Animal &
Grassland Research
and Innovation
Programme

Teagasc
National Beef Conference 2022

"Profitable Pathways to Sustainable Beef Farming"

Tuesday 13th December
Shearwater Hotel, Ballinasloe, Co. Galway

Teagasc
Agriculture and Food Development Authority

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Table of Contents

Programme

'Profitable Pathways to Sustainable Beef Farming'

6:00pm	**Welcome** *Pat Clarke, Teagasc Regional Manager, Galway*
6:10pm	**Opening Address** *Prof. Frank O'Mara, Teagasc Director*

'Key enablers to improving sustainability on beef farms'

Chaired by: *Trevor Boland, Teagasc FutureBeef Farmer*

6:20pm	**Assessing the potential to improve key profit drivers on beef farms** *Dr. Paul Crosson, Beef Enterprise Leader, Teagasc Grange*
6:45pm	**Abattoir lesions in cattle are associated with an increased age at slaughter** *Dr. Natascha Meunier, Programme Manager Beef HealthCheck, Animal Health Ireland*
7:10pm	**Reducing the age at first-calving for suckler heifers – a key profit driver for beef farms** *Dr. Colin Byrne, Beef Researcher, Teagasc Grange* *Shane Keaveney, FutureBeef Farmer, Co. Roscommon*
7:35pm	**Has red clover a role in your beef production system?** *Drs. Nicky Byrne & Peter Doyle, Beef Researchers, Teagasc Grange* *Martin Connolly, DairyBeef 500 Farmer, Co. Roscommon*

'Delivering sustainability at farm level'

Panel Discussion: *Facilitated by: Matt O'Keeffe, Irish Farmers Monthly*

Panel participants: *Prof. Sinead Waters, Teagasc* – **Current research and the potential of feed additives to reduce methane emissions.**
Dr. Dominika Krol, Teagasc – **Protected Urea / LESS / Anaerobic Digestion research results.**
Dr. Andrew Cromie, ICBF – **How improved breeding can help to reduce emissions from the Irish beef herd.**
Pearse Kelly, Teagasc – **What measures are Irish beef farmers taking up to make them more sustainable, and what more can they do?**

9:00pm	**Close of Conference** *Prof. Pat Dillon, Director of Research, Teagasc*

Foreword

Welcome to the 2022 Teagasc National Beef Conference. It has been three years since our last 'in-person' conference and since then the topic of sustainability has come to the fore of Irish agriculture across all sectors. The Government commitment to reduce Ireland's Greenhouse Gas (GHG) emissions by 51% by 2030 has implications for all parts of the Irish economy. The reduction target for agriculture of 25% is challenging and to achieve that target significant changes will have to take place on all farms across the country including beef farms. The papers being presented and the panel discussion later in the evening all aim to address the theme of this year's conference 'Profitable Pathways to Sustainable Beef Farming' to get a better understanding of the many technologies that can be employed on Irish beef farms that not only reduce our emissions, but also improve the profitability of our beef systems.

Irish beef farmers have consistently shown that they can adapt to the many new challenges and opportunities that they have had to face over the years. The last 12 months have been particularly challenging with significant increases in input prices. Rising fertiliser, concentrate and energy costs to a level never seen before, have put beef margins under significant pressure. These rising costs have impacted more negatively on the more intensively stocked beef farms as the rise in beef price which we have witnessed over the last 12 months has not being enough, on many farms, to compensate for the extra costs incurred. The focus now on many farms will be to examine where inputs can be reduced, while still maintaining output. There are a number of papers in our conference that look at the options open to beef farmers to do just that.

Teagasc are committed to supporting farmers and the agri-industry to play its part in reducing emissions and increasing carbon sequestration. Earlier this month we launched a number of important new initiatives, as part of the Teagasc Climate Action strategy, to further advance this goal. From early in 2023 Teagasc will be providing all farmers with a new Signpost Advisory Programme that will help them to navigate the pathway for their farm towards improved sustainability. We will also be advancing, in partnership with ICBF and Bord Bia, the development of our new unique Sustainability Digital Platform that will aid farmers in getting a better understanding of the sources of emissions on their farms, and how through the implementation of proven technologies they can reduce emissions. Teagasc has also launched a new Virtual National Centre for Agri-Food Climate Research and Innovation. This centre will focus on the development, testing and implementation of innovative technologies to facilitate farmers to combine economic and environmental sustainability.

I would like to take this opportunity to thank all of our speakers and panellists at the conference. I would also like to thank all my colleagues in Teagasc involved in putting together and organising a conference that addresses many of the different challenges and opportunities that now face the Irish beef industry. I hope each and every one of you can take something from the presentations and discussion, and that you leave with an improved understanding of the many different areas that can make your farm more profitable and environmentally sustainable into the future.

Professor Frank O'Mara, Director, Teagasc

Assessing the potential to improve key profit drivers on beef farms

Paul Crosson[1], Edward G. O'Riordan[1], Paul Cormican[1] and David Kelly[2]

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Summary

- Beef production in Ireland is based on the spring-born progeny of the suckler and dairy herds.
- Optimising live weight performance from birth-to-slaughter is a key objective and is associated with higher profitability.
- The beef farming sector has made good progress in increasing live weight performance in recent years, and related reductions in slaughter age evident for most categories of cattle, with further progress possible.
- Feeding management, good herd health status and high-merit beef genetics are important enabling factors.
- The above factors also support a second key performance indicator for suckler beef production systems; age at first-calving.
- There has been no change in age at first-calving for suckler cows in Ireland in recent years; however, a higher number of cows first-calve at between 22 and 26 months of age than at any other four-month age range indicating that progress is possible.

Introduction

Beef cattle in Ireland are predominantly from spring-calving suckler beef and dairy herds where the objective is to align calving date with the commencement of the grazing season. The aim of these spring-calving systems is to take advantage of the relatively low production cost of grazed grass when compared to grass silage and concentrate ration. This is particularly important following calving when the energy demand for suckler and dairy cows increases substantially to meet lactation requirements.

Following calving, the aim of beef cattle production systems is to optimise progeny live weight performance over the animals' lifetime while minimising the cost of feed provision. A further consideration for suckler beef systems is to optimise reproductive performance. This incorporates first-calving at close to 24-months of age, producing a calf approximately every 365 days and ensuring good suckler cow survival rates to minimise the cost of cow replacements. Age at first-calving in particular has very substantial implications for farm profitability with recent analysis indicating that delaying calving by 12 months (from 24 to 36 months of age) reduces net farm margins by approximately 75% (McGee et al., 2022).

Given the importance of these two efficiency measures to farm profitability, the objective of this article is to assess the recent trends and implications of: 1) beef progeny performance in respect of live weight gain and, 2) age at first-calving for suckler beef cows.

Live weight performance

Live weight performance is influenced by factors such as feed availability and quality, animal health and genetics. Figure 1 provides an overview of live weight performance targets for spring-born steers from the suckler and dairy herds. Grazed grass constitutes the main dietary component and, therefore, excellent grassland management skills are key; this ensures that cattle have adequate quantities of highest 'quality' pasture available at all times over a long grazing season. Enabling factors in this regard include optimising soil nutrient status to maximise pasture growth, particularly during early and late season, and grass budgeting to present pasture at the optimum stage of growth to cattle. Excessively long grass regrowth intervals, and associated very high pre-grazing pasture mass, reduces herbage digestibility and animal live weight performance. In contrast, where regrowth intervals are too low, herbage production is likely to be adversely affected. Similarly, in terms of grazing management, excessively low post-grazing sward height has a negative impact on dry matter intake and reduces growth rate of beef cattle.

Live weight performance targets during 'first' indoor winter feeding period is based on optimising compensatory growth during the subsequent grazing season. Research at Teagasc Grange has established that a live weight gain target of 0.5 to 0.6 kg/day for spring-born beef cattle over the first winter provides an economic optimum. This can typically be achieved by offering grass silage with a dry matter digestibility content (g/kg DM) of 700 to 720 g/kg DM supplemented with 1.0 to 1.5 kg (fresh weight) of concentrate feed ration. Live weight performance in excess of 1.0 kg/day is usually readily achievable in the first half of the second grazing season. Although performance is likely to decline somewhat thereafter, target average live weight performance over the full second grazing season is approximately 1.0 kg/day.

A proportion of cattle will be suitable for slaughter at the end of the 'second' grazing season. These will typically be early-maturing breed types and/or early spring-born (i.e. older) beef cattle. Most beef cattle are housed for a second winter. Where these cattle are intended for slaughter during or towards the end of the second winter at approximately 24 months of age, high-quality grass silage (DMD >720 g/kg DM) and up to 5 kg of concentrate feed ration is required. Alternatively, where cattle are returned to pasture for a 'third' grazing season, feeding practices similar to that for the first winter (grass silage of DMD 700-720 g/kg DM supplemented with 1.0 to 1.5 kg concentrate ration) will likely achieve the target live weight gain of 0.5 to 0.6 kg/day. The objective is to maximise compensatory growth during the third grazing season and to achieve target slaughter ages of 26 to 28 months of age (Figure 1).

Excellent animal and herd health status is essential to meet the desired live weight targets. Elsewhere in these proceedings, the implications of parasitic and respiratory infection on live weight performance and slaughter age are highlighted. High herd health status is underpinned by a robust biosecurity plan, prompt diagnoses and early treatment of infectious challenges and a vaccination plan appropriate to the characteristics of each farm. The latter should involve the input of the farm's veterinary practitioner.

Genetics plays a key role in animal performance across a wide range of productive and reproductive traits. In the case of live weight performance, the 'carcass weight' and 'maternal weaning weight' traits are most important. The carcass weight trait provides an indication of the expected carcass weight performance (corrected for age) of the progeny of a beef sire/dam. The maternal weaning weight (daughter milk) trait indicates the expected weaning weight performance of the progeny of a daughter from a beef sire/dam. Essentially this trait provides an indirect measure of the milk yield potential of the daughter progeny of a sire/dam. Research at Teagasc, Grange has demonstrated that cow milk yield is a major determinant of calf live weight gain pre-weaning (McGee et al., 2005).

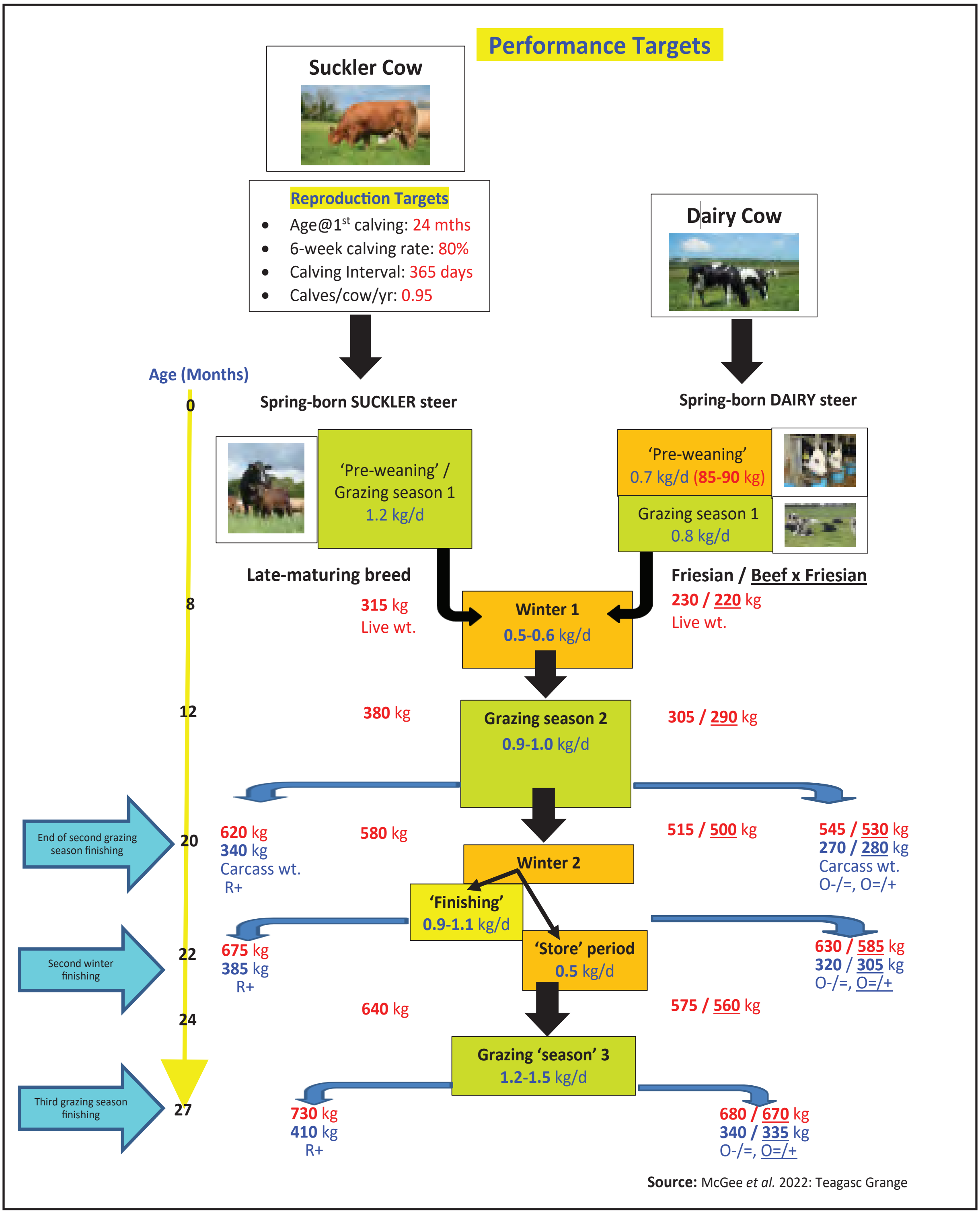

Figure 1. Live weight and carcass performance targets for spring-born grass-based suckler and dairy steer calf-to-beef production systems (Source: McGee et al. 2022).

These performance traits are encompassed within composite indexes such as the Terminal Index which farmers can use to select 'finishing' animals i.e. destined for slaughter. These composite indexes include the most important traits expressed by beef cattle and weight these according to their economic value to derive an overall economic value for breed selection decisions. In 2021, the Irish Cattle Breeding Federation (ICBF) launched the

Commercial Beef Value (CBV) which is a genetic index for non-breeding cattle and therefore focusses on production (live and carcass weight) and feed intake traits. Retrospective analysis of the dairy-beef research herd at Grange indicated that over a three-year period, five-star CBV steers had a 22 kg heavier carcass at a slightly younger age (four days) than one-star animals.

There has been steady progress in live weight performance of the national beef cattle herd in the ten-year period between 2012 and 2021 (Table 1). This is particularly apparent for suckler-bred progeny with daily live weight gain of steers, bulls and heifers increasing by 11%, 8% and 3%, respectively. This has resulted in a large reduction in time to slaughter for suckler-bred steers and bulls. In the case of suckler-bred heifers, there has been a small increase in slaughter age. This warrants further investigation. There has been no change in carcass weight for suckler-bred bulls over the ten-year period; however, carcass weight for suckler-bred heifers and steers has increased by 19 and 3 kg, respectively.

Table 1. Change in live weight, carcass weight and slaughter age for suckler-bred and dairy-bred beef cattle in Ireland between 2012 and 2021.

Live weight gain, kg/d		2012	2021	Change
Heifers	Sucker-bred	0.79	0.81	3%
	Dairy-bred	0.74	0.77	4%
Steers	Sucker-bred	0.79	0.88	11%
	Dairy-bred	0.75	0.81	9%
Young bulls	Sucker-bred	1.22	1.32	8%
	Dairy-bred	1.03	1.03	0%
Carcass weight, kg				
Heifers	Sucker-bred	321	340	6%
	Dairy-bred	283	283	0%
Steers	Sucker-bred	389	392	1%
	Dairy-bred	343	330	-4%
Young bulls	Sucker-bred	404	404	0%
	Dairy-bred	327	328	0%
Age at slaughter, months				
Heifers	Sucker-bred	25.1	25.5	+12 days
	Dairy-bred	25.2	24.1	-33 days
Steers	Sucker-bred	30	26.8	-98 days
	Dairy-bred	29.7	26.2	-107 days
Young bulls	Sucker-bred	18.9	17.3	-49 days
	Dairy-bred	20.1	20	-3 days

Daily live weight performance for dairy-bred progeny between 2012 and 2021has also shown steady improvement for steers and heifers with substantial decreases in slaughter age. There has been no change in carcass weight for dairy-bred heifers or bulls; however, carcass weight for steers has reduced by 13 kg over the ten-year period.

Although there has been progress in live weight performance in recent years, there is still scope for further improvement when considered in the context of performance achieved by the highest-performing farms. Analysis by Taylor et al. (2018) at Teagasc Grange showed that, when comparing suckler beef farms generating 'high' versus 'low' levels of profitability, progeny live weight performance was 13%, 19% and 8% greater for heifer, steer and bull progeny, respectively, for the high-profit farms. This difference was primarily attributed to differences in post-weaning performance of cattle.

Carcass fatness is the primary indicator of level of 'finish' in beef cattle with a fat score of greater than or equal to 2+ (15-point scale) required by Irish beef processors. The carcass fatness distribution for steers and heifers slaughtered in Ireland in 2021 is summarised in Figure 1. Almost half (47%) of the heifer carcasses and 25% of steer carcasses were in fat classes ≥4- implying that there was an opportunity to slaughter these animals much earlier.

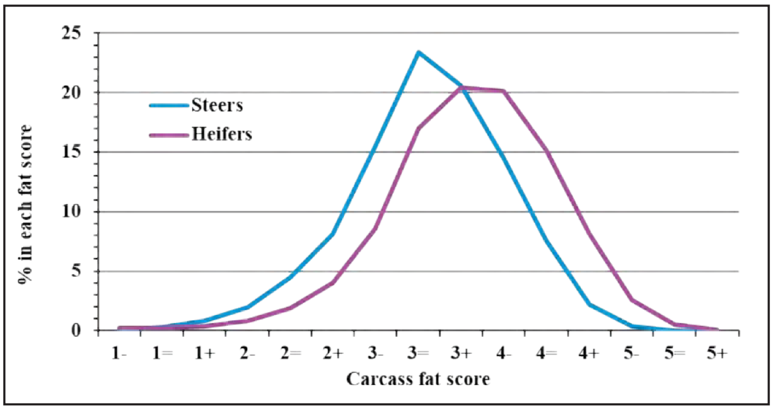

Figure 1. Distribution of carcass fat score for steers and heifers slaughtered in Ireland in 2021 (Source: O'Riordan et al., 2022).

Age at first-calving for suckler beef cows

A target age at first-calving of 24 months for suckler beef cows is important as it provides the foundation for maximum potential lifetime productivity – 'unproductive' older replacement heifers are inefficient. Analysis by ICBF has indicated that suckler cows which first calve at 24 months of age have better performance (lower subsequent calving interval and similar cull cow carcass weight) when compared with those which first calve at older ages. Analysis of Irish suckler beef farms by Taylor et al. (2017) at Teagasc Grange found that age at first-calving was positively correlated with calving interval and negatively correlated with gross output. Despite the economic cost of later calving, there has been very little change in the age at first-calving nationally over the most recent 10-year period with an average of 962 days (31.6 months) in 2012 and 951 days (31.3 months) in 2021.

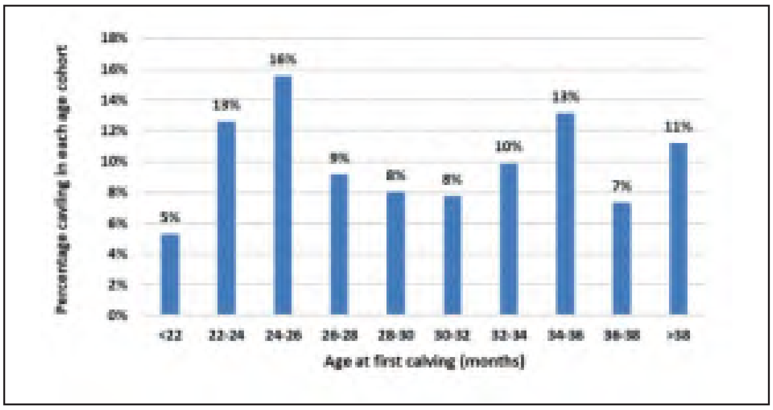

Figure 2. Distribution of age at first-calving for suckler beef cows in Ireland in 2021 (Source: ICBF).

Although this indicates that average age at first calving for sucker cows in Ireland is approximately six months greater than target, a substantial cohort (~one-third) of suckler cows first-calved in the target range of 22 to 26 months of age (Figure 2). Indeed, more cows calve in this age range than at any other four-month age range. Furthermore, these data indicate that there are two peak calving periods at about 24 and 36 months age. This is consistent with the 'seasonal' calving structure of the Irish beef herd. There is also a reasonably large cohort calving between these two age ranges, indicating that 'early'-born heifers are calving later in the same season two years hence, or alternatively autumn- (or spring-) born heifers are calving in spring (or autumn).

The main effect of reducing age at first-calving for suckler beef herds is to reduce the costs associated with rearing replacements, particularly feed costs. Enabling factors described in the previous section that improve live weight performance for beef progeny also support earlier age at first-calving; namely, feed availability and quality, plus animal health and genetics.

Conclusion

Although beef farm incomes are heavily influenced by direct support payments, technical efficiency also has a critical role to play. In the context of beef systems, the key measure in this regard is the live weight performance of beef cattle. The economic optimal live weight performance for Irish grass-based beef production systems is predicated on the relative costs of feeds whereby the objective is to achieve high levels of live weight gain over long grazing seasons. The implications of higher live weight performance is to reduce slaughter age with minimal effects on carcass weight. This results in similar output value with lower production costs (Taylor et al., 2020). Likewise, reducing age at first-calving has the effect of maintaining farm productivity (output per head) while reducing costs. A co-benefit to reducing slaughter and age at first-calving is that greenhouse gas emissions per animal and per kg of beef is reduced (Taylor et al., 2020). Thus, these measures can improve farm profitability while supporting the objective to reduce emissions from the agricultural sector.

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Abattoir lesions in cattle are associated with an increased age at slaughter

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Summary

- Poor health is widely recognised to negatively affect performance in cattle.
- Liver fluke, liver abscesses and pneumonia lung lesions were related to increased slaughter age.
- The impact of health status on slaughter age varied with animal type and farm type, but on average heifers and steers were 40-46, 8 and 12-14 days older at slaughter if liver fluke, liver abscesses and pneumonia lung lesions were present, respectively.
- The prevalence of liver fluke at slaughter has been decreasing since 2016 but it is still widespread, with 44% of herds that slaughtered cattle exhibiting liver fluke in 2022.
- Gains in animal production and subsequent reductions in greenhouse gas emissions can be achieved if animal health is improved.

Introduction

Disease in farm animals has a significant economic impact on livestock production, with the farmer typically bearing most of the direct costs relating to endemic diseases. In order for farmers to make informed investment decisions regarding interventions to prevent or control disease, it is essential that they understand firstly the level of disease and cost of disease on their farm and secondly, the trade-off between intervention costs and disease losses that can be avoided. The type of production system also needs to be taken into account when evaluating costs as it will drive not only disease processes but also husbandry practices. Subclinical losses (when an animal is not visibly ill) can have a dramatic effect on production by affecting feed conversion efficiency, mortality, fertility, reproductive performance, and milk yield of ruminants. However, due to its nature farmers might not realise these losses are even occurring. Their quantification is essential to provide farmers with a holistic view of what is happening in their farm.

Liver fluke (*Fasciola hepatica*) is a common parasite affecting the health and welfare of cattle and sheep worldwide. Adult fluke live in the liver of affected animals and produce large numbers of eggs in the bile ducts, which are subsequently excreted in the faeces. Once on the pasture, mobile larvae hatch from the eggs and infect an intermediate host, the mud snail. Larvae further develop and multiply within the snail, emerging to settle on the pasture as infectious fluke cysts. Grazing cattle are susceptible to infection when ingesting vegetation contaminated with these cysts. There is considerable global evidence that infection with the liver fluke parasite has an adverse effect on cattle production. Decreased carcase weight (Charlier et al., 2009; Sanchez-Vazquez et al., 2013) and increased days to slaughter (Mazeri et al., 2017) have been reported for beef cattle, whilst decreased milk yields (Howell et al., 2015) and increased calving interval (Charlier et al., 2007) have been reported for dairy cattle. In Ireland, a study showed that steers infected with liver fluke were likely to be 36 kg lighter at slaughter compared to those not infected (Carroll et al., 2020).

Liver abscesses in cattle are unrelated to the liver fluke described above, and while caused directly by bacteria, are usually associated with feeding a high-energy ration containing limited roughage. Cattle are particularly at risk if a concentrate ration is introduced too quickly to allow the rumen to adapt or if feeding patterns change, giving rise to an increase in acid production and acidosis. The acidosis is often subclinical and leads to liver abscesses and laminitis, which can result in reduced feed intake, weight gain and feed efficiency in cattle (Nagaraja and Lechtenberg, 2007).

Pneumonia is an inflammation of the lungs usually caused by respiratory disease which can result in changes to lung tissue which can be seen at slaughter. Respiratory disease in cattle is multi-factorial with a range of potential primary causes such as viruses, bacteria, or lungworm, and the presence of secondary stressors such as poor ventilation or weather, transport and weaning. Respiratory disease usually results in clinical signs such as difficulty breathing, coughing and nasal discharge but it can also be subclinical and go undetected. The presence of lung lesions at slaughter in beef cattle without respiratory clinical signs has been associated with a lower carcase weight (Fernandez et al., 2020). In young beef bulls, respiratory disease was shown to decrease growth performance and extend the fattening period (Bareille et al., 2008).

In the current study, using abattoir data, we aimed to quantify the unseen performance 'losses' due to liver fluke, liver abscesses and pneumonia in beef cattle by examining the average age of slaughter for animals with and without these conditions.

The Beef HealthCheck Programme

The Beef HealthCheck programme has been collecting slaughter health information from cattle across 17 Irish meat factories since 2016. The Animal Health Ireland-led programme runs in partnership with Meat Industry Ireland and the Department of Agriculture, Food and the Marine. Health information is digitally captured with each batch of cattle slaughtered at a participating factory by the veterinary inspectors working on the line and a report is made available for the farmer. This information, including all historical information since 2016, is also available on the ICBF website for farmers, advisors and veterinary practitioners to view. Farmers can access their herd, batch or individual animal data at beefhealthcheck.icbf.com after using their ICBF login details. If they have been granted access by the farmer, Teagasc advisors and vets can also access their client's herd information on ICBF. The individual animal information and interactive graphs on ICBF can help visualise trends in the health data and is a tool to help determine the liver fluke status on-farm and make health decisions.

The liver fluke information captures whether an active infection with live fluke was seen or chronic liver damage likely due to liver fluke was observed. The presence of liver abscesses and pneumonia lung lesions were also captured (Figure 1). It is apparent that the slaughter prevalence of liver fluke in young stock has been decreasing, from 17.5% in 2016 to 6.4% in 2022. Liver fluke damage has decreased from 15.1% to 5.2% and active liver fluke, (i.e. live parasites present in the liver), has decreased from 2.4% in 2016 to 1.2% this year. Liver abscesses have remained relatively stable, varying between 3.1% and 4.2%. After an initial peak at 3.3% in 2016, pneumonia lung lesions have also remained stable between 1% and 1.9%.

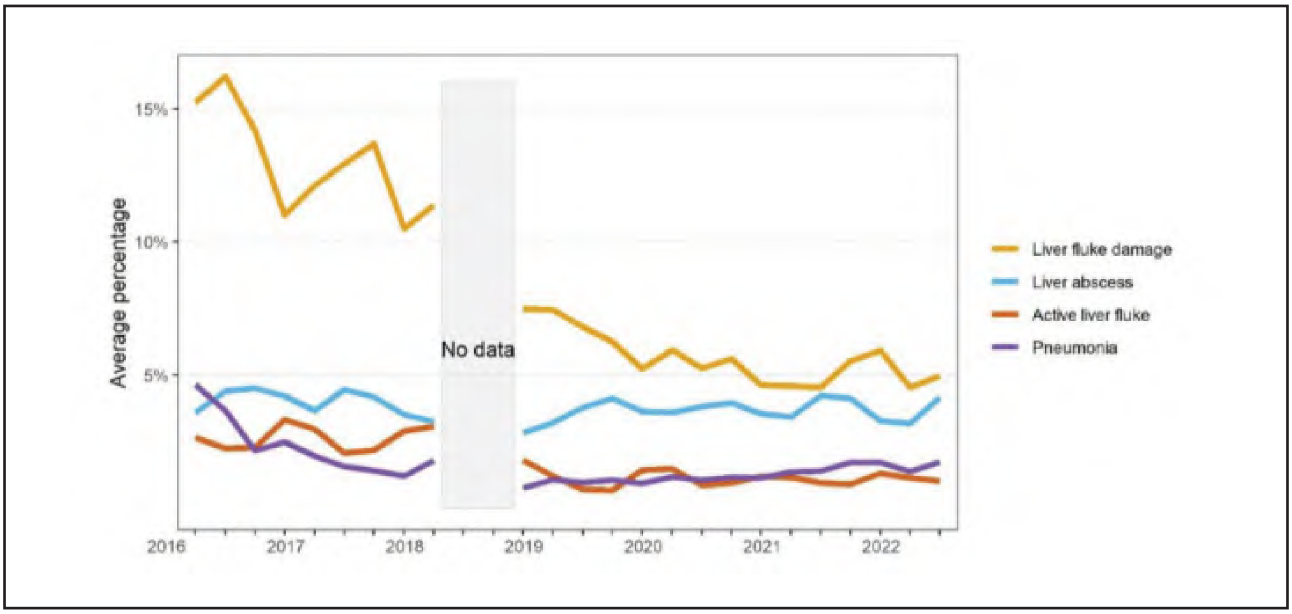

Figure 1. Percentage of health conditions seen at slaughter for heifers, steers and young bulls captured in the Beef HealthCheck programme from 2016.

[Liver fluke damage and active liver fluke (live parasites seen) are represented, as well as liver abscesses and pneumonia lung lesions. No data was captured for the second half of 2018].

The average age at slaughter for animals captured in this programme was 777 days for heifers, 831 days for steers and 579 days for young bulls (Figure 2), although this varied widely.

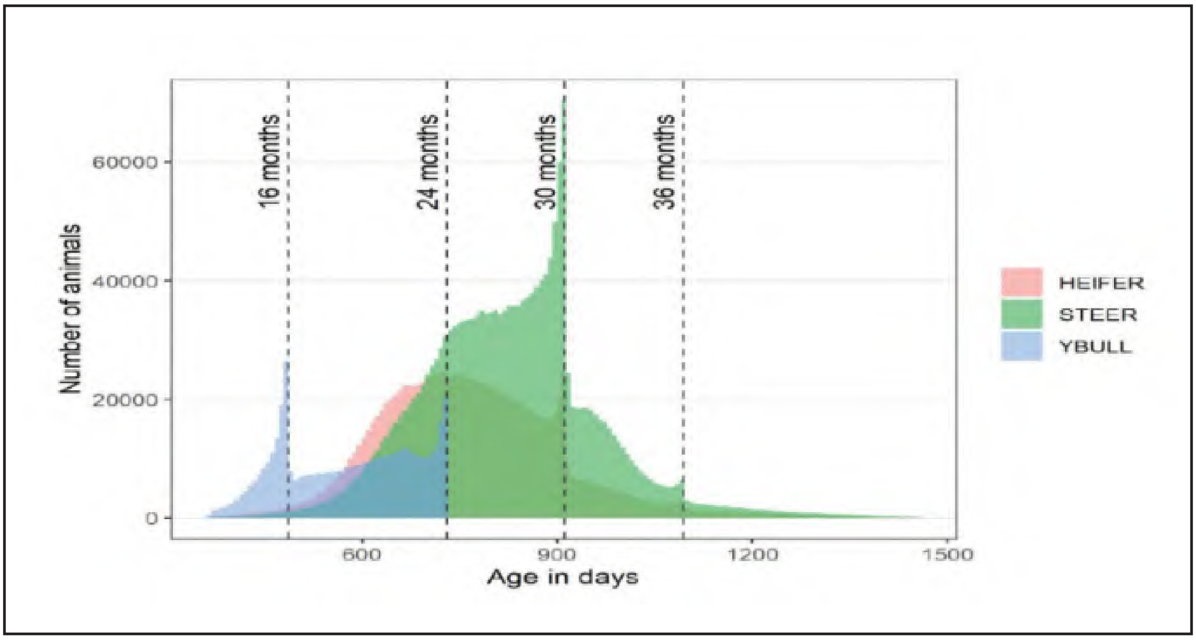

Figure 2. Slaughter age of animals in the study split into heifers, steers and young bulls, as classified by the factory.

[Note the peaks in animals slaughtered before 16 and 24 months in young bulls (YBULL), as well as 30 and 36 months of age for heifers/steers].

An analysis was conducted of all heifers, steers and young bulls slaughtered at the participating factories between 2016 and 2021. We examined the difference in slaughter age between those animals with and without health conditions present at slaughter, while taking other factors such as the region, herd type, breed type and season into account. Although there are a range of management practices between herds which influence when animals are brought to slaughter, we assumed for this analysis that reaching an acceptable size or weight would most influence a decision to slaughter unless the animal was reaching a critical target age. These critical ages can be seen as peaks in the number of animals slaughtered before 16 months (young bulls), and 30 months for steers and heifers; smaller peaks are seen at 24 months and 36 months (Figure 2).

The results of the age-analysis showed that there were large differences in slaughter age between those heifers and steers with and without liver fluke (Table 1). On average, heifers with liver fluke were 40 days older at slaughter than those without observed evidence of liver fluke, while for steers this difference was 46 days. For animals from herds that were primarily 'beef' production, i.e. non-dairy herds, this effect was slightly lower (38 days). No difference was seen in young bulls affected by liver fluke, but these animals are likely to be less chronically affected due to their younger finishing age or a reduced liver fluke burden from the shorter grazing duration used in these production systems.

The difference in slaughter age between animals with and without liver abscesses varied between 5.5 days in young bulls and 8.6 days in heifers and steers. In terms of pneumonia lung lesions, affected young bulls were 2.7 days older, and affected heifers and steers were 14.1 days and 12.4 days older, respectively, at slaughter compared to healthy animals.

Table 1. Additional days to slaughter for animals with liver fluke, liver fluke damage, active liver fluke, liver abscesses or pneumonia, compared to healthy animals[1]

Type of animals	Any sign of liver fluke	Liver fluke damage	Active liver fluke	Liver abscess	Pneumonia
Heifers					
All herds	39.8	41.8	32.6	8.6	14.1
Beef herds	38.5	43.3	18.8	9.2	11.4
Steers					
All herds	46.0	46.7	43.1	8.6	12.4
Beef herds	38.0	40.9	24.8	8.2	15.3
Young bulls					
All herds	No effect	No effect	No effect	5.5	2.7
Beef herds	No effect	No effect	No effect	5.6	3.7

[1] Data were analysed separately for heifers, steers and young bulls, and considered cattle from all herds or from beef herds only.

Liver fluke tends to be a chronic condition in cattle, although acute cases of disease can occur when there is a high rate of infection. It makes sense then that if disease is allowed to develop unchecked over time, the effect on production will be cumulative. Animals with active liver fluke showed less of an effect on days to slaughter than those that showed liver fluke damage, which is likely to be reflective of a more chronic infection. For example, on average from all herds, heifers with liver fluke damage were 9 days older than those with active liver fluke. The cumulative impact could explain why the effect on the days to slaughter for liver abscesses and pneumonia lung lesions was also more pronounced in heifers and steers, which are slaughtered later, compared to young bulls.

Conclusion

While the difference in slaughter age between those animals affected by liver fluke and their healthy herd mates appears dramatic, there are still notable differences in age for the liver abscesses and pneumonia lung lesions captured. These ‘conditions’ are by their nature chronic and probably without overt clinical signs and likely remained undetected while the animal was alive, yet still impacted on efficiency and growth rates. Although this particular study only examined three post-slaughter conditions to demonstrate the effect that ill health can have on animal performance, it also applies to varying degrees for any disease. The costs of decreased performance are often overlooked if an animal appears healthy and is not ‘directly’ costing money in the form of vet bills or treatment.

The next step is to incorporate these results into an economic farm model to quantify the financial impact of these health conditions, including the ‘hidden’ costs such as additional feed and labour. However, if a farmer simply considers the daily cost of keeping cattle, they can roughly estimate what unhealthy underperforming animals are costing in terms of additional days on farm. Additionally, it will also be important to consider the potential benefits of improving health status at farm level in terms of ‘lost’ beef production but also its contribution to greenhouse gases through reduced slaughter age.

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Reducing the age at first-calving for suckler heifers – a key profit driver for beef farms

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Summary

- Calving suckler heifers between 23 and 26 months of age is a 'win-win' measure that can be implemented on suckler farms to increase the profitability and reduce the carbon footprint of the enterprise.
- 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 weigh 380-420 kg at breeding, and 550-600 kg at calving, depending on breed type.
- 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.
- Differences of 75 and 12% in favour of reduced age at calving can be achieved in net margin per cow and carbon footprint, respectively, when calving at 24 versus 36 months of age.

Introduction

Nationally, only 24% of beef heifers calve for the first time between 23 and 26 months of age (ICBF, 2022). This is in contrast to the top 10% of commercial suckler enterprises and suckler research farms consistently and successfully calving 100% of beef heifers between 23 and 26 months of age. This means that 75% of beef heifers in Ireland are unproductive for a year longer than they should be. 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 (Crosson and McGee, 2012). This paper will discuss: (i) barriers to the adoption of reduced age at first-calving for farmers, (ii) how these barriers can be overcome if a heifer is reared correctly and (iii) the environmental and economic benefits of calving beef heifers between 23 and 26 versus 36-40 months of age.

There are many reasons that some farmers do not calve their heifers between 23 and 26 months of age. These include, apprehension that the heifer will not reach full weight potential, will be too difficult to get back in-calf, will have greater calving difficulty and will not 'last' in the herd. As with all animals, any setback due to poor health, restricted nutrition or anything else that reduces growth may negatively affect mature weight. Any negative impacts on mature weight can be prevented by high levels of technical efficiency in a suckler system. Beef cattle are not expected to reach their mature weight until approximately four years of age, depending on breed and nutrition (Stockton et al., 2012), which makes it very difficult to predict what a cow's mature weight will be when she is selected for breeding. There is no scientific evidence that calving between 23 and 26 months of age will reduce the mature weight of a cow. In fact, Irish data summarised in Table 1 from over 131,000 replacement heifers highlights that there is no significant difference in the mature weight of cows that calved for the first time at 23-26 months or 36-40 months of age.

There is a perception among farmers that heifers calved between 23 and 26 months of age are unlikely to go back in calf in their second breeding season. Again, the data in Table 1 indicate a very small difference (4%) in the proportion of heifers that calve for a second time between those that have calved at 23-26 months compared to 36-40 months of age. Heifers that calve in the first 21 days of the calving season have a 50% chance of making it past their fourth lactation compared to heifers that calve after day 21 (Cushman et al., 2013), and this will be discussed in subsequent sections. Additionally, meeting growth (> 1 kg) and weight-for-age (> 280 kg weaning, > 380 kg at breeding) targets throughout the lifetime means that a heifer will have the best chance of calving down and resuming cyclicity in a timely manner so that she will go back in-calf in her second breeding season. The same growth and weight-for-age targets are also vital for ensuring that a heifer is sufficiently grown to reduce potential calving difficulty issues. Bull selection is also critical when calving heifers between 23 and 26 months of age. Using artificial insemination (AI) on breeding heifers will give farmers the greatest choice of bulls and those with low calving difficulty and, most importantly, high reliability (i.e. greater confidence that the proportion of cows requiring assistance will not differ from the predicted calving difficulty) can be selected. Where a single stock bull is used on-farm, it is very difficult to have a 'suitable' bull for use on both mature cows and heifers; AI should be considered for use on heifers. Table 1 highlights that there is very little difference in the average calving difficulty of the bulls used on first-time calvers, and there is only a small difference (7%) in the proportion of heifers calving unassisted. Taken together these data highlight that regardless of age a similar level of assistance is needed by heifers calving for the first time.

From the data in Table 1, the benefits of calving heifers between 23 and 26 months of age on survivability is clear. Thirty-nine percent of heifers that calved between 23 and 26 months of age reached a fifth parity in contrast to 0% of heifers reaching the same milestone if they calved for the first time between 36 and 40 months of age. Increasing the lifetime productivity of a cow will also reduce her rearing and production costs, and therefore improve the profitability of the suckler system.

Table 1. Age at first-calving and lifetime suckler cow performance[1]

<table>
<tr><th>Age at first calving (months)</th><th>Average subsequent calving interval (days)</th><th>Calving for a second time (%)</th><th>Average calving difficulty of bulls used (%)</th><th>Heifers calving unassisted (%)</th><th>Heifers reaching 5th parity (%)</th><th>Mature cow weight (kg)</th></tr>
<tr><td>23-26</td><td>383</td><td>82</td><td>4.7</td><td>50</td><td>39</td><td rowspan="2">708</td></tr>
<tr><td>27-30</td><td>394</td><td>83</td><td>5.1</td><td>53</td><td>20</td></tr>
<tr><td>31-35</td><td>392</td><td>87</td><td>5.2</td><td>58</td><td>4</td><td rowspan="2">692</td></tr>
<tr><td>36-40</td><td>386</td><td>86</td><td>5.2</td><td>57</td><td>0</td></tr>
</table>

[1] Replacement heifers born in 2011 (131,077)

Source: ICBF

The importance of getting a heifer cycling before the breeding season

The most successful systems will have their maiden heifers pubertal well before the beginning of the breeding season. Heifers should have reached puberty two months prior to start of planned breeding to ensure that they have the best opportunity to conceive early in the breeding season. Ensuring heifers are pubertal prior to the breeding season has minimal impact on the ‘overall’ breeding season pregnancy rates, but if a heifer is not pubertal this significantly delays the date of first-calving (Martin et al., 2008). This is because conception rates as low as 20% to 30% are observed following breeding at the first or second heats after puberty (Larson, 2007). The average daily gain (ADG) and target live weights to increase chances of having attained puberty by 13 months of age, prior to breeding at 15 months of age, are outlined in the text below.

A multi-year analysis of 2,195 heifers from US commercial herds (Figure 1) indicates that when heifers calved in the first 21 days of their first breeding season 20% more made it to their fifth parity compared to those that calved after 21 days in their first-calving season (Mousel, et al., 2012). Having heifers calve early in the calving season means that there is a greater period between calving and their second breeding season meaning that, as a first-calver, the cow has more time to recover and return to cyclicity before breeding commences. This allows farmers to maintain a more compact calving pattern and reduce the percentage of cows culled as empty from the herd.

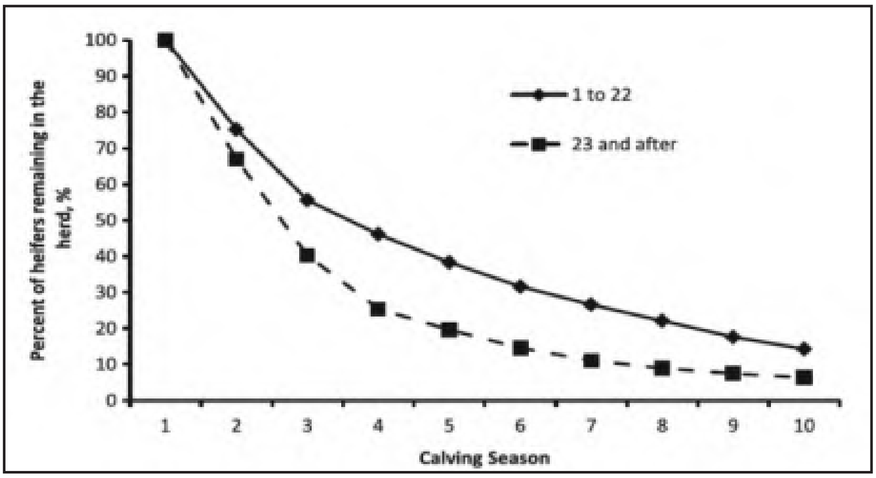

Figure 1. Timing, within first-calving season, is an important factor influencing the survivability of a beef cow (Source: Mousel et al., 2012).

Calving date in the first-calving season also influences calf weaning weight (Mousel, et al., 2012). Heifers that calved in the first 21 days of her first-calving season had heavier calves at weaning for the first six calvings compared to those calving after day 21 (Figure 2). The data above highlight that ensuring heifers calve early in the calving season is a key driver of successful calving between 23 and 26 months of age, promoting both longevity as a cow and maximising calf output through increased weaning weights.

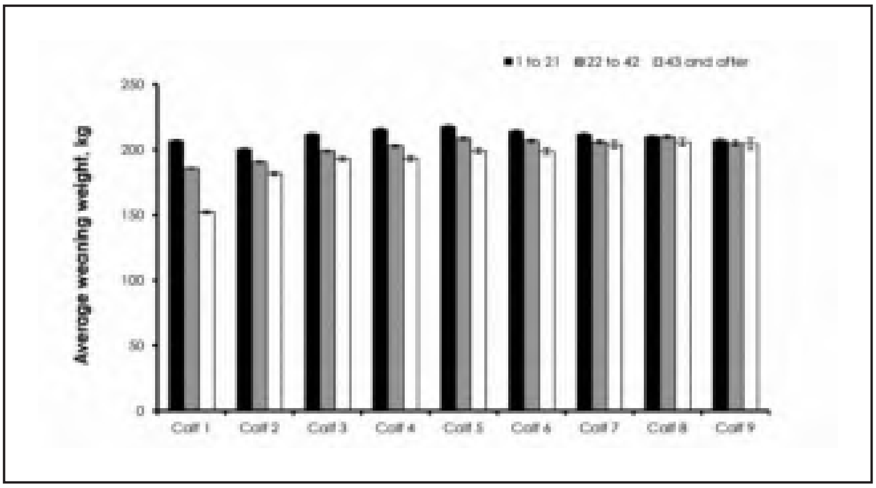

Figure 2. Influence of calving date on weaning weights of calves born over a cow’s lifetime (Source: Mousel et al., 2012).

Birth-to-weaning

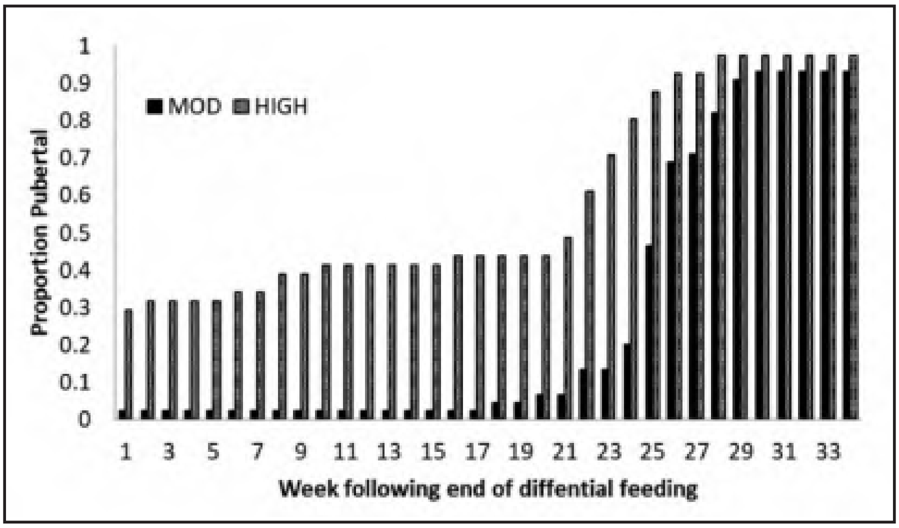

Figure 3. Effect of plane of nutrition between 4.5 to 9 months of age on timing of puberty onset in Angus × Holstein-Friesian heifers (Source: Heslin et al. unpublished – Teagasc Grange).

Up to 60 days of age, the nutrient requirements of a heifer calf are met primarily by her dam's milk production, but by 60 days of age the heifer calf consumes about 1.5% of her bodyweight as forage dry matter, depending on dam milk yield. As plane of nutrition, in early life has a major influence on sexual development (Kenny et al., 2017), it is important that replacement heifers are selected from high milk-producing dams. This will ensure that the heifer achieves a high ADG early in life and also that she is more likely to be a better milk-producing cow herself. Farmers should monitor the ADG of their potential replacement heifers during the first two-to-three months of life as the plane of nutrition and resulting growth during this phase has a large influence on the timing of puberty. In comparison, the effectiveness of later dietary manipulations to influence age at puberty are relatively limited. Indeed, research from Teagasc Grange has shown that Aberdeen Angus × 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 (Figure 3). In contrast, when Limousin- and Aberdeen Angus-sired suckler-bred heifers were fed a high or low plane of nutrition after eight months of age (post-weaning), to grow at 1.0 kg/day or 0.6 kg/day, the difference in age at puberty was only 13 days in favour of the high plane of nutrition (Heslin et al., 2020). Therefore, high average daily gain pre-weaning is critical to achieving early puberty and there is much less opportunity to influence age at puberty as the heifer gets older.

Weaning-to-breeding

An important outcome from the research by Heslin et al. (Figure 3) at Teagasc Grange was 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 usually similar in this situation, heifers that were offered a high plane of nutrition, with higher ADG and higher puberty levels had 12% better six- and eight-week conception rates than their contemporaries offered a moderate plane of nutrition and reduced puberty levels (Heslin et al., unpublished; Roberts et al., 2017). These findings are very important in the context of the influence of calving date in the first-calving season, as discussed above, but also for achieving a compact calving and maximising the quantity of grazed grass in the diet of suckler cows.

Although studies above report that post-weaning nutrition has less impact on age at puberty in heifers compared to early-life pre-weaning nutrition, it is still important that heifers be

Table 2. Suckler-bred replacement heifer target weights at 14-15 months of age

Breed	Weight (kg)
Aberdeen Angus X	370
Hereford X	370
Simmental X	400
Limousin X	420
Charolais X	430

well-grown prior to the breeding season. The target breeding weights for the predominant breed types in suckler systems in Ireland are outlined in Table 2. These weights should be taken as minimum targets and will have heifers on track to weigh 60% of their expected mature weight at breeding, and 80% of their expected mature weight at her first-calving.

Breeding to calving and post-calving care of the replacement heifer

Once scanned in-calf, heifers should remain on high 'quality' grazed grass until housing. Heifers should have a minimum body condition score (BCS) of 2.75 (scale 0-5) 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. 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 feed intake. A suitable pre-calving mineral is vital to reduce the risk of dystocia, calf vigour problems 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-digestibility grass silage (>70% dry matter digestibility), and concentrates should be considered if silage is of poor quality or if BCS is very low. Heifers not consuming enough energy will have delayed cyclicity and may be slower to go back in-calf (Gunn, 2016).

Economic and environmental benefits from reducing age at first-calving

An analysis was conducted based on a 40 hectare, spring-calving, suckler calf-to-weaning system to assess the economic and financial performance when calving heifers at 24 versus 36 months of age (Table 3). Cow numbers will change in the analysis based on what a 40 hectare farm can feed. In the scenario where heifers calve for the first time at 36 months of age, there are 20% more 'unproductive animals' on the farm compared to where heifers calve at 24 months of age. This results in a lower cow 'carrying capacity', and thus a reduction in the number of progeny available for sale; this has a negative impact on gross output. The reduced gross output means that the net margin per cow is only €38/cow if calving at 36 months of age compared to €152/cow if calving at 24 months of age, a 75% difference in net margin per cow.

The greater gross output from a system calving at 24 months compared to 36 months of age also means that the greenhouse gas emissions from this system are associated with more kilograms of live weight. This means that per kg of 'output', the CO_2 equivalents are lower for 24 versus 36 month calving systems i.e. 11.2 versus 12.7 kg CO2eq/kg live weight, respectively (Table 3).

Table 3. Summary of the performance, profitability and greenhouse gas (GHG) emissions of a 40 hectare calf-to-weanling suckler system, where heifers are calving at 24 or 36 months of age[1]

40 ha Farm	Calving at 24 months	Calving at 36 months
Suckler cows (number)	71	63
Heifers 0-1	35	32
Steers 0-1	36	31
Heifers 1-2	16	15
Heifers > 2	0	15
Replacement rate (%)	20	20
Animals sold 0-1	61	55
Animals sold 1-2	2	0
Animals sold >2	16	17
Stocking rate (LU/ha)	2.40	2.59
Gross output (kg/ha)	752	673
Gross output(€/ha)	2015	1798
Gross margin (€/ha)	962	724
Net margin (€/ha)	309	69
Net margin (€/cow)	152	38
GHG (kg CO2eq/kg live weight)	11.2	12.7

[1] Input prices assumed: Fertiliser - Urea: €950/ton, Concentrate: €440/ton

Source: Crosson, unpublished - Teagasc Grange

Conclusion

Reducing the age at calving of beef heifers will improve the profitability, while also reducing the environmental impact of a suckler system. Although adoption of this practice by farmers is still low, the common reasons for poor adoption are overcome by ensuring that heifers are managed to achieve a high ADG of greater than 1 kg, from as early in life as possible. Aiming to have replacement heifers pubertal in advance of the first breeding season will mean they calve earlier in their first-calving season, which is beneficial to longevity and lifetime performance. Calving heifers at 24 months of age results in a 75% difference in net margin per cow compared to calving heifers at 36 months of age.

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Calving heifers at 24 months of age – a farmers experience

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[2] *Teagasc, Future Beef Programme Adviser*

Farm profile

Shane farms full-time, with help from his wife Grainne and three children in Granlahan, Ballinlough, Co. Roscommon. He took over the farm in 2014, starting with five Saler in-calf heifers and has since grown the suckler cow herd to 37.

The farm comprises of 27.5 hectares (ha), which is split into three blocks. The main grassland block of 18.1 ha is approximately half a kilometre from the farmyard. Most of the soil on the farm is a mixture of clay and peat, and is 'heavy' in nature. The farm is 'well-stocked' at 160 kg organic nitrogen/hectare. The main grazing block is well-paddocked and Shane is measuring grass regularly on PastureBase. In terms of grassland management, the overall aim is to make high-'quality' silage and to maintain high-quality grass swards in front of the herd over a long grazing season. Shane is a member of the local beef grass group and this has helped him a lot with decision-making regarding paddocks, fertiliser, reseeding etc.

The spring-calving suckler production system operated is uncomplicated. The cow type is mainly Limousin × Saler, and a 'terminal' Charolais bull is used on the mature cows. All cows are calved in February and March. The male calves are finished as under-16 month bull beef. The heifers are sold as 'forward' stores or slaughtered at under-21 months of age.

Breeding performance

Since 2014, Shane has focused on building a high-value, maternal herd by using a Saler bull. His cow type could be described as very functional with plenty of milk and the ability to rear a heavy calf. The herd has an average Replacement Index of €118, compared to the national average of €87. In 2022, the male calves weighed 300 kg at 200 days of age, and the heifers weighed 280 kg. The breeding performance of the herd is excellent as summarised in Figure 1.

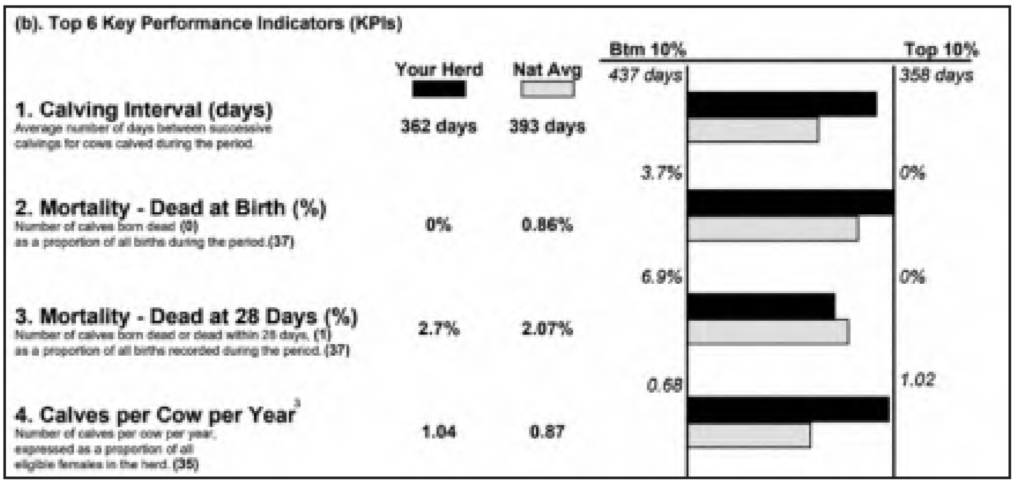

Figure 1. Breeding performance of the cow herd

Breeding Policy

The breeding system operated is 'simple' with a 'terminal' stock bull used on the mature cows, and artificial insemination (AI) used on the replacement heifers. The target start date for calving is 1 February so the Charolais stock bull is let out at the end of April each year. In 2022, all of the cows calved within 8 weeks and this will remain the target going forward.

All replacement breeding heifers are sourced from within the herd and are calved at two years of age. At this point, all of the cows in the herd have calved at two years of age and have an average mature weight of 650 kg. Shane picks the best heifers for potential replacements from the best cows early in the year. At least 20% of the female calves in the herd are identified as potential breeding replacements. These heifers are the progeny of cows with the following specific characteristics;

- 365-day calving interval or less
- Calve early in the season
- Good docility
- Consistently delivers a top-quality calf
- High maternal Replacement Index: €100+
- Has good conformation, milking ability and feet

This group of heifers are 'priority' stock on the farm. The heifer must have a weaning weight of 280 kg or greater. During the 'first' winter, they receive high quality (>70% dry matter digestibility – DMD) grass silage *ad libitum* plus 1.0 kg of concentrate per head daily. The target live weight gain is 0.6 kg/day over the first winter.

The maiden heifers are let out to grass in spring as early as possible, and will be at least 410 kg at the time of breeding on 1 May. Artificial insemination is used on the heifers as a stock bull cannot be justified for a group of this size. A vasectomised bull with a chin ball is used for heat detection.

This year, 12 heifers were identified for breeding and ten went in-calf to AI. Six are in-calf to a sexed semen Limousin bull called 'Tweedale Lennox', while the other four are in-calf to Limousin using conventional semen. Utilising sexed semen guarantees heifers from AI. The bull 'Lennox' is easy-calving (2.37%) and has a high Replacement Index of €157.

During the second grazing season, the in-calf heifers are offered top-quality leafy grass. During the second winter they are penned on their own, and are offered grass silage *ad-libitum*. Shane keeps a close eye on body condition, to ensure that the heifers are 'fit and not fat' prior to calving. The heifers calve along with the main cow herd and after calving receive high-digestibility (>70% DMD), first-cut grass silage. In spring, weather permitting, Shane tries to get these heifers out to grass first. The post-calving 'care' is very important to ensure that they will go back in-calf again.

Has red clover a role in your beef production system?

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Summary

- Red clover-grass silage swards can produce high herbage yields without the need for chemical nitrogen (N) fertiliser inputs due to its ability to fix in excess of 200 kg N/ha annually.
- Red clover is more suited to silage than grazing systems.
- The high intake potential of red clover-grass silage compared to grass silage can increase animal live weight gain.
- Harvesting red clover at 6-8 week intervals will help swards persist for 3-4 years.
- Red clover-grass silage has an economic advantage over grass silage at current market prices.
- High levels of management are necessary for red clover-grass silage swards compared to conventional grass silage swards.

Introduction

Forage legumes, such as red clover (RC), can contribute substantially to organic, low-input and conventional animal production systems due to their ability to fix atmospheric nitrogen (N), thus reducing the reliance on chemical N fertiliser. Through RC's biological N fixation ability and through its capacity to support higher animal performance (Phelan et al., 2015), improved farm gate N-balance can be expected. Given the rising cost of fertiliser and feed, and increasing environmental constraints, incorporating RC into swards can offer significant benefits to beef production systems. Despite the many benefits of RC inclusion, it has had limited uptake on pasture-based production systems in Ireland. The poor on-farm uptake of RC is likely due to its more complex management requirements, unsuitability to frequent grazing, reduced persistence (approximately 3-4 years), and the relatively low cost of chemical N fertiliser in the previous years.

Nitrogen fixation

Red clover swards have the ability to fix high levels of atmospheric N, making it available to plants in the soil. Swards with a high content of RC - 75% on a dry matter (DM) basis - are capable of fixing 24-36 kg N/tonne DM produced, meaning that such swards are potentially fixing in excess of 200 kg N/ha annually (Peoples and Baldock, 2001). At Teagasc Grange, RC-grass swards receiving no chemical N were found to have similar annual DM production to grass-only swards receiving up to 412 kg N/ha per year in plot studies (Clavin et al., 2017). The application of chemical N fertiliser to RC-grass swards has antagonistic effects, reducing the proportion of RC in the sward, annual DM production and persistence. For example, a single application of chemical N fertiliser (50 kg N/ha) in March to RC-grass swards was found to reduce the proportion of RC by 13% (Clavin et al., 2017).

Agronomy

Unlike for perennial ryegrass and white clover varieties, no 'Recommended List' currently exists for RC varieties in Ireland, with Irish producers relying on information from the UK Recommended/ National List to identify suitable varieties. The breeding goals for RC varieties suited to Irish farm systems are for improved DM production and persistence (Conaghan, 2018).

Red clover varieties differ in their DM production potential and persistence under frequent cutting, with newer varieties offering improved persistence through better DM yield stability and plant survival over multiple harvest years. Similar to perennial ryegrass, RC varieties are categorised by heading date (early or late) and ploidy level (diploid or tetraploid). Early-heading varieties typically flower 1-2 weeks sooner than late-heading varieties while providing more vigorous regrowth and stable yields in a multi-cut system. Late-heading varieties produce most of their annual yield in the first-cut, with less vigorous regrowth than early varieties thereafter; however, late varieties store more energy reserves in their root system and have increased growing points from the plant crown, which contribute to improved persistence. Tetraploid varieties tend to be higher yielding, more disease resistant and persistent than diploid varieties.

Red clover should be grown in rotation with a standard grass or grass and white clover sward, allowing for a minimum four-year break to control diseases such as stem eelworm and Sclerotinia fungus (clover rot). This four-year break can be achieved by sowing RC with perennial ryegrass and white clover, with both of these species remaining productive beyond the lifespan of RC. Research at Teagasc Grange has shown that the inclusion of perennial ryegrass with RC at sowing will improve annual herbage production, silage digestibility and ensilability (Clavin et al., 2017). Red clover should be incorporated into swards on soils that are well-drained and have a pH ranging from 6.5 to 7. Typically, sowing rates of between 7.5 to 10 kg/ha (3 to 4 kg/ac) of RC in addition to 20 to 22 kg/ha (8 to 9 kg/ac) of perennial ryegrass are recommended depending on the quality of the seedbed and season. Reseeding in spring rather than in autumn provides a better opportunity to optimise pre- and post-sowing management and overall establishment.

Unlike white clover which has a stoloniferous growth habit, RC typically has a deep taproot, an erect growth habit, with larger shoots and a lower shoot density (Figure 1). Stems are formed from the growing points located on the crown at the top of the taproot. Reserves of carbohydrates and N are stored in the crown and taproot, where they are remobilised to fuel regrowth after defoliation. The crown/growing point of RC is solitary and exposed, making it vulnerable to physical damage

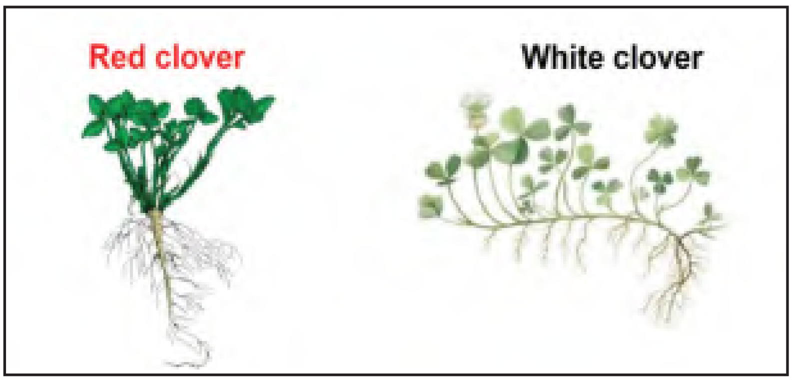

Figure 1. Red and white clover growth habit

by machinery and animals. This means that RC is less suitable to frequent and intensive grazing. Consequently, it is established more often as a silage crop, with infrequent cuts (6-8 weeks), in order to minimise damage to the crown and allow the canopy to intercept sunlight to replenish carbohydrate reserves. Red clover swards generally persist for 3-4 years under a multi-cut system, although well-managed swards can persist somewhat longer.

Agronomically, RC is best suited to a three-cut silage system, with the first-cut harvested by mid-late May, which promotes higher clover proportions and DM production for the remainder of the growing season. Figure 2 illustrates the changes in RC percentage in silage swards on a DM basis at Teagasc Grange during 2022. The sward is managed under a three-cut system receiving zero chemical fertiliser N. The RC content increased markedly after harvesting first-cut silage in May and declined after the third-cut harvest in September, which can be attributed to reducing sunshine hours and temperatures. Increasing the defoliation frequency beyond three-cuts can reduce RC content and its contribution to DM production due to insufficient replenishment of plant reserves, and thus diminish its persistence in the sward. 'Late' autumn silage harvests can also be more difficult to ensile, due to the reduced opportunity to wilt grass coupled with the high buffering capacity of RC-grass silage. Generally, these 'late' harvests have a relatively low yield making it difficult to justify economically.

To increase DM concentration to 25-35%, RC-grass silage generally requires wilting in dry conditions for 24-to-48 hours, while ensuring that the leaf is not damaged (shattered) as a result of over-wilting and excessive machinery passes, including tedding and raking. Red clover also has a relatively low water soluble carbohydrate (sugar) concentration further reducing its ensilability. Therefore, the inclusion of grasses, which are higher in sugars than RC, as a companion species will improve the overall ensilability of RC-grass silage.

Figure 2. Red clover % (dry matter basis) in RC-grass silage swards at Teagasc Grange during 2022.

Feed value

Cattle offered RC-grass silage generally have a higher DM intake when compared to those offered grass silage (Castle and Watson, 1974; Steen and McIlmoyle, 1982). Unsupplemented (no concentrates) weanling steers offered RC silage (monoculture) had a greater live weight gain (0.89 vs. 0.59 kg/day), than those offered grass silage of comparable digestibility, which was attributed to the higher intake of RC silage (7.75 vs. 5.59 kg DM/day). In a 'finishing' study comparing unsupplemented steers offered RC silage (monoculture) with a digestible organic matter of 57% or grass silage with a digestible organic matter of 69%, animals offered the RC silage had a higher daily intake (8.52 vs. 6.82 kg DM) and similar live weight gain (0.63 vs. 0.59 kg/day), despite the substantial difference in digestibility (Steen and McIlmoyle, 1982). Red clover generally contains a greater ratio of indigestible fibre: digestible fibre (0.27 vs. 0.19, respectively) than grass silage (Halmenmies-Beauchet-Filleau et al., 2014). Although the extent of digestion is reduced for RC-grass silage when compared with grass silage, the rate of digestion of the digestible fibre is faster (Kuoppala et al., 2009). This facilitates a faster rate of passage, lower rumen fill and thus increased DM intake.

Red clover has a higher concentration of crude protein (nitrogen) compared to grass. Consequently, as the proportion of RC reduces relative to grass in silage swards, there is a corresponding reduction in silage crude protein concentration (Clavin et al., 2017). However, in practice, because RC-grass silage swards are often managed under a zero-fertiliser N regime, crude protein concentrations of RC-grass silages are generally similar to grass silage receiving conventional applications of chemical fertiliser N. For example, at Teagasc Grange in 2022, first-cut RC-grass silage swards (37% RC on a DM basis) which received 0 kg fertiliser N/ha and grass silage swards which received 85 kg fertiliser N/ha produced silages with 12.5% and 14.0% crude protein, respectively. Other factors, such as harvest date may also influence the concentration of crude protein in RC-grass silages. Additionally, RC-grass silages have proportionately more rumen undegradable protein than grass silage, which is of greater nutritional benefit to cattle.

In late autumn, it is often necessary to graze swards containing high levels of RC to avoid carrying a heavy cover (>1000 kg DM/ha) of herbage over the winter. Grazing such swards can pose an increased risk of ruminal bloat because of the rapidly rumen fermentable nature of RC. Under these circumstances, careful management is necessary to reduce the risk, including providing animals with a fibre source and adding bloat oil to the drinking water supply.

Economic benefits

Herbage DM production, persistency and fertiliser price will have the greatest influence on the economic competiveness of RC-grass swards. Using the 'Grange Feed Costings Model' the relative cost of conventional grass silage and RC-grass silage was compared for a 2-cut and 3-cut baled silage scenario. It was assumed in this scenario that grass silage and RC-grass silage swards would require reseeding every 8 and 4 years, respectively. For the purposes of the analysis, both silages were assumed to have a comparable dry matter digestibility. In this regard, future research in Teagasc will be determining the feed value of both silage types. Table 1 outlines the agronomic performance and management of grass-only and RC-grass swards managed under different nutrient managements.

Protected urea and 0-7-30 fertiliser was assumed to cost €1100/t and €883/t, respectively (CSO, 2022). It was assumed that machinery operations were completed by a contractor, with prices based on published Farm & Forestry Contractors Ireland reference prices, as follows; mowing €72/ha (€29/ac), raking and tedding €40/ha (€16/ac), baling €9/bale, wrapping €7/bale (incl. plastic), slurry agitation €120/hr, and slurry spreading (3000 gallon tanker) = €100/hr.

Table 1. Agronomic performance and management assumptions of grass silage and red clover-grass silage swards

	Grass silage 2-cut system	Red clover-grass silage 3-cut system[1]	Red clover-grass silage 3-cut system: all slurry[1]
Persistency (years)	8	4	4
Silage yield	10 t DM/ha (12 + 8 bales/acre)	13 t DM/ha (11 + 8 + 7 bales/acre)	13 t DM/ha (11 + 8 + 7 bales/acre)
Slurry applied (gallons/acre)	2500 + 2000	2500 + 2000	3000 + 2500 + 2000
Inorganic fertiliser applied	Protected urea and 0-7-30	0-7-30 (310 kg/acre or 2.5 bags/acre)	None
Dry matter digestibility (%)	73.4	72.4	72.4

[1] 3-cut RC-grass silage system had a combined silage harvest yield of 13 t DM/ha, followed by one autumn/winter grazing of 2 t DM/ha, giving a total annual yield of 15 t DM/ha.

Red clover-grass silage was €3.30/bale (€24/t DM) cheaper to produce than grass silage (Table 2); however, where all nutrient requirements of RC swards were met with cattle slurry there was a saving of €6.30/bale (€38/t DM) compared to grass silage. However, it is recognised this extra saving of applying greater quantities of slurry on RC-grass silage land area, would lead to greater chemical fertiliser costs on the grazing land area (less slurry available for grazing area). Furthermore the cost-saving would be less where there is a long travel distance with slurry to the silage land area. In the event that fertiliser prices drop by 25 % (i.e. protected urea and 0-7-30 cost €825/t and €662/t, respectively), the cost-benefit of RC-grass silage over grass silage would inevitably reduce from €3.30/bale (€24/t DM) to €2.30/bale (Table 2).

Table 2. Relative cost of grass silage and red clover-grass silage (excluding land charge)

	Grass silage 2-cut system	Red clover-grass silage 3-cut system	Red clover-grass silage 3-cut system - all slurry
	€/bale (€ t DM)	€/bale (€ t DM)	€/bale (€ t DM)
Fertiliser (incl. spreading)	11.89 (59)	7.10 (34)	4.16 (20)
Harvesting costs (incl. plastic)	24.48 (122)	23.69 (113)	23.69 (113)
Other (feeding, herbicides etc.)	2.49 (12)	2.64 (14)	2.64 (14)
Fixed costs (reseeding/facilities)	2.77 (14)	4.78 (23)	4.78 (23)
Total costs, excl. land charge	41.6 (208)	38.3 (184)	35.3 (170)
Sensitivity analysis			
25% change in fertiliser price (+/-)	2.1 (10)	1.1 (6)	0.0 (0)
4-year to 6-year persistency for RC		-2.1 (-11)	-2.0 (-11)

A disadvantage of RC swards is the expected reduction in sward persistency compared to grass swards, which can contribute to higher fixed costs associated with reseeding. Sowing appropriate RC and grass varieties, optimising soil fertility and harvest management can increase the persistence of swards containing RC. Therefore, under high levels of management it is possible to extend the lifespan of swards containing RC up to 6 years. Increasing persistent from 4 to 6 years would result in a saving of €2.10/bale (€11/ t DM).

In summary, RC-grass silage can offer a cost-saving compared to grass silage during current ‘high fertiliser priced years’. A reduction in fertiliser price would ultimately reduce the cost savings associated with RC inclusion in silage swards. Improving management and increasing the persistency of RC can provide further cost-savings.

Current research

A new research project is underway at Teagasc Grange to investigate the suitability of RC-grass silage within grass-based dairy and suckler beef systems. This research will involve plot-scale studies to assess variety performance, animal experiments, farms system experiments and bio-economic modelling to quantify the yield, persistency, animal performance, economics and environmental efficiency of RC-grass silage based diets. This research also aims to identify the 'category' of animal that can maximise the potential of RC-grass silage (e.g. beef animals within the 'first' winter or 'finishing' period).

Conclusion

The inclusion of RC into grass silage swards has great potential across Irish beef production systems of all intensities. These swards have an enhanced ability over grass-only swards to maintain high levels of herbage production and animal performance from significantly lower levels of chemical N fertiliser. Red clover-grass silage swards can reduce the cost of producing winter feed but is dependent on a high level of management to ensure swards remain productive over multiple harvest years, which will require additional levels of management compared to grass silage swards. The use of RC when combined with a range of other management and animal breeding technologies can 'future-proof' ruminant systems by reducing the level of N imported onto farms while increasing animal productivity and ultimately economic and environmental efficiency. However, more research is required to identify optimum managements to successfully grow stable yields of RC-grass silage in Ireland and to further understand the complex plant chemical and morphological characters influencing DM intake and animal performance potential.

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Red clover for beef systems - a farmers experience

Martin Connolly[1] and Tommy Cox[2]

[1] *DairyBeef 500 Farmer, Co. Roscommon*
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Farm profile

Martin Connolly farms part-time just outside the village Castleplunket in Co. Roscommon. He operates a calf-to-bull beef system. The farm consists of 60 ha of grassland in total, which is divided in four main blocks within a 3-mile radius of the farm yard. The land itself can be described as a 'heavy-type' soil, which would be typical of the area.

Approximately 140 Holstein-Friesian male calves, purchased at 3 weeks of age, are reared annually on the farm and slaughtered as bulls at about 21 months of age. The feeding programme during the finishing phase is grass silage *ad libitum* supplemented with 6 kg concentrates per head daily for a maximum of 100 days.

In recent years, a primary aim was to improve animal performance without increasing the level of concentrate input. Improvements in grassland management and grass silage 'quality' has paid dividends with increased animal growth rates evident. For example, carcass weight of bulls slaughtered to date this year is on average 334 kg, which is 13 kg heavier for the same period in 2021, while simultaneously a reduction in average time to slaughter of 20 days was achieved.

Why red clover?

With input costs, especially feed and fertiliser, increasing drastically this year, Martin explored various cost-saving options that would not only cut costs but also maintain high levels of animal performance. From researching red clover swards Martin was impressed with its enhanced ability over grass-only swards to maintain high levels of herbage production and animal performance from significantly lower inputs of chemical nitrogen fertilizer. In early June 2022 the decision was made to reseed 10 acres of grass to a 'red clover sward' to see if these benefits could be obtained in his farming system.

Sowing

In preparation for tilling, weeds and grass was 'burned off' using 2 litres of glyphosate per acre. Ten days post-spraying, 10 tonnes of farmyard manure per acre was spread on the ground and this was subsequently ploughed in. After ploughing, the ley was given two passes of a power harrow to ensure a firm fine seed bed, and on the second pass 16 kg/acre of seed was sown. The seed mixture used comprised of: perennial ryegrass, 4.0 kg 'Aberclyde' & 3.5 kg 'Aberwolf '; red clover, 3.0 kg 'Garant' & 1.0 kg 'Aberclaret'; and white clover, 0.5 kg 'Alice'. The reseeded area received 3 bags of 10-10-20 per acre to provide adequate nitrogen (N), phosphorus (P) and potassium (K) for growth, as well as 2 tonnes of lime per acre to increase soil pH. A clover-safe, post-emergence spray, was applied 5 weeks after sowing to control weeds.

Results to date

To date, the red clover sward has performed exceptionally well delivering two high-'quality' cuts of silage. The first-cut was harvested on 8 August and yielded close to 4.8 bales per acre. Subsequently, 2000 gallons of cattle slurry per acre was applied for the second-cut, which was harvested on 25 September and yielded just over 4.5 bales per acre. The red clover silage dry matter, preservation characteristics, chemical composition and nutritive value are presented in Table 1.

Table 1. Red clover silage analysis

Unit of measure	First-Cut	Second-Cut
Dry matter (DM) (%)	33.3	25.0
pH	4.6	4.3
Ammonia Nitrogen (% N)	6.3	5.3
Neutral detergent fibre - NDF (% DM)	42.7	44.9
Dry matter digestibility - DMD (%)	73.6	75.4
Metabolisable energy - ME (MJ/kg DM)	10.6	10.9
UFV/UFL (unit/kg DM)	0.92	0.95
Crude protein (% DM)	13.9	15.4
Ash (% DM)	9.8	8.8

Opinion so far

At this stage, the majority of the first-cut red clover silage has been fed and overall Martin is satisfied that it has 'delivered'. One concern though, given the climate and the land type for the area, is the ability to 'graze-off' any covers in the autumn. The high temperatures this autumn has meant that herbage growth rates have remained high, and Martin has found this to be particularly evident in the red clover sward where growth has been exceptional. To date, over 5 acres of the red clover area has been grazed but the recent wet weather has prevented any further grazing as Martin was fearful that any damage to the red clover plant would result in reduced persistency. Aware of the importance of 'cleaning-out' the sward to allow light reach the base of the plant and thus help ensure the persistence of clover, Martin will monitor the situation; if the opportunity arises a 'light' grazing will be applied.

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