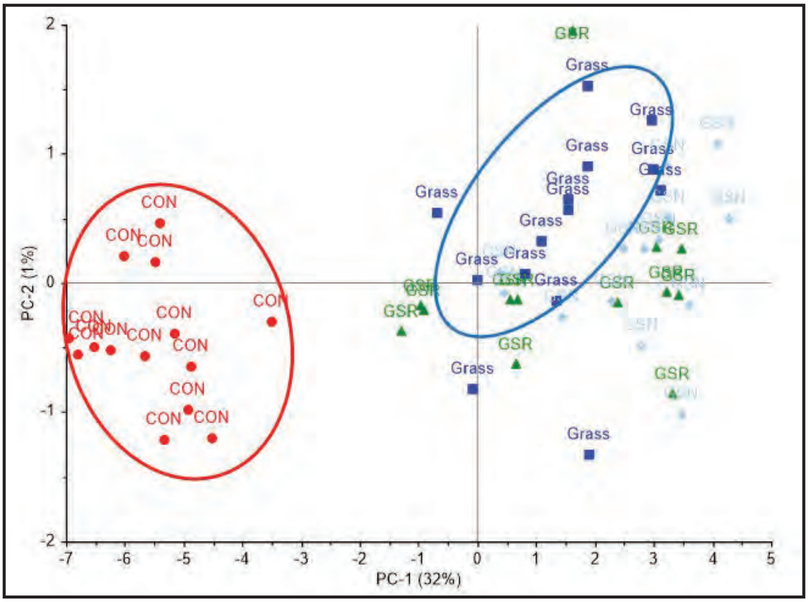


Figure 4. Discrimination of beef from cattle offered grass, grass silage and concentrates (GSR and GSN) or concentrates (C), based on the NIRS spectrum.

Conclusions

Much progress has been made in recent years in advancing our capabilities in the area of food authentication. Development of robust signatures of beef provenance is likely to involve the use of multiple methodologies and advanced chemometric techniques. These signatures could then become a reference database for routine application of rapid methods.

Acknowledgements

The above information has been generated within projects supported by Teagasc and the Department of Agriculture, Food and the Marine Competitive Research Programmes (06/R&D/D/481, Biomarkers), (13/F/514, BeefSig), (11/S/122, Flavoromics). The assistance of Kepak Group in the BeefSig project is gratefully acknowledged.

Sustainable Beef and Lamb Assurance Scheme (SBLAS)

Michael Houlihan

Bord Bia, Ballsbridge, Dublin 4

Summary

- Bord Bia Quality Assurance Schemes have all been developed in response to the demands of the marketplace.
- The *Sustainable Beef & Lamb Assurance Scheme (SBLAS)* is accredited under ISO 17065.
- A full independent audit of each member is carried out to evaluate compliance with the SBLAS standard at least every 18 months.
- A team of 100 farm-auditors undertake approximately 700 independent farm audits each week.
- Each farm audit undergoes a full review from at least three different people prior to certification within the scheme.
- The scheme includes a closeout model which means participants have the opportunity to address any issue identified during the audit and remain certified for a period of time until the issues are addressed. The time allowed to address non-conformance(s) is one month.
- The Bord Bia helpdesk (01 524 0410) can assist farmers prepare for their audits and advise on non-conformances raised during an audit.

Introduction

Bord Bia Quality Assurance Schemes have all been developed in response to the demands of the marketplace. Purchasers of Irish dairy, beef and lamb products have need for proof that our produce is produced sustainably, on farms that are certified members of an accredited quality assurance scheme. In other words Ireland's customers require it. We in the Irish food and drink industry need to put our best foot forward in order to gain access to higher value markets. Irish beef retails in over seventy of the major food retailers across Europe and it is a product that retains premium shelf space. The regard that Irish food is held in internationally is due to huge commitment by farmers to best farming and sustainability practices and participation in quality assurance schemes. With over 53,400 Beef and Lamb certified members, Irish farmers have realized the importance of quality assurance schemes to the agricultural sector.

The primary objectives of our Quality Assurance Schemes are:

- To set out the best practices in production at farm level.
- To provide a uniform way of recording and monitoring quality assurance criteria on the farm with a view to achieving continuous improvement in production standards.

- To provide a means of demonstrating best practice at farm level to international customers.
- To underpin the successful marketing of our quality assured beef, lamb and dairy produce.

Origin Green and SBLAS

Origin Green is Ireland's food and drink sustainability programme. It is a voluntary programme, led by Bord Bia, that brings together our food industry – from farmers to food producers, retailers and foodservice operators – with the common goal of sustainable food production. This programme enables Ireland's food industry to set and achieve measurable sustainability targets that respect the environment and serve local communities more effectively. Crucially, Origin Green is about measuring and improving how we do this on an ongoing basis. Origin Green members include farmers and food businesses such as food and beverage manufacturers, retailers and foodservice operators.

The *Sustainable Beef and Lamb Assurance Scheme (SBLAS)* is accredited under ISO 17065. A team of 100 farm-auditors undertake approximately 700 independent farm audits each week. Each farm audit undergoes a full review from at least three different people prior to certification within the scheme. The scheme includes a closeout model which means participants have the opportunity to address any issue identified during the audit and remain certified for a period of time until the issues are addressed. The time allowed to address non-conformance(s) is one month. The Bord Bia helpdesk (01 524 0410) can assist farmers prepare for their audits and advise on non-conformances raised during an audit.

Through the SBLAS audits, auditors gather information in relation to the sustainability practices in place on SBLAS/Origin Green farms every 18 months. As a result, Ireland's agri-food industry delivers proof of sustainability from the ground up and is rooted in an outdoor-reared, grass based system. Any farmer who is certified under Bord Bia Quality Assurance Schemes is automatically a verified member of the Origin Green programme.

How do I apply?

Membership of Bord Bia quality assurance schemes is voluntary and open to all dairy, beef and lamb producers who have a valid herd/flock number. To apply for membership, farmers can contact the Bord Bia service office on 062 54900**.** Once the application is registered on the Bord Bia system, farmers will receive a start-up pack in the post which contains a copy of the SBLAS standard as well as a record book that you can opt to fill out and keep up-to-date. If you are already keeping your farm records up-to-date using another system, this is totally acceptable provided all the required information is recorded. If this is the case there is no need to use the record book provided by Bord Bia as we do not expect records to be duplicated for the purpose of scheme membership. Following the processing of the application, Bord Bia will assign an auditor. A farm visit will be conducted by an independent auditor on every member's farm at 18-month intervals and audits are arranged following discussion between the auditor and farmer, at a day and time that suits the farmer.

What is expected of my farm at audit time?

The purpose of the visit is to audit the farm against the quality assurance criteria set out in the SBLAS standard. These criteria cover areas such as, traceability of animals; medicines purchased and used; feed; farm health and safety; animal welfare and management practices; housing and handling facilities. A lot of the requirements for the Bord Bia Quality Assurance schemes are required by the Department of Agriculture for cross compliance so the SBLAS audit is a good preparation for these type of inspections. Like the cross compliance inspection for the Department, the 'paperwork' is very important but nothing for a farmer to feel overly burdened by or anxious over. The auditor is not looking to catch-out the farmer and most farms that have records up-to-date, are clean and tidy and using best practices usually pass the farm audit easily. The visual inspection of the facilities and animals is done relatively quickly as the auditors are well-trained to spot anything that is out of place. The farm.bordbia.ie website has preparation checklists which are a useful guide for farmers preparing for the audit. If the farmer can tick all items on the checklist off before the audit then there is a good chance that the audit will run smoothly with no major issues.

Compliance Criteria

There are 154 criteria in total in the SBLAS, including 9 critical criteria. For a farm to be eligible for certification into the scheme, the member must be in full compliance with all criteria.

These compliance criteria cover the following topics:

- Records
- Stockmanship, capability and competence
- Identification and traceability
- Animal remedies and related equipment
- Animal feeds and water
- Land management
- Specified management tasks: bovines
- Specified management tasks: ovines
- Animal health and welfare
- Biosecurity and pest control
- Housing
- Transport
- Environment
- Farm personnel: health, safety and social sustainability
- Pesticides (plant protection products and biocides)

Additional Sustainability Criteria

Within the SBLAS Standard, there are additional sustainability criteria for which information is gathered through the sustainability survey. The survey is completed as part of every audit and is used to assess the sustainability performance of the farm and generate feedback report for farmers. Bord Bia has recently made improvements to the Sustainability Survey to reflect changes in practices and adoption of new technologies on farm. For example, additional options will be included for fertilizer usage including four different types of protected urea. The overall ease-of-use of the survey has also been improved. The survey must be completed before your audit using the online portal farm.bordbia.ie. Alternatively, you can contact the Bord Bia Helpdesk on (01) 524 0410 (Monday to Friday, 9am to 8pm) and they will assist you. Completing the survey takes approximately 30 minutes Feedback is given around implementing measures to address these criteria which will improve the farm's sustainability performance.

This essential on-farm data collection is repeated every 18 months and covers the following areas:

Part 1: Housing and turnout	Part 8: Soil and fertilization
Part 2: Manure management	Part 9: Pesticides and herbicides
Part 3: Feeding	Part 10: Biodiversity
Part 4: Silage (beef & dairy)	Part 11: Economic sustainability
Part 5: Sheep data	Part 12: Social sustainability
Part 6: Water use	Part 13: Energy
Part 7: Fertiliser (beef & dairy)	

Farmer Feedback Report

The Farmer Feedback Report is generated for every farm following the completion of an SBLAS audit. The data collected as part of the audit process is combined with other sources such as AIMS and ICBF to report back to the farmer on the environmental performance of the farm. For example, the carbon footprint for each farm is calculated using the accredited Bord Bia Carbon Footprint Model and a comparison is made with the farm's previous assessment and typical values for farms within the same system type. A similar structure is followed under headings such as General Farm Performance, Greenhouse Gas Emissions, Nutrient Management, Soil and Grassland Management, Grass Fed Compliance and Farm Health and Safety.

This report broadens the focus of feedback provided to farmers and brings attention to parts of the farm operation where scope exists to improve efficiency and environmental sustainability performance. The Farmer Feedback reports are primarily focussed on promoting the most current Teagasc MACC measure advice to achieve emission reductions and other sustainability targets. These include the following aspects (this is a non-exhaustive list):

- Extended grazing season
- Improved genetic merit (Eurostar)
- Improved nitrogen efficiency
- Improved live weight gains
- Improved calving rate
- Switching to protected urea

The purpose of the report is to demonstrate to farmers how their farm inputs and activities contribute to Greenhouse Gas (GHG) production and it contains advice and feedback on how to mitigate against these emissions and improve production efficiencies. This advice and feedback has been formulated in collaboration with Teagasc and focuses on targets as identified in the Teagasc MACC document. Farmers are encouraged to work with their farm advisor to make improvements across as many areas as possible.

Tight European supplies underpin demand for Irish beef

Mark Zieg

Bord Bia, Ballsbridge, Dublin 4.

Summary

- Demand for beef remains strong across our markets, driven by a supply scarcity which has been particularly evident in Europe.
- The foodservice sector has experienced a strong recovery since early in the year and this has driven demand for beef, especially manufacturing beef used in burgers and mince.
- Beef price has steadily increased in all European beef markets in the last 12 months as supplies have tightened.
- Overall EU beef production will be down by around 1%, while global supplies will only show a marginal increase of 1%.
- Estimates suggest that Irish slaughterings in 2022 will increase by around 110,000 head on 2021, but may deviate from this depending on producer decisions around increased input costs.
- The main concern around beef price is the effect of inflation on beef consumption; as consumer prices have increased, retail sales volumes have begun to decline.

Beef prices in Ireland – 2022 vs. 2021

The average R3 steer price reported by DAFM in the first week of May was just short of the €5 mark, at €4.97/kg. In the corresponding week in 2021 the R3 steer price was €4.11/kg. For the year-to-date the Irish R3 steer price has averaged €4.59/kg against an average of €4.05/kg in 2021 and €3.63/kg in 2019.

Beef prices in the EU

Beef prices in the EU have also experienced a positive uplift with average male prices throughout the EU up 35% on last years' levels. Beef supplies are tight across most European markets and prices for R3 young bulls have increased to an average of €5.15/kg. However, there are significant variations across some of the major producing countries with prices in Germany at €5.56/kg, Spain at €4.97/kg, France at €5.09/kg and Italy at €4.30 /kg (excluding VAT) for the week ended 8 May 2022. The German young-bull price has fallen back 63 c from its highpoint of €5.99/kg reached at the end of March. The prime export benchmark price reached €5.08/kg last week, compared to an average value of €3.99/kg the full year 2021.

Cattle slaughter numbers in Ireland - 2022 vs. 2021

A total of 638,771 cattle have been processed during 2022 to date, an increase of 72,664 head from the corresponding period in 2021 (+13%). This increase in throughput has been driven by an additional 39,421 prime cattle (+7%) and a strong increase in the cow kill by 25,104 head (+22%).

The latest available cattle population statistics indicate an increase in the number of slaughter age cattle on Irish farms. In March 2022, cattle in the age range 18-24 months were 5,488 or 1% higher than a year earlier, while cattle in the age range 24-30 months were 35,972 head higher, representing a 13% increase.

Overall, production of finished cattle is predicted to increase by 108,000 head for the year or +6%. This reflects the strong kill to-date and the expectation that farmers will continue to cull higher numbers of cattle through the late summer and autumn**.** However, decisions made at individual farm level to counteract the sharp inflation in production costs will ultimately determine the finished cattle production figure. This may see a progression in the trend-to-date of additional cow slaughterings particularly in late summer through to autumn. There is also the prospect of prime cattle being killed younger and lighter than previous years.

Market Outlook

Cattle supplies in our markets will recover to some extent but overall beef supplies will remain well balanced. Overall the EU Commission forecasts a further decline in cattle production of -1% (after a 0.5% decline in 2021). This is borne out by the predictions from many of the main beef producers in Europe where declines are forecast: beef production in Sweden is predicted to fall by 4.3%, in Spain by 3.9%, Italian beef production to fall by 2.3%, French by 1.4%, and German by just 0.2%. These figures will fluctuate depending on individual producer decisions in terms of culling to mitigate rising production costs.

In the UK supplies also forecast to increase marginally (+1%). Meanwhile, in terms of the global picture the USDA predicts an overall production increase of 1% in supplies worldwide, while beef consumption and import demand are both forecast to increase by +0.5%.

Import demand is strongly driven by demand from China where imports are continuing the growth-trend of the last five years, to increase by 6% in 2022. Similar import demand growth is also predicted for other Asian markets like Japan and South Korea, while import demand in the US is also predicted to grow by 2.7%.

Consumer demand

Although cattle production figures indicate good demand for beef imports, there are also a number of challenges on the beef consumption front. Accelerating inflation across Europe has had a visible effect on retail beef sales. European inflation rates in March ranged between 6% in Sweden, to as high as 11.9% in the Netherlands. This leads to real challenges for consumers such as 23% of UK consumers reporting difficulty in paying bills (WARC 2022) and a 6% reduction in products In Irish retail being sold on promotion (ESM 2022).

In Britain, *Kantar* beef retail sales figures to 17 April indicate consumer price rises of 6.2% and corresponding sales volume declines of 13.8%, resulting in a decrease in spend of 8.5%. In Germany and France, equivalent retail figures for January to February showed sales declines of 17 and 12%, respectively.

Bord Bia's *Meat Shopper Insights* tracker looks at the issues driving consumer demand and the results for quarter 1 of 2022 have shown decreases in consideration of beef for the

weekly shop of 4% in Britain, 6% in Germany and 7% in Italy over last year. 'Expensiveness' is becoming more prominent as the reason for this change. In the foodservice channel the strong recovery continues creating unprecedented demand, while high prices have seen some transitioning from steaks toward burgers.
The duration and scope of impact of the Ukraine war will play a large role in determining production costs, consumer spending power and as a result the consumption and demand for beef in the rest of 2022 and early 2023.

Bord Bia's beef market development strategy

Our strategic priorities for beef for 2019-2023 are set out to:

1. Grow the share of Irish beef exported to priority markets. These are the markets that consistently offer the greatest prospects for growing export volumes, while returning the highest prices.
2. Form partnerships with key customers globally, who are committed to Irish beef and offer further volume and value growth opportunities
3. Differentiate Irish beef through robust and verifiable proof points. This utilizes our unrivalled *Sustainable Beef and Lamb Assurance Scheme* (*SBLAS*) (see page 250) and *Origin Green* architecture to deliver proof points for sustainability, nutrition and welfare across a range of criteria in order to build a stronger competitive positioning for Irish beef.
4. Grow awareness and preference for Irish beef in priority markets. This builds a unique differentiated position for Irish beef with our trade customers and their consumers to drive a long-term preference and deliver higher prices.

The above priorities have provided the essential transparent and verifiable proofs that have advanced our promotion of Irish beef with key customers in selected markets that deliver a premium back through the supply chain to Irish beef farmers.
The Bord Bia verified grass-fed standard also relies on the capability and reach onto over 51,000 quality-assured farms and enables a world-first in terms of authenticating for consumers Irish beef raised from a grass-based pastoral system. The *SBLAS* equally allows us to report favourably on the performance of Irish farmers in reducing the carbon footprint of Irish beef, which is equally unique at this scale globally and a huge focus for our priority customers. These aforementioned proofs, combined with the reputation underlined by our *Chefs Irish Beef Club* members have allowed us to get a PGI application for *Irish Grass Fed Beef* approved in principle with the EU Commission. We hope to get the approval process finalised over the next few months. Irish suckler beef has been trialled in the German market and we are working with selected suppliers and customers for a wider market launch in premium channels in the German market later in the year. Over the last year we have performed in-market taste-tests in Britain, the Netherlands, Sweden and Japan, with results showing a strong appreciation for the differentiated eating experience that Irish grass-fed beef delivers. This, underlined by our strong performance in awards such as the *World Steak Challenge* and the endorsements provided by the premium chefs in the *Chefs Irish Beef Club*, will enable us to reach our strategic goals of placing Irish beef as a verified industry leading premium product across our main markets.

Technology Village

ADVISORY, EDUCATION & POLICY

The economic performance of cattle farms in Ireland

Jason Loughrey[1], Fiona Thorne[2] and Anne Kinsella[1]

[1] Teagasc, Rural Economy and Development Programme, Mellows Campus, Athenry, Co. Galway
[2] Teagasc, Rural Economy and Development Programme, Ashtown, Dublin 15

Summary

Farm incomes remain under pressure despite rising output prices:

- The Russian Federation invasion of Ukraine has led to much sharper increases in input prices (including feed, fertilizer and fuel) above those forecasted in December 2021.
- The average gross margin for cattle finishing enterprises is forecasted to be similar in 2022 relative to 2021. However, rising overhead costs are forecasted to lead to a fall in farm income.
- The average gross margin for single suckling enterprises is forecasted to be lower in 2022 relative to 2021 despite rising weanling prices.

Introduction

The profitability of cattle farms in Ireland is low with farm subsidies accounting for the majority of farm income. In the following, we use Teagasc National Farm Survey (NFS) data to describe recent trends in farm income and margins.

Farm income for beef systems

Family Farm Income represents the return to family farm labour, capital and land and is the principal measure of farm income used in the Teagasc National Farm Survey. In calculating farm income statistics, we distinguish between two main cattle systems i.e. 'Cattle Rearing' and 'Cattle Other'. Cattle Rearing systems include farms where the main activity is suckler cow farming and there are approximately 26,000 farms in this system. Cattle Other systems comprise farms involved in the purchase of cattle (various ages) and the sale of store cattle in the marts or finished cattle to beef processing factories with approximately 28,000 farms in this system. Some farms in Cattle Other systems maintain a sheep or crop enterprise in addition to their main cattle enterprise.

In 2020, the average Family Farm Income was €9,043 and €15,023 per farm for Cattle Rearing and Cattle Other systems, respectively. During 2021, a number of specialist cattle finishing farms are likely to have experienced modest increases in Family Farm Income but no significant changes are estimated for other cattle, or indeed Cattle Rearing farms. For 2022, forecasting the outlook is difficult given the level of uncertainly in production costs and cattle prices (both live and carcass). The revised Teagasc economic outlook for cattle farming (published in April https://www.teagasc.ie/publications/2022/situation-and-outlook-for-irish-agriculture---april-2022.php) forecast a 25% decline in Family Farm Income for Cattle Rearing farms and a 16% decline for Cattle Other farms. DAFM have introduced a new Fodder Scheme involving a maximum payment of €1,000 per farm and this, together with other measures introduced to counteract rising prices (e.g. scheme to support establishment of multi-species swards), may offset some of the forecasted decline in Family Farm Income. However, the overall effect will depend on the rate of adoption to these schemes and the costs incurred in participating.

Single Suckling

Single Suckling enterprises are the predominant cattle enterprise in Ireland, operated on over 31,000 farms. The NFS includes herds of greater than 10 non-dairy cows. In most years, the total costs per cow exceeded the total output per cow (Figure 1). The total output is mainly comprised of weanling and store cattle sales with the inclusion of coupled payments such as the Beef Environmental Efficiency Programme (BEEP-S) and the Beef Data Genomics Programme (BDGP). Total costs include direct costs to the enterprise and a proportion of overhead costs to the farm. The method for allocating overhead costs is based on the share of farm output attributed to the various enterprises on the farm.

Figure 1 shows that farmers in this enterprise kept direct costs relatively stable from 2012 to 2020 albeit with some difficulties in 2013 and 2018 due to fodder crises. However, costs have risen dramatically in 2022. Average direct costs per cow are forecast to increase from €630 in 2020 to €932 in 2022, an increase of 48% in two years. These direct costs include concentrate feed, fertilizer, contractor costs and veterinary costs. Overhead costs have increased to a lesser extent in 2021 and 2022.

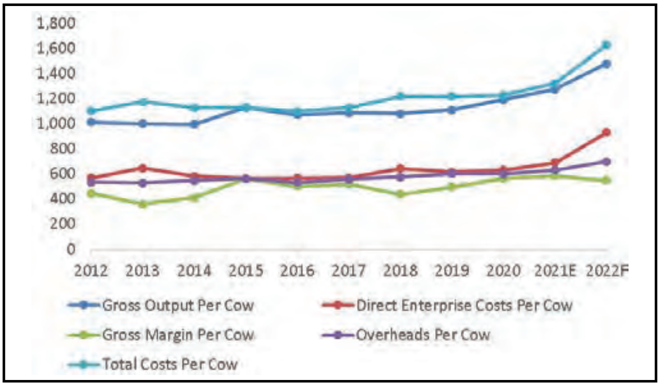


Figure 1. Average economic performance (€ per cow) on Single Suckling enterprises, 2012-2022. Source: Teagasc National Farm Survey 2012-2020, Author's estimate 2021 and Author's forecast for 2022

On the output side, there have been steady improvements since 2018 with rising mart prices for weanlings and store cattle and the introduction of the BEEP-S scheme. Based on results from the Teagasc NFS survey, the average gross output per cow is 26% higher in 2020 relative to 2012. A 16% increase is forecasted for 2022, albeit with significant uncertainty around mart prices in the second half of the year. For individual farm businesses, the timing of cattle marketing will be particularly important in 2022.

Cattle Finishing

An enterprise is defined as Cattle Finishing when over 70% of the animals are sold for slaughter. The data presented are for enterprises with more than 10 Livestock Units (LU) with approximately 12,800 farms nationally represented in this analysis.

In most years, the total costs exceed the total output on Cattle Finishing enterprises (Figure 2). Cattle Finishing enterprises managed to keep direct costs relatively stable between 2012 and 2020, but dramatic increases are evident in 2022. Overhead costs increased steadily from 2012 to 2020 with additional increases estimated for 2021 and forecast for 2022. The average gross margin per LU is forecasted to be similar in 2022 relative to 2021 and 2020. However, the increase in overhead costs may lead to a decline in the net margin per LU. The direction of the change in margin in 2022 is likely to vary according to the initial profitability of the enterprise. Cattle finishing farms with a lower ratio of inputs to outputs relative to the average cattle farm are more likely to maintain their margins and incomes at 2021 levels. However, this is contingent on beef prices remaining at current levels or increasing over the remainder of the year.

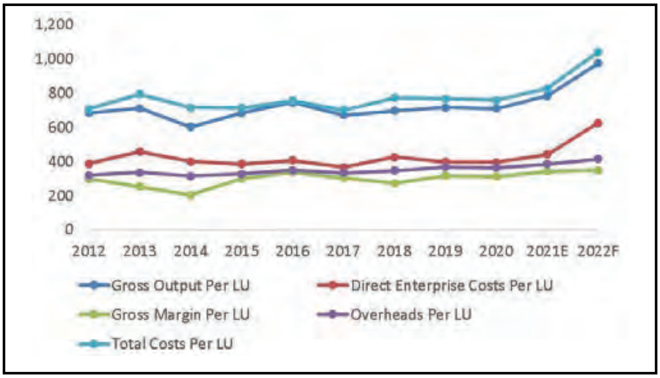


Figure 2. Average economic performance (€ per Livestock Unit, LU) on Cattle Finishing enterprises, 2012-2022. Source: Teagasc National Farm Survey, Author's estimate for 2021 and Author's forecast for 2022

Impact from Russia invasion of Ukraine

Ukraine is a major grains and oilseeds exporter and Russia also has a significant presence in these export markets. The prospect of a reduced supply of grains and oilseeds on world markets led to a sharp rise in international grain and oilseed prices in the first half of 2022 with consequent increases in concentrate feed prices. Large increases in fertilizer prices had already been forecast in late 2021; however, the rate of inflation in both energy and fertilizer prices increased dramatically following the Russian Federation's invasion of Ukraine. Up to that point, the increase in fertilizer prices was largely due to rising demand as economies emerged from COVID-19 restrictions.

The price of finished cattle had increased prior to the invasion of Ukraine. The average factory price in mid-February 2022 for an R3 steer was €4.67 per kg (inc. VAT), 8% higher than the average reported for this category in 2021. This had risen to €5.42 per kg (inc. VAT) in May, 25% higher than the average price in 2021. In May, cull cow prices were 27% higher relative to the annual average for 2021. In terms of mart prices, there is strong price growth for forward store cattle but less significant increases for weanlings. Based on DAFM meat market reports for April and May, it appears that calf prices are down significantly in 2022 relative to 2021.

Beef price fluctuations are usually explained by the demand for beef in key export destinations and the supply of beef in competing beef producing countries, with some influence from the domestic supply situation. A decline in EU beef production appears responsible for a proportion of the increase in Irish beef prices. Demand for beef remains strong in key export markets. Data from the Freightos organisation points to substantial increases in freight costs which tend to increase the cost of beef imports to the EU, thereby favouring domestic production. However, beef price increases of 20-25% cannot be attributed entirely to freight costs and the supply/demand situation for beef. Production costs have increased sharply and the Russian Federation's invasion of Ukraine has been a major factor in accelerating input prices and production costs. In their most recent quarterly beef report, Rabobank conclude that 'a number of the cost increases will be permanent and will need to be accommodated within the supply chain'. This accommodation may already be happening in the second quarter of 2022.

Supply and demand conditions appear capable of keeping output prices elevated. Strong milk prices incentivize EU dairy farmers to limit cow disposals further reducing beef output. Global tightness in beef availability will support exports from Europe. Beef demand remains strong at an EU level. Retail demand for Irish beef has increased in UK markets. One possible risk is that high input prices could incentivise cattle farmers in the EU to deliver additional slaughterings due to the burden of additional feed costs.

Conclusion

Teagasc NFS data shows that total inputs exceeded total outputs on the average cattle enterprise over the past decade. However, there have been notable improvements between 2018 and 2021 in the gross margin per cow earned on the suckler farm enterprise. On both Single Suckling and Cattle Finishing enterprises, the increase in direct costs in 2022 vastly exceed those observed in previous years. Cattle Finishing enterprises are forecast to maintain a similar gross margin in 2022 relative to 2021. However, the increase in overheads may lead to a decline in farm income. Both gross and net margins are forecast to decline on Single Suckling enterprises despite the assumption of rising mart prices for weanlings and stores in the second half of the year.

In terms of the situation and outlook, a significant part of the recent increase in output prices can be attributed to the decline in beef supply at the EU level and the continued strong demand for beef in key exporting countries (including the EU). However, these factors do not fully explain output price developments. The additional cost pressures associated with the Russian Federation invasion of Ukraine have led market analysts and supply chain participants to believe that additional costs are long-term.

Acknowledgements

The authors gratefully acknowledge the contributions of Brian Moran, John Lennon and the Teagasc National Farm Survey recorders in collecting and validating the Teagasc National Farm Survey data. The authors are grateful to the farmers for participating in the Teagasc National Farm Survey.

The economic competitiveness of cattle farms in Ireland

Fiona Thorne[1], Anne Kinsella[2] and Jason Loughrey[2]

[1]*Teagasc, Rural Economy and Development Programme, Ashtown, Dublin 15*
[2]*Teagasc, Rural Economy and Development Programme, Mellows Campus, Athenry, Co. Galway*

Summary

- Irish beef farms have a competitive advantage within Europe based on cash costs of production.
- Cattle finishing farms in Ireland tend to have lower cash costs of production relative to the U.S. or Canada, higher than Brazil and similar to Argentina.
- Ireland compares favourably to other main global cattle producing countries in terms of the number of weaned calves per 100 cows (weaning percentage).

Introduction

How do beef farms in Ireland compare with farms in other countries in terms of output price, costs of production and profit margin? The competitive position of Irish agriculture and the determinants of this competitiveness continues to be critical in framing public policy that seeks to maximise the contribution of the agri-food sector to the Irish economy. Hence, the objective of on-going research by Teagasc is to measure the competitiveness of Irish beef production in the context of our major competitors in the international market. In measuring competitiveness, it is important to consider both the costs of production and the returns from production.

Data analysis was confined to the specialist cattle farms as defined by the EC Farm Accountancy Data Network (FADN). The competitive position of Irish farms was compared against all farms within the FADN dataset, and the EU-28 average, based on data from 2019. A number of cost and return based indicators of competitiveness were examined for beef systems: costs as a percentage of output, margin over costs per hectare and margin over costs per LU. Overall, these results for beef rearing and fattening enterprises show that, for the latest available data from FADN, Irish producers had a competitive advantage when cash costs were examined compared to the other European countries examined, with cash costs as a percent of output below the EU average.
Based on the main beef producers within Europe, namely, France, Germany, UK and Ireland, the cash cost to output ratio (including coupled and decoupled payments) was lowest in Ireland (67%) and highest in UK (78%). However, it is important to note that when total economic costs were considered Ireland's competitive position worsens.
The above analysis is concerned with a comparison between EU-28 countries in 2019 and therefore includes the United Kingdom.

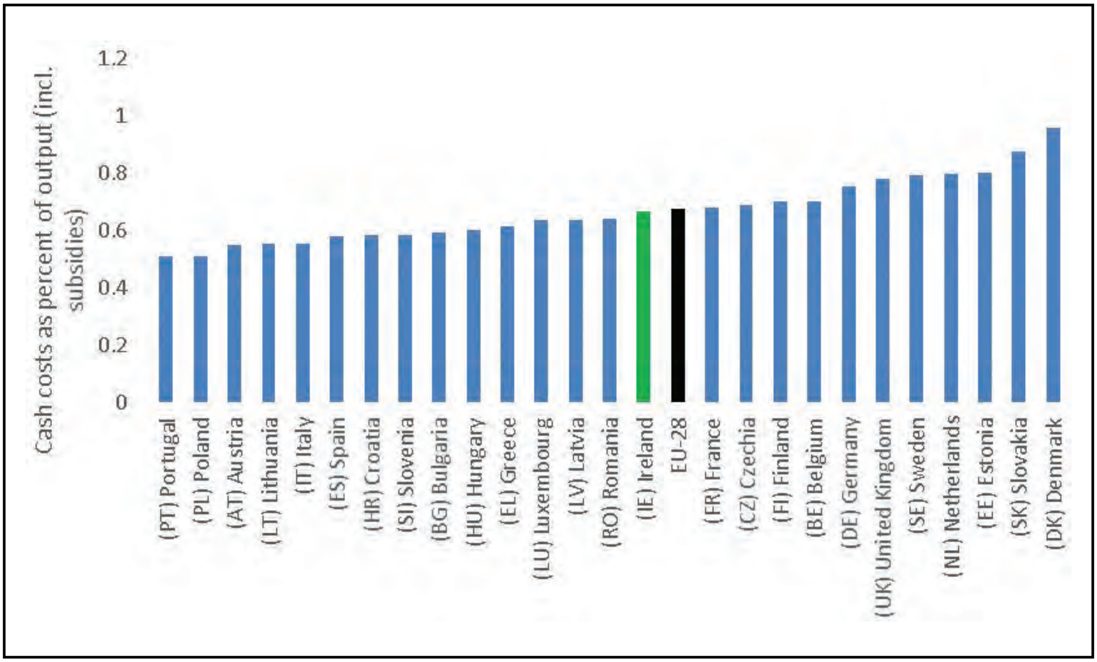


Figure 1. Costs as a % of total output (incl. subsidies) for European specialist cattle farms, 2019. Source: Author's estimate based on EC FADN data, 2019.

Agri Benchmark

Agri Benchmark is a global, non-profit network of agricultural economists, advisors, producers and specialists in key sectors of agricultural and horticultural value chains. This network uses internationally standardised methods to analyse farms, production systems and their profitability. Teagasc is a key and long-standing partner in this global network and is the Agri Benchmark representative for Ireland. Agri Benchmark maintains a global farm data set based on internationally standardised farm analysis methods.

Agri Benchmark not only provides relevant information to policy makers, but to national governments and to partners, to allow them to strengthen their position in a global agricultural economy. The rich database facilitates the in-depth analysis of the impact of changing economic, technological and political framework conditions on farming operations, farm structures and on agricultural production.

Powerful tools have been developed and refined for worldwide analysis of agricultural systems, and in the comparison of typical farms, their production costs and competitiveness, while also including additional analysis of climate change mitigation strategies and sustainable production systems. Agri benchmark is recognised by national and international organisations as a source of reliable information on agriculture through joint projects.

Agri Benchmark competiveness findings

Agri Benchmark findings point out that the costs of production in Ireland compare well with other EU countries. In addition, the Agri Benchmark analysis shows that, on a per 100 kg carcass weight basis, cash costs on cattle finishing farms tend to be lower in Ireland relative to the U.S. or Canada, higher than in the case of Brazil and similar to Argentina.

Cow-calf results

The number of calves weaned annually per 100 cows (weaning percentage), by country, as an average of the farms are illustrated in Figure 2. Weaning percentages vary from 50 to almost 100%, mainly depending on natural conditions. The lowest weaning percentages are linked to low-input grazing systems, for example in some regions of Brazil and in the Northern Territory of Australia. European systems tend to have higher performance with weaning percentages increasing with the use of 'winter-barn' systems and the extent of supplementary feed. These systems show weaning percentages of more than 80%.

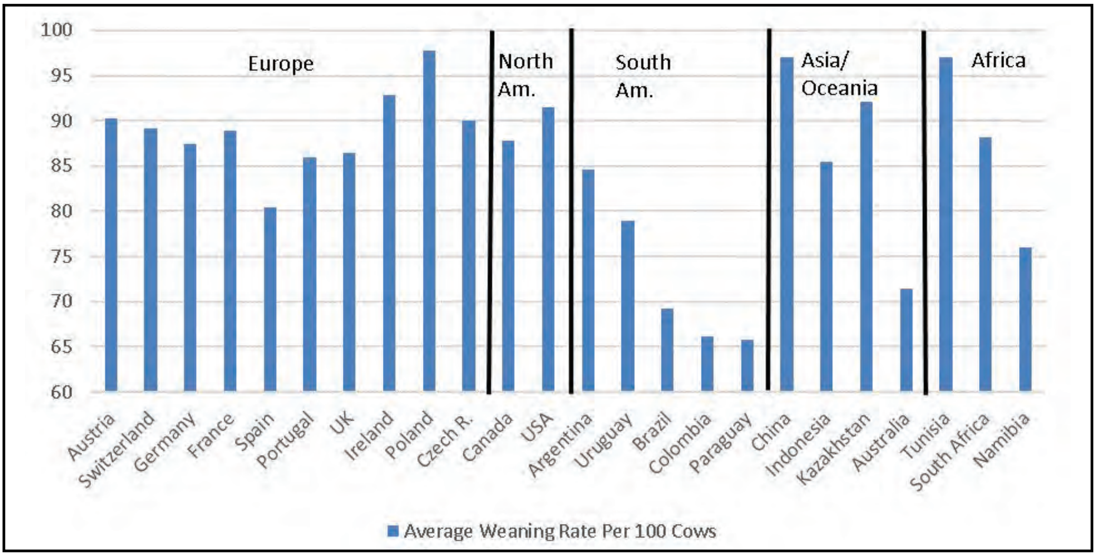


Figure 2. Number of calves weaned annually per 100 cows (data pertains to 2020)

Conclusion

Irish producers have a competitive advantage in terms of cash costs when compared with other European countries, with cash costs as a percentage of output below the EU average. This is an important consideration at a time of rapidly rising input prices internationally. The recent upswing in both output and input prices is likely to favour the most competitive cattle farms within Ireland. At an international level, maintaining cost competitiveness (relative to other key exporting countries) will assist cattle producers in Ireland to benefit from rising output prices.

Acknowledgement

The authors gratefully acknowledge the provision of Teagasc National Farm Survey staff and participating farmers in provision, collecting and validating data. The authors are also grateful for access to FADN and Agri Benchmark data.

Teagasc education and training - pathways for the land-based sector

Brian Morrissey, Carmel Finlay and Tara Fitzsimons

Teagasc, Curriculum Development & Standards Unit, Grange, Dunsany, Co. Meath

Summary

- Teagasc provides a range of education and training pathways to suit the differing needs of farm families and the wider agri-food industry.
- Teagasc Further Education courses are suitable for people who wish to develop a career in agriculture, horticulture, equine or forestry.
- All learners entering fulltime education at agricultural colleges complete a two-year programme.
- A "Green Cert" is an educational award that qualifies the holder as a "trained farmer" for the purposes of DAFM (Department of Agriculture, Food and the Marine www.dafm.ie) schemes.
- Teagasc Education Officers run part-time and distance education courses from Teagasc offices throughout the country.
- Teagasc agricultural and horticultural colleges and Teagasc partner/private colleges hold college open days each autumn and spring for potential applicants and their families.

Introduction

Education and training is a key consideration for all farmers given that it will improve the overall technical and financial efficiency of a farm. Teagasc is the primary provider of accredited further (vocational) education for the land-based sector, and provides progression routes to other educational programmes. Teagasc has a major input into higher education and post-graduate education delivery through its extensive partnership with the higher education sector. This means that Teagasc education and training enable progression from Level 5 through to Level 10 on the National Framework of Qualifications. Teagasc also has a substantial involvement in providing short courses and continuous professional development across the land-based and food sectors. It is important to select the most suitable educational programme, whether for full-time, part-time or distance education courses or continued professional development.

Teagasc Education has an un-matched advantage because we are part of an integrated research, advisory, and education organisation. Teagasc courses are delivered at 7 colleges, with 1,100 hectares of farmland, 1,000 dairy cows, 300 suckler cows, 1,400 ewes, and 100 hectares or more in crop or biomass production. Teagasc also has partnerships with Institutes of Technology and universities; links to 1,500 land sector hosts; and access to 87 benchmark farms. Teagasc is committed to supporting all students, including those with disabilities or specific learning difficulties within their learning environment. Teagasc education and training is developed, delivered, and assessed with built-in quality assurance and all courses are validated by Quality and Qualifications Ireland (QQI).

Planning your education pathway - 5 steps

There are 5 steps you can follow when planning your education pathway.

1. *Identify your education and training requirements*
2. *Review which courses would meet these needs*
3. *Consider your long term career plan*
4. *Decide on the course or courses you want to take*
5. *Talk to Teagasc staff*

You can do a lot more research on your education pathway on the Teagasc public website (www.teagasc.ie/education), and you can apply for most Teagasc courses through the online application system you will find there.

Quality Assurance

Our courses are developed to take account of the needs of the industry as determined by the Education Forum, a long-standing stakeholder group that Teagasc convenes. We operate a Quality Assurance process for delivery and assessment, external course authentication and regular Whole College evaluation. Teagasc provide a learner handbook to students, learner support when required, and a student assistance programme. And we take into account the learner experience through our student satisfaction and graduate feedback surveys.

Further Education Courses

These courses are suitable for people who wish to develop a career in agriculture, horticulture, equine or forestry. Further education training programmes are focused on practical skills training in addition to theory-based learning. Many graduates of further education courses in agriculture return to farming either in a full-time or part-time capacity.
Teagasc offer the following QQI Accredited Level 5 and Level 6 courses:

QQI Level 5 Certificate Courses

Certificate in Agriculture
Certificate in Horticulture
Certificate in Horsemanship
Certificate in Forestry

QQI Level 6 Advanced Certificate Courses

Specific Purpose Certificate in Farming (Teagasc "Green Cert")
Advanced Certificate in Agriculture (Dairy Herd Management)
Advanced Certificate in Agriculture (Drystock Management)
Advanced Certificate in Agriculture (Agricultural Mechanisation)
Advanced Certificate in Agriculture (Crops & Machinery Management)
Advanced Certificate in Horsemanship
Advanced Certificate in Equine Breeding (Stud Management)
Advanced Certificate in Forestry
Advanced Certificate in Pig Management
Advanced Certificate in Poultry Management

Full Time Agriculture Education

All learners entering fulltime education at agricultural colleges complete a two-year programme. This allows students to gain both knowledge and practical skills in a wide variety of subject matter encompassing both Level 5 and Level 6 course work and practical learning periods, while also allowing them to specialise in their preferred farm enterprise. Options include Dairy Herd Management, Drystock Production, Crops & Machinery*, Agricultural Mechanisation*, Pigs*, or Poultry *.

**Note: these courses may not be offered every year*

What is a "Green Cert" award?

A "Green Cert" is an educational award that qualifies the holder as a "trained farmer" for the purposes of DAFM (Department of Agriculture, Food and the Marine www.dafm.ie) schemes. Being the holder of a "Green Cert" is also one of the Revenue conditions of stamp duty exemption on the transfer of land (www.revenue.ie). Teagasc provides full-time, part-time, and distance education and training towards many land-based educational awards in agriculture, horticulture, forestry, equine and other subjects. Teagasc offers the Distance Education Green Cert for Non-Agricultural Award Holders and the Part-Time Green Cert courses.

QQI Level 6 Specific Purpose Certificate in Farming "Green Cert"

The QQI Level 6 Specific Purpose Certificate in Farming is commonly known as the Teagasc Green Cert. Participants first complete the QQI Level 5 Certificate in Agriculture in order to gain entry to the QQI Level 6 Specific Purpose Certificate in Farming. There are 2 modes of delivery available for completion of this Green Cert programme:

1. Part-time: duration 2.5-to-3 years approximately in an agricultural college or local Teagasc training centre
2. Distance Education*: duration 18-to-20 months approximately in an agricultural college or local Teagasc training centre

**Note: Only holders of major awards at Level 6 or higher on the NFQ in a non-agricultural discipline are eligible to apply for the Distance Education option.*

Higher Education Courses

Higher Education courses are suitable for people who wish to gain a qualification at higher level in the land-based sector. Courses are available in universities and a number of Institutes of Technology. Graduates of higher level programmes may return to farming while others will develop careers in the agricultural services sector. Recruitment to these courses is through the CAO system. There are progression routes from further education into higher education courses.

Teagasc Professional Diploma in Dairy Farm Management

The Teagasc Professional Diploma in Dairy Farm Management is aimed at those intending to manage a commercial dairy farm as an owner, partner or employed manager. The course consists of two years professional work experience on approved commercial dairy farms, while attending block release periods at Kildalton College and Moorepark Agricultural & Grassland Research and Innovation Centre. Applicants to the PDDFM programme must possess a Level 6 Advanced Certificate in Agriculture or an equivalent agricultural award. Course fees are currently €990 per annum. Students are paid at least minimum wage by host farms, which is currently €10.50 per hour worked.

Education addressing the climate challenge

Teagasc Education is integrating measures to address the climate change challenge across its activities. For example, college farms are participating in the Signpost Farms programme; we have dedicated Sustainable Farming in the Environment modules at level 6 with sustainability to the forefront of all husbandry modules; and we use climate-smart technologies and methods in teaching and learning, for example, Low Emission Slurry Spreading, Protected Urea, Biodiversity (planting hedgerows, coppicing/laying), genetics, energy audits, multi species swards. These kind of measures are also used in the management of college farms, for both livestock and tillage enterprises.

Life Long Learning and Continuing Education

While QQI Level 5 and Level 6 courses are a foundation for learning, farmers need to continually improve knowledge and skills. As with any career, it is very important to keep up-to-date with new developments or advances in technology and Teagasc facilitate a range of means of achieving this:

- Formal Training through Teagasc ConnectEd for accredited short courses such as Best Practice in Milking Routine, Managing Ruminant Animal and Managing Crop Nutrition and Health and Safety.
- Informal Training through Teagasc Evolve for non-accredited by attending discussion group meetings, open days, conferences.

Walsh Scholarship programme

The Knowledge Transfer Walsh Scholarship Programme is designed to equip participants with the skills and knowledge to be effective in building the capacity of farmers to adopt new practices and technologies. Students complete a knowledge transfer-focused research project during their scholarship with Teagasc, while studying for a higher degree. For more information, visit www.teagasc.ie

Locations, information, open days

Teagasc Education Officers run part-time and distance education courses from Teagasc offices throughout the country. For more details, visit your local Teagasc office or log on to www.teagasc.ie/education/local-education-centres/

Teagasc agricultural and horticultural colleges and Teagasc partner/private colleges hold college open days each autumn and spring for potential applicants and their families. Further information can be obtained from the college of your choice or by visiting www.teagasc.ie/education

College of Amenity Horticulture, Botanic Gardens	john.mulhern@teagasc.ie
Gurteen Agricultural College	jparry@gurteencollege.ie
Ballyhaise Agricultural College	john.kelly@teagasc.ie
Kildalton Agricultural & Horticultural College	tim.ashmore@teagasc.ie
Mountbellew Agricultural College	edna.curley@mountbellewagri.com
Clonakilty Agricultural College	keith.kennedy@teagasc.ie
Pallaskenry Agricultural College	derek.odonoghue@pallaskenry.com

Technology Village

FARMING LIFESTYLE

Best practice for health and safety on beef farms

John McNamara [1], Francis Bligh[2] and MJ Kelly[3]

[1] *Teagasc, Health and Safety Specialist, Kildalton, Co Kilkenny.*
[2] *Teagasc, Health and Safety Specialist, Abbey Street, Roscommon.*
[3] *Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath.*

Summary

- Farm accidents and ill health cause tragedy, suffering and long-term disability. They can also jeopardise a person's capacity to farm effectively and hence jeopardise farm income. Therefore, it is in everyone's best interest to give practical safety and health management adequate attention.
- In 2021, ten fatal accidents occurred associated with farming, one with 'forestry and logging' and one due to farm construction. An estimated 2,800 serious accidents take place each year.
- Farmers have been identified as an occupational group who have a high level of ill health. Research suggests that farmers need to give more attention to their health, including having a regular medical check-up with their GP.
- Considerable grant aid support for farm safety improvements is currently available through the Targeted Agricultural Modernisation Scheme (TAMS11). Beef farmers need to consider how to make optimum use of this scheme.
- Farmers need to comply with the legal requirements for agricultural vehicles and trailers used in public roads, and with the Sustainable Use of Pesticides Directive.

Introduction

Farming is one of the most dangerous work sectors in Ireland. Typically, about 20 workplace deaths occur in the agriculture sector annually. In 2020, 20 farm deaths occurred, accounting for 37% of all workplace deaths. In 2021, the number of farm deaths reduced to 10 with one in 'forestry and logging' and one due to farm construction. In 2022, five deaths were reported up to early-June. Childhood deaths are particularly tragic and in recent years, there has been a significant increase in the occurrence of these fatalities. Farm accidents causing serious injury occur at the high level of 2,800 per year. Drystock farms account for 17% of total accidents. An accident can lead to a permanent disability and interfere with a person's capacity to farm effectively. Farmers as an occupational group have been identified with having high levels of preventable ill health. Ill health effects quality of life and a person's capacity to farm effectively. More awareness of health promotion practices are needed among the farming community.

Legal duty to complete a Risk Assessment

All workplaces, including farms have a legal duty under Safety, Health and Welfare at Work (SHWW) legislation to conduct a risk assessment to ensure that work is carried out safely.

The 'green covered' Risk Assessment Document is available to accompany the Farm Safety Code of Practice. It is a legal requirement to complete this updated document annually and when major changes occur to farming systems. The requirement to conduct a risk assessment replaced the requirement to prepare a safety statement for farms with three or less employees, which are estimated to make up about 95% of farms nationally.

Targeted Agricultural Modernisation Scheme (TAMS11).

Grant aid is available through the various TAMS Schemes up to 2022 (closing dates to be finalised). Full details of each scheme are available on the DAFM web site at *http://www.agriculture.gov.ie/farmerschemespayments/tams/*. The principle areas where funding is available include: slurry aeration and access manholes; electrical installations and lighting; livestock handling facilities, safety rails and sliding doors. It is mandatory that all applicants will have completed, within the last five years prior to the submission of their claim for payment, the half-day Farm Safety Code of Practice course (given by Teagasc or other trained persons) or the FETAC Level 6 Advanced Certificate in Agriculture (Green Cert.). The claim for payment will not be processed until evidence of completion of the course is provided. It is recommended to discuss a TAMS application before submission with an advisor, to optimise the benefit. The FBD Insurance booklet 'Build in Safety – An Advisory Booklet for Farmers', outlining how to comply with SHWW Construction Regulations, is an important reference source.

Accelerated Capital Allowance Scheme.

An Accelerated Capital Allowance programme for farm safety and disability adaptation equipment is in place. To be eligible to claim the accelerated wear and tear allowance, the qualifying equipment purchase must occur between 1 January 2021 and 31 December 2023. Currently, capital allowances are available at 12.5% per annum (p.a.) over eight years for agricultural equipment generally. This scheme allows for accelerated capital allowances of 50% per annum over two years for certain eligible equipment. This eligible equipment includes, for example, chemical storage cabinets, anti-backing gates, big-bag lifters, quick hitch mechanisms for rear and front three-point linkage to enable hitching of implements without need to descend from tractor, as well as adaptive equipment to assist farmers with disabilities. Full details of the scheme are available on the DAFM web site at *https://www.gov.ie/en/publication/4133b-farm-safety/?referrer=http://www.gov.ie /farmsafety/*

Agricultural Vehicle Standards for Public Roads

Revised standards for use of agricultural vehicles on public roads are in place. In addition to the vehicle, the standards include both trailers and attached machines. The purpose of the standards is to enhance the safety of road users. A booklet on the revised standard can be downloaded from the RSA website at:

http://www.rsa.ie/en/RSA/Your-Vehicle/Vehicle-Standards/Agricultural-Vehicles/

Key requirements of the new legislation include:

Braking: More powerful braking systems will be required for agricultural vehicles operating at speeds in excess of 40 km/h. Most of the correctly maintained tractors which have come into use in the past 30 years already meet these requirements.

Lighting and visibility: Agricultural vehicles will need to be equipped with appropriate lighting systems, flashing amber beacons and reflective markings.

Weights, dimensions and coupling: New national weight limits have been introduced. These will enable tractor and trailer combinations which are un-plated to continue in use at limits which are safe for such vehicles. Plated tractors and trailer combinations can operate at higher weight limits of up to 24 and 34 tonnes for tandem and triaxle agricultural trailers, respectively, that meet certain additional requirements.

Sustainable Use of Pesticides Directive

The purpose of the EU Sustainable Use Directive is to put a legislative system in place to ensure that farm pesticides are used responsibly, safely and effectively, while safeguarding the environment. Professional pesticide users (PU) must be registered with DAFM and have a PU Number. Famers are classified as professional pesticide users. In order to register, a farmer must have completed a training course provided by an approved training provider. A list of training agencies is provided on the DAFM web site at http://www.pcs.agriculture.gov.ie/sud/. In the event of a DAFM inspection, a farmer will be required to produce evidence of having completed appropriate training.
All boom sprayers greater than 3 m boom width must be tested. The interval between tests must not exceed five years until 2025. A list of approved sprayer testers is available on the DAFM website.

Safety of children on farms

The safety of children and young persons must be paramount on farms. The following precautions need to be considered when children are present on a farm:
- Provide a safe and secure play area for children away from all work activities. Where children are not in a secure play area a high level of adult supervision is needed.
- Children should not be allowed to access heights.
- Action should be taken to keep children away from dangerous areas such as slurry tanks. All open water tanks, wells and slurry tanks should be fenced off.
- Give children clear instruction on farm safety issues.
- Children to be carried in the tractor cab (aged 7 or older) need to wear a seat belt.

The renowned safety booklet for children 'Stay Safe with Jesse' is a key reference.

Preventing machinery accidents

Vehicle and machinery-related deaths account for 53% of all farm deaths. For vehicles, being struck (25%) is the most frequent cause of death followed by being crushed or trapped by the vehicle (24%), fall from vehicle (12%) and being pierced by a vehicle part (2%). With machinery, being crushed (23%), struck (18%) or collapse (18%) are the most frequent causes of death followed by power drive entanglement (14%). The fatal data shows that most accidents occur due to being crushed or struck, so safety vigilance is especially needed when in proximity to moving vehicles/ machines. Entanglement deaths and serious injuries are particularly gruesome and occur most frequently with machines used in a stationary position, such as a vacuum tanker or slurry agitator where contact can occur between the person and the PTO. Quads (ATV's) are useful machines on farms for travel but they have a high risk of death and serious injury if miss-used.

Preventing accidents with cattle

On Irish farms, livestock deaths make up 19% of all deaths and 42% of farm accidents. Cows or heifer accidents account for 33% of livestock-related deaths, with bulls (18%), horses (8%), bullocks and other cattle (41%) accounting for the remainder. The notable trend is that the percentage of cow/heifer incidents causing death has increased dramatically in the last decade so additional precautions with this livestock group are required. Farmers are advised to keep a bull's temperament under constant review, have a ring and chain fitted, keep a bull in view at all times and always have a means of escape or refuge. Breeding cattle for docility should always be considered.

Preventing deaths with slurry

Farm deaths associated with slurry and water account for 10% of farm deaths with the majority of these being drowning. Particular care is needed when slurry access points are open and physical guarding needs to be put in place. Slurry gases are a lethal hazard on cattle farms. Hydrogen sulphide is released when slurry is agitated and in calm weather can be present at lethal levels. The key mitigating controls are to pick a windy day for agitating, evacuate all persons and stock from housing and open all doors and outlets. A range of other gases including methane, ammonia and carbon dioxide are produced from slurry due to fermentation in semi-emptied tanks. Never enter a slurry tank as lack of oxygen or the presence of poison gases could be fatal. Also, never have an ignition source near a slurry tank due to the methane explosion risk.

Farmer health

A major Irish study has indicated that farmers in the 'working age' (16-65 years) have a 5.1 times higher 'all cause' death rate than the occupational group with the lowest rate. The major causes of elevated death rate include cardiovascular disease (CVD), cancers and injuries. A further Irish study indicated that 59% of farmers had a health check with their GP in the last year compared to 74% for the general population. Among farmers just 27% believed that they were too heavy despite 60% being classified as overweight or obese. Farmers have been shown to achieve an adequate 'number of steps' daily; however, in general, the level of moderate-to-high intensity exercise achieved, which is essential for cardiovascular health, is inadequate.

Looking after wellbeing

We can all go through low points from time-to-time times in our lives and it is not unusual to experience symptoms related to stress, anxiety and depression. In this regard, a number of national organisations that promote positive mental wellbeing, including Mental Health Ireland and Samaritans Ireland, will be present at BEEF2022. Embrace Farm, who support Farm Families after a Farm Accident will also be in attendance.

Further Information

New and current information can be downloaded at the following web sites: Teagasc: http://www.teagasc.ie/health_safety/ and H.S.A.: http://www.hsa.ie/

Notes

Notes

Notes

Notes

Notes

Notes

Notes

Notes

Notes

Notes

Notes

Contact Details:

Grange, Animal & Grassland Research and Innovation Centre,
Teagasc,
Grange,
Dunsany,
Co. Meath.

Tel: +353 (0)46 9061100
Fax: +353 (0)46 9026154

www.teagasc.ie

ISBN: 978-1-84170-678-8

teagasc
Agriculture and Food Development Authority

FBD
INSURANCE