

BEEF 2018

‘Enhancing Knowledge’

Tuesday, 26th June 2018

Teagasc, Grange, Dunsany, Co. Meath



BEEF 2018

Enhancing Knowledge

SITEMAP

Main Stands

- 1 Infrastructure Village
- 2 Suckler
- 3 Calf to Beef
- 4 Breeding / Genetics
- 5 Grassland

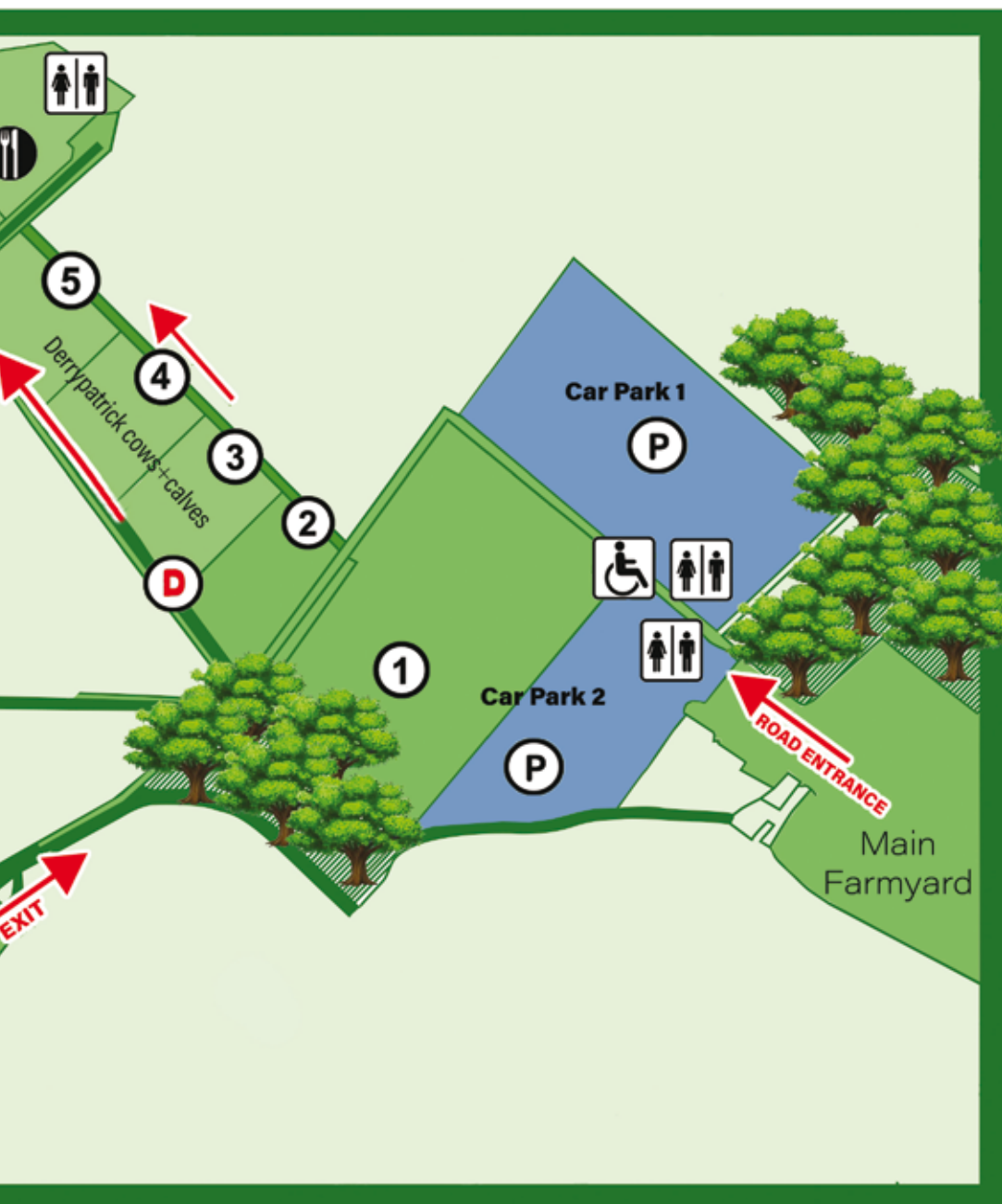
Technical Villages

- 6 Grass10
- 7 BETTER Beef Programme
- 8 Dairy Calf to Beef
- 9 Health & Breeding
- 10 Feed & Meat Quality
- 11 Education
- 12 Environment

Displays

- 13 Suckler Breeding Demonstration
(Incl: Teagasc | Irish Farmers Journal | Irish Cattle Breeding Federation)
- 14 Quad Demonstration
- 15 Health & Safety
- 16 Kevin Dundon Cookery Demonstration
- 17 Bord Bia & Beef Factories
- 18 Farmer Forum





Acknowledgements

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the support of FBD Insurance,
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Compiled and edited by:
Mark McGee and Aidan Moloney

Teagasc, Grange Animal & Grassland Research and Innovation Centre



AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

BEEF 2018

ACKNOWLEDGEMENTS

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Health, Safety and Bio-Security

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

Use Footbaths

Not Handle Cattle

Not Enter Pens or Paddocks containing Cattle

Thank You



Beef 2018

Foreword



You are all very welcome to the BEEF 2018 Open Day in Grange, Co. Meath where the theme is 'Enhancing Technologies' and where the latest research, advice and innovations taking place in cattle farming and in the beef sector are on display for you to engage with. I don't need to remind this audience that the beef sector is among the most important Irish indigenous industries. Total production increased by 4.5% to 615,000 tonnes in 2017 and beef exports were worth €2.5 billion, representing a 65% increase in value compared to 2010. The outlook for beef prices in 2018 is good. However, in the medium term, there will be significant challenges around Brexit, CAP reform and climate change.

The emphasis of BEEF 2018 is to highlight those technologies that will help underpin the future profitability of the beef sector. Technical updates will be provided on how to exploit superior genetics, improve performance from pasture and plan your herd's health, so there are steps that you as individual farmers can take inside your own farm gate that will help to insulate your business, to some extent, from external shocks. Achieving profitability in your beef enterprise requires good management and an awareness and implementation of the new developments in the key areas such as breeding, grassland, animal health and financial management. The Derrypatrick suckler herd and the Maternal Index suckler herd form the backbone of the applied suckler beef research demonstration farms here in Grange. But this year we have also put in place a dairy calf-to-beef enterprise, reflecting the increased numbers of animals entering the cattle finishing business in recent years from the expansion of the dairy herd. In addition, our work with commercial cattle producers through the Green Acres Calf-to-Beef programme and the Teagasc/Irish Farmers Journal BETTER Farm Beef programme, ensure that important research findings are transferred out to support the development of beef farms around the country. At the end of today, you will get an opportunity to hear beef farmers who have taken up key technologies we are promoting tell their story, at the Farmers' Forum facilitated by Richard Curran from RTE.

The spring weather created difficulties for all farmers, not least cattle producers. Thankfully weather has improved considerably since then, grass growth has improved, and some good quality silage has been made. The Grass10 programme is focused on

growing and then utilising as much grass as possible on all farms, either by grazing or ensiling. Teagasc, along with all stakeholders, will be carrying out a fodder census on 1st July and again on 1st of September to assist farmers in ensuring they have adequate stocks of winter feed. There will be an opportunity to sit down with a Teagasc advisor today to do an initial fodder budget.

Can I finish, by thanking FBD Insurance who, once again, are kindly supporting the main Teagasc Beef Open Day here in Grange. The contribution from other organisations, with whom we work closely throughout the year, to this major beef Open Day, is also appreciated. My colleagues in Teagasc, from all business units in the organisation, have come together to organise this key event, and I would like to thank them for their efforts in professionally staging such an occasion. I expect that each one of you will find today's open day informative and will leave with a clear message of what technologies you can implement to improve your cattle enterprise.

Professor Gerry Boyle
Director Teagasc



Beef 2018

Welcome to Grange

Edward O'Riordan and Pearse Kelly

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

Introduction

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 2018. The theme today is **'Enhancing knowledge'** and entails highlighting resilient technologies that help beef farmers achieve more economically and environmentally viable production systems. The focus is on technologies within the farm-gate, which are predominantly under the farmers' control; these include applications and technical knowledge relating to farm infrastructure, grassland production, management and utilisation (grazing/grass silage), animal nutrition (forage/concentrates), animal genetics and reproductive management, and animal health and disease prevention, within the context of competitive and sustainable suckler-beef and dairy-beef farm enterprises.

Today's event is comprised of four main 'speaking' stands and a series of 'villages' that elaborate on the topics discussed at the "main stands" and enable a more informal 'one-to-one' communication. BEEF 2018 finishes with a 'Farmer Forum' where a group of farmers speak about their future plans for beef farming.

With its integrated programmes of research, advisory, training and education, and with the many industry stakeholders, Teagasc is well-positioned to assist farmers with technological developments aimed at improving the economics of beef farming.

As in previous years, there are heightened bio-security measures in place, so please use footbaths provided and follow the directions provided. Livestock at pasture are displayed behind 'double' fences, for bio-security and safety reasons, and visitors are requested not to enter areas containing livestock. Your help and cooperation with these safety measures will be appreciated.

Again, on behalf of Teagasc and Grange staff we hope you find the day useful and enjoyable.



Enhancing Technologies

Key performance indicators for suckler calf-to-weanling production

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¹Teagasc, Grange Animal & Grassland Research and Innovation Centre, Dunsany, Co. Meath

²Teagasc, Cavan Lower, Ballybofey, Co. Donegal

Summary

- Suckler beef farming in Ireland is a key contributor to the national economy.
- Farmers must achieve the highest levels of efficiency to remain profitable.
- Key drivers of efficient suckler beef production are animal performance, grass utilisation and stocking rate.
- Key performance indicators underpinning profitability of suckler calf-to-weanling production systems are: age at first calving, calves per cow per year, 6-week calving rate, calf average daily gain to weaning, and concentrates consumed per cow-calf unit.
- There is substantial scope for the 'average' suckler farm to improve individual animal efficiency and subsequently improve farm profitability and environmental sustainability.

Introduction

The contribution of beef production to the national economy was €2.5 billion in 2017. Globally, Ireland is the fifth largest net exporter of beef products, with over 90% of our beef exported. Of the 2.3 million calves born in Ireland in 2016, 45% originated from suckler beef dams. This alone highlights the significant contribution of suckler beef to the Irish beef industry. Additionally, suckler beef farming occurs within a diverse range of farming 'environments', and over a wide geographic area nationally, underlining its economic significance to rural communities throughout Ireland. The 2016 National Farm Survey indicated, however, that the 'average' suckler beef farm generates very low financial returns with an average farm net margin per hectare of -€52, excluding premia. The scope for improvement is substantial as indicated by the Teagasc eProfit Monitor whereby the top third of suckler farms in 2016 generated a net margin per hectare of €258 excluding premia. It is thus, critical to explore the key factors that underpin profitability in suckler beef production.

Key factors underpinning profitable suckler beef production

Profitability in suckler beef enterprises is determined by three main variables; grass utilisation, individual animal performance and stocking rate.

Grass utilisation (grazed and conserved)

Feed costs account for approximately 75% of total variable costs in the average suckler beef farm. Of the primary feeds, grazed grass is considerably less-costly than grass silage, which in turn is generally less expensive than concentrate feeds. One of the strengths of Irish suckler beef production systems is the ability to capitalise on these relatively low-cost feed resources,

especially grazed grass. Therefore, achieving high levels of grass production and utilisation (grazed grass and grass silage), in order to maximise live weight gain from grass, along with the efficient use of supplementary concentrate, is essential to maintaining economic sustainability (see pages 32, 52 148, 152).

Individual animal performance

To improve profitability on suckler farms initial focus needs to be on increasing individual animal production efficiency, followed by increasing farm output in terms of higher stocking rate. Central to high individual animal efficiency in suckler calf-to-weanling systems is good herd fertility, coupled with low levels of calf mortality and morbidity, and high pre-weaning growth of progeny.

Stocking rate

Increasing profitability on suckler beef farms also relies on the ability of the farmer to match stocking rate to the 'carrying capacity' of the land taking into account factors such as the prevailing soil type and climatic conditions, which are quite diverse nationally. It is essential that any increase in stocking rate is predominantly supported by higher levels of grass grown and utilised on farms. This starts with correcting soil fertility deficits. Assessment of the capability of infrastructure, such as winter housing, manure storage, calving and animal-handling facilities, of supporting any increase in the number of stock on the farm must be carried out. This is especially important at key points in the production cycle e.g. calving time. Increased labour requirements may also limit an increase in stocking rate. Farm facilities and labour demands should be at a sufficient level to provide the highest levels of safety to both the operator and the animal. Through recent farm improvement schemes such as Targeted Agricultural Modernisation Scheme (TAMS) farmers can avail of financial supports for upgrading of existing facilities (see page 206). It is important to note that there is a close relationship between investment in farm facilities and improvements in labour efficiency on farms.

Key performance indicators (KPI)

Quantifying levels of efficiency on suckler beef farms can be achieved through the use of on-farm metrics known as key performance indicators (KPI). Getting a measure of the relative strength of these KPIs allows farmers to benchmark their comparative efficiency against the most profitable systems, and get an indication of their farms strengths and weaknesses. There are a number of KPIs that determine efficiency and ultimately profitability on suckler calf-to-weanling farms. For the purposes of this paper five KPIs considered essential for suckler calf-to-weanling farms are identified; 1. age at first calving, 2. calves per cow (in the herd) per year, 3. six-week calving rate, 4. calf average daily gain to weaning and 5. concentrates consumed per cow-calf unit. The first three KPIs can be categorised as 'reproductive' and the remaining two KPIs, as 'productive'. These five KPIs capture where improvements can occur in farm technical efficiency. They also apply to other suckler beef systems where calves are reared e.g. calf-to-store or calf-to-beef enterprises.

1. Reproductive measures

Recent research at Teagasc, Grange has shown that rearing heifers to calve at 36 months versus 24 months of age reduces NM per hectare on suckler beef farms by ca. 20 to 30%; this reflects the added cost accrued by maintaining a cohort of 'unproductive' animals within

the herd for 12 extra months. Nationally, statistics show that only 24% of beef heifers calve between 22 and 26 months of age. Thus, the primary target for suckler calf-to-weanling farmers that breed replacement heifers from within their herd should be to calve heifers at 24 months of age and thereafter, to maintain good herd fertility with the principle objective being to produce one calf per cow per year. Recent national data from the Irish Cattle Breeding Federation (ICBF), however, indicate that only 85 out of every 100 cows in a herd produce a calf every year. This indicates that calf mortality and calving rate are limiting output on suckler beef farms.

A further measure of a herd's fertility is the percentage of cows that calve within the first 6 weeks of the calving period (6-week calving rate). High-performing herds are achieving six-week calving rates in excess of 80%. Grass-based production systems aim to match peak grass growth with the peak energy demand of the herd. Increasing six-week calving rate ensures a higher proportion of calved cows are turned out to grass at the beginning of the breeding season. Other benefits such as increased labour savings due to a more uniform calf age, allow certain management and husbandry procedures such as vaccination/'dosing', disbudding, castration and weaning to be implemented more efficiently on-farm, as well as having, on average, older (and heavier) calves at weaning.

2. Productive measures

A key component to increasing the live weight produced per suckler cow on the farm is maximising the average daily live weight gain (ADG) of the progeny; however, this pre-weaning calf performance must be achieved cost-effectively and should be predominantly derived from the dam's milk and grazed pasture. In practice, a high level of concentrate supplementation to suckling calves often occurs. High utilisation of grass, both grazed and conserved, is an essential component of meeting the energy demands of the suckler cow (and calf) cost-effectively. This entails integrated grassland management - good grazing management and planned grass conservation practices - to ensure an adequate supply of feed (fresh grass or grass silage), of appropriate 'quality' (dry matter (DM) digestibility, DMD) throughout the year. Where this is not achieved, costs typically increase - for example, when grass silage DMD and/or body condition score (BCS, fat reserves) of cows at housing, are below optimal, supplementation with concentrates may be needed to maintain performance.

Economic impact of increased efficiency

To assess the economic effect of increasing technical efficiency on suckler calf-to-weanling farms, a farm systems modelling evaluation was carried out to quantify the financial impact that a change in each of the five aforementioned KPIs has on net margin per cow (Table 1). To achieve this, performance of 'average' farms, obtained from national databases such as Teagasc, National Farm Survey and ICBF, was compared with that obtained on 'high-performance' commercial and research farms.

A 40-hectare grass-based spring-calving suckler calf-to-weanling farm was assumed. All progeny, except those which were retained as replacement heifers (replacement rate, 16%), were sold after weaning. The efficiency levels of the high performance farm matched those which were achieved on high-performing research and commercial farms as follows: 6-week calving rate was 80%; calves per cow (in the herd) per year was set to 0.95; average age at first calving was 24 months; and, calf ADG to weaning was 1.25 kg. The stocking rate was fixed on the 40-hectare platform at 2.28 livestock units /ha equivalent to an organic nitrogen limit of

170 kg/ha. Cow numbers were therefore set to the land carrying capacity under this stocking rate, while taking account of the number of replacement heifers retained. First-cut grass silage quality was 68% DMD, with only first-calving cows receiving concentrate supplementation from the total breeding herd, at a supplementation rate of 1 kg/day per head from calving until turnout to pasture. Calves received concentrate supplementation from approx. 4 weeks pre-weaning until two weeks post-weaning. This equated to an average of 1 kg per head per day over a six-week period. The total amount of concentrates consumed annually was 200 kg when expressed on a per cow/calf unit basis. Prices assumed were as follows: fertiliser urea, €360/t; fertiliser CAN, €260; and concentrate ration at €254/t (fresh weight). A sale price of €2.50 kg/live-weight was assumed for weanlings. The analysis excluded land and labour charges so as to replicate the traditional family farm. All direct support payments were excluded in order to quantify the direct effect of changes in the KPIs on farm profitability. Table 1 indicates the change in net margin per cow that can be seen when each individual KPI was adjusted independently within the baseline herd.

Table 1. An economic evaluation of an improvement in efficiency for five key performance indicators

Key performance indicators	High performance farms ¹	National average farms ²	Difference in net margin per cow in the herd
Reproductive			
Calves weaned per cow in the herd per year	0.95	0.85	€87
Age at first calving (months)	24	32	€50
6-week calving rate (%)	80	55	€28
Productive			
Calf average daily gain to weaning (kg) ³	1.25	1.05	€86
Concentrates fed to cow-calf unit annually (kg)	200	450	€52

¹ Data were taken high-performing research and commercial farms. ² Data taken from NFS and ICBF records. ³ Based on a 200-day weaning weight.

Changes in net margin per cow were observed as the reproductive efficiency of the herd declined (Table 1); reducing the number of calves per cow (in the herd) per year and increasing the average age at first calving reduced net margin per cow by €87 and €50, respectively. A €28 per cow difference in net margin was demonstrated when 6-week calving rate decreased from 80% to 55%. Where pre-weaning performance was reduced from 1.25 kg to 1.05 kg per day, an €86 change in net margin occurred. Similarly, increasing the level of concentrate

supplementation by 0.25 tonne, to 450 kg, per cow-calf unit annually, reduced farm net margin per cow by €52. The 'additive' effect of reducing the level of technical efficiency in all five KPIs listed above showed a total reduction in net margin of ca. €300 per cow on a suckler calf-to-weanling farm.

Achieving improved efficiency

It is clear from the economic results shown in Table 1 that management to achieve certain key performance targets can improve profitability substantially on the average suckler farm in Ireland. The policy of every suckler farmer should be to manage their herd to wean one calf per cow per year, with a good weight per day of age. This entails a combination of good reproductive performance and management, the use of high-genetic merit animals, provision of adequate nutrition, coupled with low mortality rates and good animal health. Herd health plans should be developed in conjunction with a veterinary practitioner in order to put in place strategies to reduce the risk of disease.

Ensuring that beef females being retained on the farm as replacements calve at 22 to 26 months of age is the first step to improving reproductive efficiency. Research within Teagasc and targets achieved on high-performing commercial farms has demonstrated that, although challenging, beef heifers can be calved down at ca. 24 months of age, across a range of breed types, by implementing the correct management strategies. A key component to successfully calving heifers at two years of age is ensuring that they achieve puberty and oestrus cycling before the onset of the breeding season. Various elements can affect the age at puberty such as genetics and nutrition (see page 134). Several management factors dictate the duration of the calving to conception interval in beef cows such as cow BCS at calving coupled with post-partum nutrition and the presence of the suckling calf (See page 134). By implementing the correct reproductive management practices that ensure the early-onset of oestrous cyclicity (heat cycles) after calving, followed by breeding and establishment of pregnancy, the target six-week calving rate is achievable.

Given that the main driver of calf pre-weaning gain is cow milk yield, emphasis should be placed on selecting cow genotypes with good milk production and selecting sires with a high genetic potential for daughter milk yield. In addition to producing heavier calves at weaning, Teagasc Grange studies have shown that calves from cow breed types with higher milk yields, have superior passive immunity, mediated through improved colostrum production, which means fewer health-related problems and associated treatments in the calves. It is therefore imperative that selection for good milk production potential is incorporated into any breeding decisions being made on-farm. Although ADG from birth-to-weaning is largely a reflection of the milk yield of the cow, it is important to recognise that, increasingly, as the calf gets older, grass supply and its nutritive value become more important.

Recent updates from Pasture Base Ireland have indicated that many Irish beef farms are capable of achieving yields in excess of 12 tonnes of grass DM per hectare each year, under optimum soil fertility. However, soil analysis results from Irish grassland farms indicate that 90% of samples have sub-optimal fertility. On drystock farms in particular, the analysis showed that soils were highly deficient in lime and below adequate levels for phosphorous (P) and potassium (K). Correcting soil fertility to maximise the grass growth potential of each individual farm can only be done with the aid of a recent soil test. Once soil fertility is corrected, and grass growth potential can be realised, good grassland management practices should be carried out to ensure the highest levels of utilisation.

An annual feed budget should be developed in order to quantify the feed demands of the

herd throughout the year. Grass conservation needs to be planned; the quantity and quality of grass silage required to maintain target animal performance for all animals over the winter period, including provision for exceptional winter/summer conserved feeding periods, should be estimated (See page 148). Within suckler beef systems a key objective in terms of cow nutrition is the mobilisation and deposition of body fat reserves. This is achieved by increasing BCS during the grazing season with cheaper grass, and 'utilising' some of these body reserves throughout the expensive winter period; for spring-calving cows in good BCS (3.5, scale 0-5) at housing in autumn and offered moderate 'quality' (DMD, 68%) grass silage *ad libitum*, feed savings over the indoor winter period of up to 25%, equivalent to 1.0 to 1.5 tonnes fresh weight of grass silage, can be achieved in this manner, compared to those in poor BCS (e.g. 2.5) at housing.

Using a rotational grazing system will help facilitate and ensure that grass supply and quality is managed correctly. It is important to utilise grazing management tools such as grass measuring and budgeting which allow for the early identification of surpluses and deficits in supply throughout the season. This helps maintain high herbage nutritive value over the grazing season, and thus high animal performance. Additionally, removal of excess herbage as conserved forage (pit or bales) ensures maximum utilisation of grass grown whilst also providing additional winter feed. Variability in seasonal weather patterns annually means accessing grazed grass can often be a challenge, especially in spring and autumn. In this regard, adequate grazing infrastructure such as paddocks with multiple access points and farm roadways are worthwhile investments.

Environmental sustainability

An increasingly important measure of the performance of food production systems is environmental sustainability. The primary concern globally is the capacity to meet food demand from ever-scarcer resources whilst minimising adverse environmental impacts such as greenhouse gas (GHG) emissions. The ability of suckler beef systems to convert grasslands to high quality human-edible proteins can be viewed as an important strength of Irish beef systems; however, greater emphasis has been placed by consumers and thus, policy-makers on the contribution of suckler beef production to environmental emissions, particularly GHG emissions, in recent years. This gives emphasis to the significance of efficient production systems in terms of both 'reproductive' and 'productive' performance as described above. Methane output as a result of enteric fermentation contributes greatly to the emissions profile of ruminant production systems. Through increasing the efficiency of suckler beef systems the relative contribution of methane per kg beef output is reduced.. Within the context of suckler calf-to-weanling systems reducing the number of 'unproductive' female animals by lowering the age at first calving and increasing the calves per cow per year, achieves this. Research at Teagasc, Grange, has shown that for every percentage unit increase in the metric 'calves per cow per year' there is a reduction of 0.8% greenhouse gas emissions per kg of beef produced. Additionally, any increase in ADG of suckler-bred cattle, which ultimately reduces age at slaughter, lowers the emissions profile of suckler beef farms. This further reinforces the point that pasture-based suckler beef production must be underpinned by high levels of individual animal efficiency in order to maximise both profitability and environmental sustainability.

Acknowledgements: The contribution of Paul Crosson is acknowledged.

Key performance indicators for dairy calf-to-beef systems

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²Teagasc, Kells Road, Kilkenny

Summary

- Male Holstein-Friesian and early-maturing breed (Angus and Hereford) dairy crossbred calves represent 85% of calves from the dairy herd available for beef production.
- Dairy calf-to-beef production systems can be profitable; however, key performance targets must be achieved, particularly during the calf stage.
- Pasture-based steer production systems can produce carcasses that have adequate weight and fat cover at slaughter.
- Utilisation of high quantities of pasture and high animal output per hectare are fundamental to profitable production systems.

Introduction

Growth in the national dairy cow population will result in a proportional increase in the number of dairy calves available for beef production. Approximately 370,000 dairy calves born are destined as replacements heifers within the dairy herd, with the remainder (circa. 900,000) available for beef production. Male Holstein-Friesian calves and early-maturing breed (Angus and Hereford) dairy crossbred calves represent 85% of the dairy-bred calves considered for beef production (Figure 1); Limousin (circa. 60,000 calves) is the dominant 'continental' breed used on the dairy herd. Mean age at slaughter nationally for steers from the dairy herd is 29 months. Improvements in Irish dairy-beef production can be made by enhancing efficiency within the farm gate and reducing the age at slaughter. Low dairy calf price in spring 2018 has generated significant interest in dairy calf-to-beef production systems.

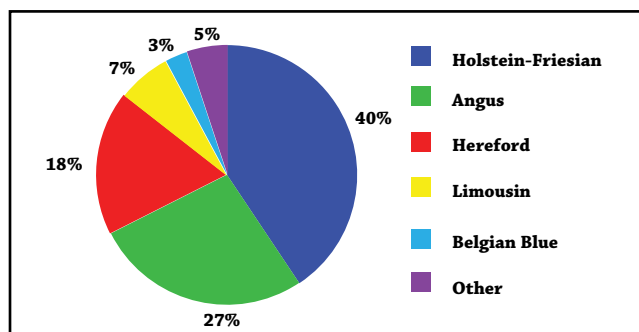


Figure 1. Sire breed profile of calves generated from the dairy herd that are available for beef production (Animal Identification and Movement, 2018).

Although dairy calf-to-beef systems have the potential to be profitable, key targets must be achieved to ensure high levels of animal performance throughout the production cycle. For this to be accomplished, dairy calf-to-beef producers must know the target live weights at critical points in the production cycle (i.e. first housing, turnout, etc.), establish a stocking rate that matches the grass growth potential of the farm and ideally purchase calves from a known dairy producer that has a high herd health status. Calves with poor levels of immunity and/or having suboptimal performance, have a lower average daily live weight gain (ADG), a consequent reduction in carcass weight at a fixed slaughter date, take longer to 'finish', and may be ineligible for quality assurance payments. This, in turn, can mean more health-related treatments, increases the dependence on concentrate feed input, reduces the stock carrying capacity of the farm, alters the intended sale date of the animals and, ultimately, reduces profit. Animal performance targets are achievable but these objectives can only be accomplished by starting from the early calthood stage. During the calf-rearing period, management of Holstein-Friesian calves and early-maturing breed dairy crossbred heifer and bull calves are identical.

For the purposes of this paper, it is assumed that calves are spring-born and produced as steers; the production systems operated i.e. 23-month early-maturing crossbred and 24-month Holstein-Friesian - indoor finishing during the 'second' winter, and 26-month early-maturing crossbred and 28-month Holstein-Friesian steer - pasture-based finishing during the 'third' grazing season, are described below. The target ADG and live weights at critical points of production are outlined in Table 1. However, key performance indicators, particularly during the calthood stage (i.e. calf rearing and the first season at pasture), must be achieved in order to reach the targets outlined. The 'finishing' targets for the production systems are:

Table 1. Average daily gains and live weight targets of Holstein-Friesian steers.

	24-month Holstein-Friesian steer		28-month Holstein-Friesian steer	
	Average daily gain (kg)	Live-weight (kg)	Average daily gain (kg)	Live-weight (kg)
Weaned calf	-	85	-	85
First season at pasture	0.80	230	0.80	230
First winter	0.70	320	0.70	320
Second season at pasture	0.90	530	0.90	530
Second winter	1.00	620	0.50	580
Third season at pasture	-	-	1.20	680

Key performance periods for dairy beef production

1. Calf rearing

Calf rearing is one of the most critical times for dairy calf-to-beef systems, and is also the most labour-intensive task for producers. Labour input and costs increase where facilities are not conducive to calf rearing. Nutritional, health and environmental factors imposed during the calf rearing phase have been shown to affect subsequent performance. Firstly, housing facilities should be well-ventilated and draught free and calf pens should be prepared prior

to calf arrival. Calves should be sourced from dairy farms that feed calves adequate levels of colostrum at birth and have a high herd health status. Upon arrival, calves should be housed according to the groups in which they arrived and offered two litres of electrolytes per head. During the rearing phase calves should be allocated the correct amount of milk replacer (as per manufacturer's guidelines) and be fed at the same time(s) each day. It is essential that the water temperature is not greater than 45°C for mixing with milk replacer. Slow drinkers/timid calves should be removed and grouped in a separate pen. Coarse calf 'starter' ration, hay/ straw and fresh water should be freely available. From three weeks of age calves can be fed once daily - this significantly reduces the labour input. Calves should be weaned on a weight, rather than an age basis; target weaning weight is 85 kg. Successful calf rearing enterprises have equipment such as water heaters, carts to transport the milk replacer to the calf rearing unit, milk feeders with multiple teats to batch-feed calves, and concentrate feeders that protect the ration from vermin. This equipment ensures consistency in the calf rearing process and is also labour efficient (see page 88).

2. Calf performance - first grazing season

Once weaned, calves are turned out to grass in late-April/ early-May and supplemented with 1 kg of concentrate dry matter (DM) per head daily for 2 weeks. They then remain on a pasture-only diet until early-September. Around this time they are (again) supplemented with 1 kg of concentrate DM daily for 6 to 8 weeks until housing. It is critical that good pasture management is maintained throughout the grazing season to ensure that a high level of animal performance is achieved. Calves should be grazing pasture covers of 1200 kg DM/ha (approximately 10 cm in height). Although calves can graze independently to a post-grazing residual of 4.5 to 5.0 cm, a leader-follower rotational grazing system can also be carried out with older cattle. When grass growth exceeds demand, surplus pasture should be removed as baled silage.

It is essential that attention to detail is given to parasitic infections when calves are at pasture. The three main parasites to be controlled are stomach worms, lungworms and liver fluke. Fresh dung samples (from 10 to 15 calves) should be collected approximately eight weeks after turnout and sent to a laboratory to determine the faecal egg count (FEC). Treatment for internal parasites of calves can be administered orally, by using a 'pour-on' product or by injection, and is required when FEC is greater than 200 eggs per gram. Follow manufacturer's guidelines and/or consult with a veterinary practice for guidelines on establishing a treatment regime. Calves should be moved to another paddock four to seven days after treatment. The target ADG for a calf during their first grazing season is 0.80 kg with a live weight target at housing of 230 kg for February-born calves. For later-born (i.e. April/May born) calves, the target live weight at housing is 190 kg.

3. First indoor winter

During the winter indoor period calves are offered good quality (>70% DM digestibility, DMD) grass silage *ad-libitum* supplemented with ca. 1.5 of concentrate DM per head daily, depending on silage quality. The ADG achieved during the first winter is 0.70 kg. If silage DMD is 65% the concentrate allowance increases to ca. 2.5 kg DM per head daily.

4. Steers at pasture – second grazing season

Typically 'yearling' February-born steers are turned out to pasture at 320 kg in mid-March and offered grazed pasture until housing. Throughout the grazing season pasture management should be maintained to optimise animal performance and ensure high-quality herbage is

available. The target ADG for steers during the second season at pasture is 0.90 kg. If a leader-follower system is used the ADG will be lower, ca. 0.85 kg. Steers should be grazing pasture covers of 1200 to 1400 kg DM/ha (approximately 10 cm in height) and graze to a post-grazing residual of 4.0 to 4.5 cm. Steers should be monitored for signs of worms (failure to meet growth targets, scour, faecal egg count) and treated if required. The highest risk period is in the second half of the grazing season when worm larvae have built up on pasture. Surplus pasture should be removed as baled silage. Steers are housed in November at a target weight of 530 kg.

23 and 24-month steer system: In these systems steers are finished indoors during the second winter on high-quality (72% DMD) grass silage *ad-libitum* plus 5 kg of concentrate DM per head daily. The finishing period for the 24-month Holstein-Friesian system is approximately 100 days. The target live weight at slaughter is 620 kg, resulting in a 320 kg carcass weight. During this period ADG is 1.00 kg. Carcass conformation and fat score are 'O=' and '3=', respectively. The finishing period for the early-maturing dairy crossbred steer is approximately 85 days; these animals can be slaughtered earlier as they will have an acceptable carcass fat cover (3-) at a younger age. Target carcass weight is 300 kg, and carcass conformation and fat score is 'O+' and '3+', respectively.

Store period for 26-28 month steer systems: Steers in this system are offered only high quality (72% DMD) grass silage *ad-libitum* for the second winter. During this period steers in the '28-month system' have an ADG of 0.50 kg.

26 and 28-month steer systems: Steers in these systems are turned out to pasture in March for a 'third' grazing season, and slaughtered in May/June. Average daily gain during this time is 1.2 kg. In the 28-month Holstein-Friesian system steers achieve a carcass weight of 350 kg and carcass conformation and fat scores are 'O=' and '3=', respectively. Finishing steers off pasture during the third grazing season is particularly advantageous for 'late-born' (April/May) calves, which are usually the early-maturing crossbreds. Systems where late-born steers are finished during the second winter incur higher winter finishing costs and have lighter carcasses at slaughter than their early-born counterparts. Results from Johnstown Castle showed that April-born early-maturing dairy crossbred steers finished indoors during the second winter and slaughtered at 21 months of age had a 39 kg lighter carcass weight than steers slaughtered at 23 months of age. Typically these 'late-born' steers are 26 months of age at slaughter when they are finished during the third grazing season. The target live weight at slaughter for the 26-month early-maturing crossbred system is 620 kg with a carcass weight of 320 kg; target carcass conformation and fat scores are 'O+' and '3+', respectively.

5. Feed inputs

A key element of profitable dairy calf-to-beef systems is the efficient utilisation of grazed pasture. The systems have different requirements for grazed herbage per head ranging from 2.5 t DM for the 24-month steer system to 4.3 t DM for the 28-month steer system (Figure 2). At a stocking rate of 200 kg organic N per hectare (ha), 2.5 and 2.0 livestock units (LU)/ha for the 24-month and 28-month steer systems, respectively, and assuming excellent grass utilisation, the farm would need to grow 10.1 t DM/ha and 11.6 t DM/ha for each system, respectively. Thus, the capacity of the farm to grow grass will largely dictate the stock carrying potential of the farm. Lifetime concentrate input for the 24 month Holstein-Friesian steer system is 1 tonne, and 500 kg for steers slaughtered at 28 months of age.

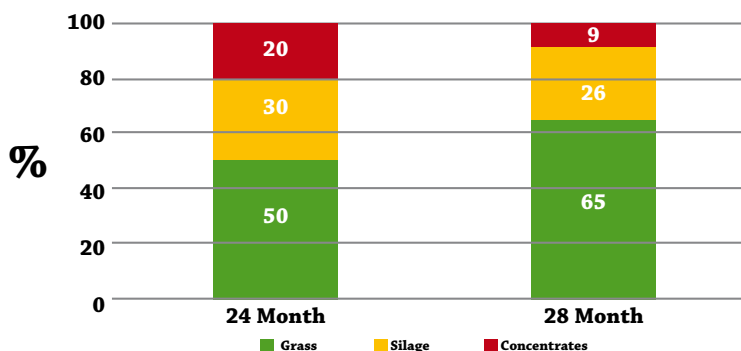


Figure 2. Proportion of grazed grass, silage and concentrate DM in the feed budget of 24-month steer and 28-month steer systems.

Economics of the systems

Where the key performance indicators described earlier are achieved, farm profit is maximised. Figure 3 shows the net margin that can be achieved from the 24-month and 28-month steer production systems for Holstein-Friesian steers, and the 23-month and 26-month early-maturing dairy crossbred steer systems based on a 40-ha farm. Price assumptions were: male Holstein-Friesian calf purchase price, €100; early-maturing dairy crossbred bull calf, €270; a base beef price, €4.00/kg; and, finishing concentrate price, €255/tonne. Actual beef price payable depends on carcass grading, seasonality (beef price being highest in May and lowest in September) and eligibility for Quality Assurance bonus. 'Breed bonuses' were included for early-maturing dairy crossbred production systems. The impact of sub-optimal growth performance during the first season at pasture (i.e. <0.70 vs. >0.70 kg ADG, equivalent to a mean ADG of 0.59 and 0.81 kg, respectively) was also investigated for the 24-month Holstein-Friesian steer system. Results clearly indicated that variation in profit exists between production systems (Figure 3). Although the 24-month Holstein-Friesian and 23-month early-maturing steer production systems were profitable, the systems where steers were slaughtered at an older age, during their third grazing season, were more profitable. This difference can be largely attributed to the lower proportion of concentrate in the feed budget and the greater beef price in May/June, despite the lower stocking rate in these systems. Differences in net profit between Holstein-Friesian and early-maturing steers were marginal. However, if early-maturing 'breed bonuses' were excluded from the analysis, the net margin would decrease by approximately 20%.

Recent research at Johnstown Castle has shown that Holstein-Friesian calves in the 24-month steer production system that had an ADG <0.70 kg (i.e. 'poor-performing') were 40 kg lighter at the end of the first grazing season than calves that had ADG >0.70 kg. Subsequent performance between the two groups was similar i.e. no compensatory growth occurred in the calves with low ADG during the first grazing season. This meant that carcass weight was 19 kg lighter, and additionally carcasses were leaner (fat score, 3- vs. 3=), for calves that had low levels of performance during the first grazing season. Carcass conformation was similar for both groups. Figure 3 also shows the impact on net margin on a 40-ha farm when optimum performance of Holstein-Friesian calves during the first grazing season is not achieved; net margin decreased by €3,800, a 20% reduction. This emphasises the importance of early-life calf management. To avoid this loss of net margin, purchase calves from dairy farms with a

high health status, ensure that calves are fed the correct levels of milk replacer during the rearing phase and that they have free access to water and concentrate during the rearing phase. The blueprints described above for the first season at pasture should also be adhered to.

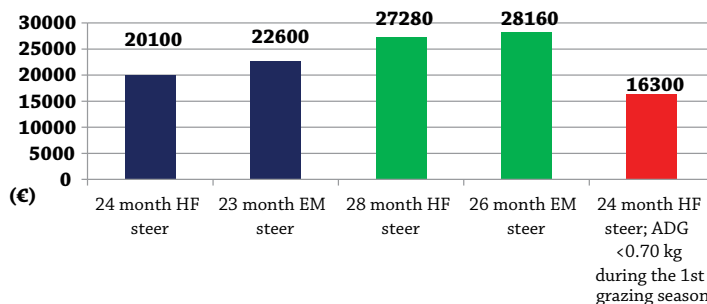


Figure 3. Net margin of dairy calf-to-beef production systems based on a 40 hectare model farm. HF= Holstein-Friesian and EM= early-maturing (Angus and Hereford dairy crossbred animals), ADG = average daily gain.

Farm management and cash flow

From a farm management (utilisation of grazed grass and silage, availability of housing etc.) and cash flow perspective, beef producers normally operate more than one production system. This ensures a number of sale dates throughout the year. Even with the most profitable production systems, operating a single system can be a challenge. For example, if a beef producer operates a 24-month steer production system, grass demand in the spring is low because yearlings will be approximately 320 kg at turnout and spring-born calves will have no demand for grazed grass until turnout in May. In this scenario having a proportion of steers carried through the second winter and slaughtered during their 'third' season at pasture would complement the 24-month steer system. This would also result in a sale date for these animals that typically coincides with higher beef prices in May/June.

Greenhouse gas emissions

Concerns regarding global warming and climate change have led to increased scrutiny of agricultural production systems. Slaughtering animals at a younger age reduces GHG emissions per animal finished and per kg of carcass. Greenhouse gas emissions, on a per kg carcass weight basis were lower for 24-month Holstein-Friesian than 28-month steer systems (14.2 and 15.8 kg CO₂ equivalent per kg beef carcass, respectively).

Conclusion

Various production systems can be employed on dairy calf-to-beef enterprises depending on the breed type and finishing system. The most profitable systems are those that optimise animal performance from grazed pasture and achieve a high proportion of total life time gain from grazed grass. Although farm profit is vulnerable to increases in concentrate input costs and calf purchase price, as well as the selling price of beef, achieving key performance indicators, particularly during the calf rearing phase and when the calf is at pasture for the first grazing season, have the potential to improve farm profit. It is also critical to realise that farm profit varies depending on the production system that is operated, irrespective of the breed of the calf that is purchased.

Genetics create the potential; management realises that potential

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Summary

- The performance of an animal is a function of the previous generations of breeding as well as the management to which the individual (and dam) has been exposed.
- Analysis of national data shows that both the Terminal Index and Replacement Index values of animals translate into superior performance and more profit.
- Bull star ratings can change over time as more data accumulate contributing to a more reliable genetic evaluation for that bull.
- Currently many of the key reproduction efficiency targets are not being met at farm level. Better planning and management practises could greatly improve this situation.
- The increased use of AI in suckler herds would offer better genetic choice and reliability at modest cost.

Introduction

The performance of an animal is dependent not only on its genetic potential, but also the management to which it (and its dam) was and is currently exposed. The contribution of genetics to differences in a range of performance traits is shown in Table 1. Many of the performance metrics in need of significant improvement in Irish beef cattle relate to the performance of the suckler cow herd. Improved reproductive performance not only impacts the cow herself, but also the performance of the offspring and especially the profitability of the enterprise. The average percentage of cows and heifers calving in February and March is just 34%, whereas the target needed to maximise the utilisation of grazed grass is 80%. Even when calving does start in spring in the suckler herd, it is protracted with only 56% of cows calved in the first 6 weeks after calving commences.

Table 1. Key targets for a selection of performance traits as well the contribution of genetics to differences in performance of the traits

Trait	Current	Industry target 2025	Teagasc target	Genetic contribution
Calving interval (days)	400	397	365	3%
Calving between Feb & Mar (%)	34	55	80	3%
Cows/heifers calving in 3 months (%)	70	85	100	3%
Heifers calving at 23-26 months of age (%)	24	25	100	31%
Replacement rate (%)	21	21	16	2%
Calves/cow/year	0.85	0.85	0.95	3%
Steer carcass weight (kg)	353	355	395	40%
Steer age at slaughter (months)	28	27	22	24%
Heifer carcass weight (kg)	307	320	334	40%
Heifer age at slaughter (months)	26	25	20	24%
Mean carcass grade	R=3=	R=3=	R+3=	35%
Carcass output (kg/ha)	230	273	555	

The Irish national breeding indexes

The contribution of genetic selection to gains in performance is well acknowledged for a whole variety of traits in a range of species; animal breeding, however, is also (rightfully) criticised for its contribution to deterioration in some performance traits. The main benefit of breeding is that it is cumulative and permanent and, as such, the performance of the current population of animals is attributable to breeding decisions made in past decades; this, however, is also a drawback of breeding. For example, failing to remain focused when selecting a bull can have lasting adverse consequences for the herd. Two beef breeding indexes exist in Ireland to aid farmers in selecting genetically elite parents of the next generation of animals for enhanced profit. These are the Terminal Index and the Replacement Index. Each index is comprised of different traits and the relative emphasis of each trait in the indexes is illustrated in Figure 2; the Terminal Index is composed of the ‘revenue-generating’ trait, carcass merit (i.e., carcass weight, conformation and fat score), and the ‘cost of production’ traits, feed intake, docility and calving (the latter made up of calving difficulty, gestation length and calf mortality).

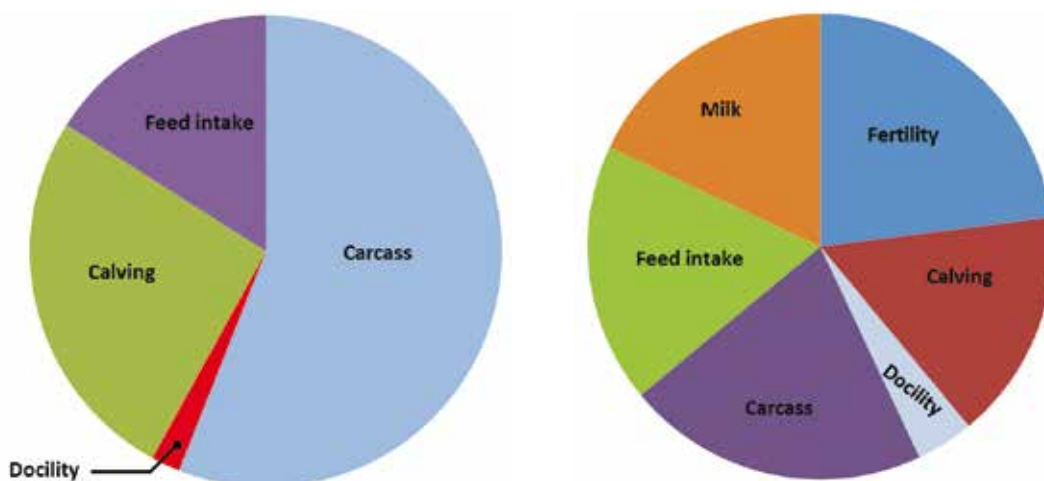


Figure 2. Relative emphasis of different suites of traits in the Terminal Index (left) and Replacement Index (right).

Terminal traits also form part of the Replacement Index (but at a much smaller proportion compared to the Terminal Index) in addition to milk yield, feed intake of the cow, fertility, docility and calving performance. Animals excelling in index value are expected to produce progeny that are, on average, more profitable. A bull with a Terminal Index of €200 is expected to produce progeny for slaughter that are, on average, worth €100 more than the progeny of a bull with a Terminal Index of €100. This extra profit originates from all the components of the Terminal Index and not necessarily just greater carcass value. A bull with a Replacement Index value of €300 is expected to produce a heifer calf that is worth €100 more as a cow than the daughters of a bull with a Replacement Index of €200.

Animals are allocated ‘star’ ratings depending on their index value relative to that of the population (Table 2). Stars can be both within-breeds and across-breeds. Within-breed stars rank purebred animals against other purebreds from the same breed; across-breed stars rank animals against all other animals – commercial animals only receive across-breed stars.

Table 2. Explanation of the star ranking system

Euro-Star ranking		
★★★★★	5 stars	Animal index in the top 20%
★★★★	4 stars	Animal index in the top 20-40%
★★★	3 stars	Average animal index
★★	2 stars	Animal index in the bottom 20-40%
★	1 star	Animal index in the bottom 20%

Why do star indexes move?

The genetic index of an animal is generated from information on 1) its parents and ancestors, 2) the animal itself, and 3) its progeny and descendants. The greater the quantity of information available, the more accurate is the star index. The accuracy of the index of an animal, male or female, is reflected in the reliability value associated with each star rating; the higher the reliability, the less likely that the index value of an animal will 'move'. The reliability of a newborn calf is simply a quarter the reliability of the sire plus a quarter of the reliability of the dam. The reliability of most beef calves from an AI sire (assuming the sire is recorded) is approximately 25%; the reliability of calves born from stock bulls is generally lower. The main objective of using DNA-testing (i.e., genomic testing) through the ear tissue tags is to look directly at the animal's genes to increase the reliability of its star ratings. This improvement in reliability is achieved by 1) correcting parentage errors of the animal itself but also herd contemporaries and 2) obtaining a more accurate direct depiction of the genes of an animal rather than calculating them based on the performance of relatives. Genomics is used widely in the global dairy industry with the vast majority of semen used being from young DNA-tested bulls in countries with genomic programs; developments in genomics in beef were slower internationally but genomics is now being used in the beef industry in many countries.

The improved reliability of genetic evaluations translates into less movement in animal indexes over time as more data accumulate; genomics does not, however, halt the movement, it just lessens it. As an animal accumulates more information either itself or through relatives, the reliability increases further and the possible extent of movement in an animal's index reduces. The reliability of the Terminal Index increases faster than the reliability of the Replacement Index and only older bulls actually achieve a very high reliability; cows will generally never achieve high reliability as they will never have sufficient progeny. While the index of individual animals can move, it is generally a particular group of animals (e.g., heifers or cows) that is of most interest. The average genetic merit of a group of animals tends to remain constant over time; this is because all animals have an equal likelihood of increasing in index value as they do of decreasing.

How can I have twin calves and one is a five-star and the other is a one-star?

The answer to this question is based on the theory of inheritance of genes. Although every individual gets half their genes from their father and half from their mother, each half is actually a relatively random half; in fact two full sibs could be genetically completely unrelated. Non-identical twins occur when the dam has a multiple ovulation and thus is essentially very

similar to two calves from the same sire-dam born over consecutive years (sharing a common uterine and post-natal environment, as would be the case in twins, does however affect performance). If the threshold in Replacement Index determining a one-star is <€43 and the threshold determining a five-star is >€96, then a calf born with a Replacement Index of €70 and reliability of 30% has a 10% probability of being a one-star animal when genotyped and a 11% chance of being a five-star when genotyped. When the animal is eventually proven (i.e., 99% reliability), there is a 25% probability of the animal being a one-star animal and a 26% chance of it being a five-star. For twins, both with a €70 replacement index at 30% reliability, there is a 2% chance that one will be a one-star and the other will be a five-star once genotyped. There is, however, an 8% chance that one will be a five-star and the other will be a two-star or worse once genotyped. Therefore, genetic merit can differ substantially even among non-identical twins or calves born from the same sire-dam combination.

Evidence of indexes translating into profit

While the actual differences in performance from animals differing in genetic merit has been well-proven across a range of species, constant re-evaluation is always desirable. To this end, the validation of the Replacement Index using Irish data is summarised in Table 3. Clearly large differences in performance exist with the genetically-elite animals outperforming their genetically inferior contemporaries.

Table 3. Performance of 97,723 cows born in 2008 and now in herds that joined the beef data genomics programme in 2015.

5 Star v 1 Star Cows										
BDGP Cows			Fertility				Milk		Carcass	
ICBF Euro-Stars	Replacement Index	Number of cows	Number of Calvings	Age at 1 st Calving (days)	Calving Interval (days)	% Alive after 7 years	Growth of Calves	Farmer Milk Score	Carcass Weight of progeny (kgs)	Age at slaughter of progeny (days)
★★★★★	€124	25,311	4.33	971	399	72%	1.17	4.11	363	752
★★★★	€85	19,776	4.03	988	405	66%	1.12	3.86	359	772
★★★	€64	16,020	3.82	1000	409	62%	1.09	3.75	358	784
★★	€44	16,823	3.71	1007	413	59%	1.09	3.69	358	783
★	€8	19,793	3.46	1022	420	52%	1.06	3.48	359	791
Difference			+0.87	-51	-21	+20%	+10%	+15%	+4	-39

A need for better management

Table 3 clearly shows that enhanced genetics will lead to greater profitability. Genetics provides the potential but it takes good management to realise this potential. Many of the key reproductive indicators in Table 1 within our suckler herd are currently not being achieved. A large component of such inefficiencies can be attributed to suboptimal management practises. Age at puberty, age at first calving, anoestrous interval post-calving which are key components of reproductive efficiency can all be reduced through planning and good management. Currently only 24% of heifers calve down for the first time between 22 and 26 months. If this figure is to improve we need to achieve the targets specified in Table 1 and discussed below: this involves planning.

Calving heifers at 24 months of age

Analysis carried out at Teagasc, Grange has clearly shown that the most profitable age to calve heifers is 24 months; for a 50-cow herd calving 10 heifers, each additional month delay in age at first calving costs €490. There is a widespread perception that it is not possible to calve beef heifers at 24 months of age. There is also the notion that heifers that calve at 2 years of age, do not calve again at 3 years of age. The evidence, however, does not support this (Table 4). Heifers that calved at 23 to 26 months had as good a calving interval and calved again as frequently for the second time as heifers that calved for the first time at an older age. Another reason often cited for not calving at 24 months of age is that calving difficulty is greater when calving at 2 years of age. While the figures do show that younger calving heifers do have slightly higher calf mortality, heifers, irrespective of age will be more difficult to calve than cows and as the figures show will need a high level of assistance at calving. More selective use of sires (i.e., easier calving, high reliability) on heifers could help ameliorate such calving difficulty. The younger-calving heifers were mated with sires with an average calving difficulty of 4.7%. The level of sire genetic merit for calving difficulty used by dairy farmers on heifers calving down at two years of age is 2% or less. The recommendation for beef heifers is to use high reliability (>70% reliability) bulls with a calving difficulty no more than 4%.

Table 4. Statistics for beef-cross females calving for the first time at different ages

Age at first calving (mths)	Average calving interval (days)	% Calving for second time	Average calving difficulty of bulls used on heifers (%)	% of heifers calving unassisted	Calf mortality at first calving (%)
23-26	383	85%	4.7	50	3.2
27-30	394	84%	5.1	53	2.8
31-35	392	88%	5.2	58	2.6
36-40	386	86%	5.2	57	2.0

Performance targets for heifers calving at 24 months

Target growth rates and live weights are outlined in Table 5 for replacement heifers.

- *Birth-to-weaning* – If the heifers are selected from the 'best' cows 1.1 kg/day up to weaning is easily achievable with good grassland and animal health management.
- *Weaning-to-turnout* – Often weaning will coincide with housing so heifers should be introduced to 1 to 2 kg concentrate/head daily prior to weaning. Once weaned, good quality silage plus up to 2 kg concentrate per daily will be required to achieve the 0.6kg live weight/day required. This is the stage where animals are most likely to fall behind target because of poor quality silage, inadequate supplementation etc.
- *Turnout-to-mating* – Early turnout to pasture is essential for heifers in order to gain around 60 kg live weight prior to mating. In practise this means a February/March turnout for heifers to be mated in April/May. Sire selection is hugely important so you should select a proven sire with a calving difficulty of $\leq 4\%$.
- *Mating-to-housing for second winter* – Once in-calf, the target is to keep heifers 'well grazed' up to housing. Heifers that achieve 0.8 kg live weight/day for the remainder of the grazing season will achieve their target weight for calving down and will only require modest performance up to calving.
- *Housing-to-calving* – Heifers that are on target can be maintained on good quality silage and, provided they are gaining at least 0.3 kg/day, they should maintain body condition.

They should receive pre-calver minerals in the 6 to 8 weeks pre-calving. Body condition should be monitored to avoid heifers becoming over-fat or too thin.

- *Post-calving* – How a heifer is managed post-calving could affect the length of time before resumption of oestrus. If they are turned out to good ‘quality’ grass within a few weeks of calving they will begin to gain weight quickly. Heifers that are calved and remain indoors for 4 weeks or more will need supplementation with 1.5 to 2 kg/day of concentrates up to turnout just to maintain body condition.

Table 5. Performance targets for heifers calving at 24 months of age (Cow mature weight, 700kg)

Stage	Age (Mths)	ADG (kg)	Target weight (kg)	
Birth	0		45	
Weaning/Housing	7	1.1	275	
Turnout	12	0.6	365	
Bulling	15	1.0	425	60% mature Wt.
Housing second winter	20	0.8	570	
Calving	24		560-580	80% Mature Wt.
Overall lifetime ADG required		0.72 kg		

Should we look to increase AI usage?

The average number of cows calving in national suckler herds per annum is 17; ranging from a high of 28 cows in Waterford to a low of 12 cows in Leitrim and Donegal. Herd size impacts the breeding program achievable. Nonetheless, irrespective of herd size, execution of a successful AI program is still possible. Despite this, only 24% of calves born in the suckler herd currently are sired from AI sires; the comparable figure in dairying is 60%. It is very difficult for smaller herds to justify large expenditure on a stock bull. A farmer paying €3000 for a stock bull producing 20 calves annually over 4 years costs €45/calf; this rises to €57/calf if the bull cost is €4000. Key factors to achieving a successful AI program on beef farms is to; ensure that heifers reach puberty early; cows start cycling early post-calving and subsequently conceive and establish pregnancy early in the breeding season. Using AI provides smaller herds with a greater selection of sires at a reasonable cost. The current Active AI list for Replacement Index for the top 30 bulls shows that they have an average Replacement Index value of €158, a reliability of 73%, and a calving difficulty of 4.54%, and a straw price of €16.26. Breeding the average bull on this list with the average Irish suckler cow (Replacement Index value is currently €78) would result in progeny with an average replacement value of €118, which is well ahead of the €82 replacement value of heifers in 2017. It is therefore evident that we are not maximising potential genetic gain. AI is successfully used in the Teagasc Maternal, Derrypatrick and Newford Herds using teaser bulls, tail painting, regular observation and fixed-time AI. The success is aided by having the correct infrastructure in place to facilitate easy movement of cows in the yard. To get the most from AI, a team of bulls that will correct or enhance the traits in the herd should be identified.

Conclusions

The use of high Replacement Index bulls has been proven to contribute to greater overall profitability. High Replacement Index bulls with good reliability are readily available through AI. For smaller herds using AI offers the option to introduce superior high-reliability genetics at modest cost.

Capturing the potential of grazed grass on Irish beef farms

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Summary

- Profitable beef production is based on the provision of sufficient quantities of high quality pasture to produce quality beef at a minimum cost.
- Increasing grass utilisation, farm stocking rate and the number of grazings achieved on the farm are the main drivers of increased grazing efficiency.
- One tonne increase in grass dry matter (DM)/ha utilised is worth €105/ha.
- Target soil fertility is pH 6.3, phosphorus (P) Index 3 (5.1–8.1 mg/l), potassium (K) Index 3 (101–150 mg/l).
- Each additional day at grass in spring can save up to €1.54 in feed costs/animal.
- Mid-season management should focus on offering high quality leafy swards which can sustain high grass DM intake and animal performance.
- White clover can reduce N fertiliser inputs and increase overall herbage production.

Introduction

Irish beef farmers have a competitive advantage over many of their European counterparts, due to the ability to grow and utilise high quantities of grazed grass. On average the cost of producing 1 kg of live weight (LW) in Ireland from grass is 80 to 85% less than that from an intensive concentrate-based system. It is imperative that Irish beef farmers take advantage of this cost advantage. In Ireland, when a suckler calf is weaned from the cow, there is potential to deliver 80% of its liveweight gain from weaning-to-slaughter from grass.

The optimum stocking rate for an individual farm is that which maximises profitability and is dependent on that farm's grass growth capability. While every farm situation is unique with varying soil types, local climatic conditions, stocking rates and farmer management capabilities, many Irish farms are only producing 50% of their grass growth capability and therefore, grass production is limiting output on most farms. Stocking rates on Irish beef farms are generally quite low (1.2 livestock units (LU)/ha on average [NFS, 2016]). In a low stocking rate system, grass utilisation is reduced as there is insufficient livestock on farms to take advantage of the natural grass growth curve. Teagasc Grange has set a target of 956 kg LW/ha as a benchmark to increase profitability on Irish beef farms. One of the key drivers of LW output/ha is grass utilised/ha; every additional tonne of grass DM utilised/ha is worth an extra €105/ha. On average the current amount of grass utilised on Irish beef farms is 5.4 t DM/ha/year, with a range of 4.7 and 7.8 t DM/ha. This paper discusses management strategies required on Irish beef farms to increase grass growth and utilisation in three key areas, soil fertility, seasonal grassland management and the role of white clover.

Improving soil fertility on Irish beef farms

For farmers aiming to grow the maximum amount of grass DM/ha, one of the most important components that must be correct is soil fertility. Managing soil fertility should be a major focus for Irish grassland farmers. The three key requirements when it comes to soil fertility are phosphorous (P), potassium (K) and soil pH (lime). Approximately 90% of the soil samples taken from Irish farms are limiting in one of the three major soil nutrients (P, K and/or lime). Nitrogen (N) fertiliser will facilitate some increase in grass growth; however, if soil fertility is not corrected, additional N fertiliser will not compensate. The most limiting factor in soil fertility will limit overall grass production, so a key step in identifying a deficit in soil fertility is regular soil testing. Intensively-managed farms need to be soil tested every two years, to identify nutrient-deficient paddocks, and develop appropriate fertiliser programmes.

Soil pH affects the availability and uptake of both major and trace elements by crops. The ideal pH for grass growth, N release and P and K availability is 6.3. Liming increases soil pH which stimulates the release of N from soil organic matter. Applying lime to increase soil pH will increase nutrient uptake and grass DM yield, and improve the long-term persistency of perennial ryegrass and clover in the sward. Recent research illustrates that 5 t/ha of lime applied to a soil with low pH (5.3) increased grass production by a total of approximately 1.5 t DM/ha in the following two years. Previous research on a soil with low pH (5.3) and old permanent pasture indicated that the application of 7.5 t of lime/ha increased the stock carrying capacity by 20% by the end of the first year and by 100% in the fourth year. Lime application was estimated to be equivalent in benefit to using approximately 72 kg/ha (60 units/ac) of N fertiliser per year or two bags of calcium ammonium nitrate (CAN).

The target soil index for P is Index 3 (5.1–8.1 mg/l) and for K is Index 3 (101–150 mg/l), with high values within Index 3, preferred. However, only about 30% of soils are in the agronomically optimum Index 3 range for P and K. Current trends in soil P and K levels nationally indicate a decline from higher and more productive Index 3 and 4 soils to low fertility Indexes 1 and 2. Organic manure is the cheapest form of fertiliser available to livestock farmers and therefore, its use must be optimised. The fertiliser value of cattle slurry is equivalent to approximately 6.3 and 37.5 kg/ha of P and K (5 and 30 units/acre), respectively, per 1000 gallons (very close to 1 bag of 0-7-30). Recent research has shown that soils with P Index 3 will grow approximately 1.5 t DM/ha/year more grass than soils with P Index 1. A longer-term study examining the effect of P fertiliser on grass yield on two low-soil P sites showed that low inputs of P (15 kg/ha/year) resulted in total annual yield benefits of close to 1 t grass DM/ha. Most of the DM yield response in these experiments took place in spring and early summer. Maintenance levels of soil P should at least be equal to, if not greater than, the amount of P leaving the farming system. In general, 1 kg of P is required for every 100 kg of LW gain achieved/ha. To increase soil fertility status the required amount of P and K is 50 kg P/ha and 2–5 kg K/ha for a 1 mg/L soil test change, respectively.

Grazing management

PastureBase Ireland (PBI) has been in operation since January 2013. PastureBase Ireland is a web-based grassland management tool incorporating a dual function of grassland decision supports ('spring rotation planner' (SRP), 'grass wedge' 'grass budgeting' and 'autumn 60:40 planner' for both spring and autumn) and collecting and storing a vast quantity of grassland data from dairy, beef and sheep farms in a central national database. At present most farms recording on PBI are dairy farms, with drystock farms accounting for 11% of the client base. The data accumulated to date indicate that PBI-participating farms have achieved improvements in grass DM production and grazing management.

Figure 1 shows the annual grass DM production for drystock farms recording data on PBI in 2017. This map indicates that there was little effect of location on annual DM production. Figure 2 shows the annual DM production data from a set of drystock farms recording farm covers on PBI across the country from 2013 to 2017. The annual grass DM production on drystock farms was 12.7 t/ha in 2017, which was a 2.2 t DM/ha increase from 2013. The maximum annual DM production for an individual farm in 2017 was 18.8 t DM/ha and the minimum was 9.2 t DM/ha. The number of grazings achieved on these farms was 5.2 per paddock in 2017, with a range of 2.5 to 8.0. This compares with mean value of 5.0 grazings per paddock in 2014. Achieving more grazings from each paddock during the season is a key driver to increasing cumulative herbage production.

Spring grazing management

Well-managed spring grass is a very high quality feed; it is of higher nutritional quality than silage and can be almost similar to concentrates. As a result of this, it is important to increase the proportion of grass in the diet of the animal. With early-spring grazing more expensive feeds, like silage and concentrate, can be displaced from the diet. Early-spring grazing increases the quality of grass in subsequent rotations. During February and March, a balance must be found between feeding the animal adequately to maintain high animal performance and conditioning the sward for the remainder of the grazing season. The key opportunity afforded by earlier spring-grazing is a saving of €1.54/cow/day due to lower feed costs and increased animal performance in a suckler beef production system, and up to €70/head in both finishing and store systems due to increased carcase weight.

A simple and effective tool used by grassland farms is the SRP. The best way of managing grass in spring is to set out the area to graze weekly and implement this plan during the spring period. The SRP shows the proportion of the farm to be grazed by three key dates in the early grazing season; 1 March (20 - 30%), 17 March (50 - 60%) and the desired end of the first grazing rotation approximately 10–20 April (or ‘magic day’ – when grass growth equals grass demand). On heavier soil types these targets can be at least 10 to 14 days later. The major concern is that on farms which do not target early-turnout or finish the first rotation too late, there will be a build-up of grass on the farm. PastureBase Ireland data have shown that 66% of beef farmers had no animals grazing by 1 March in 2016 and 2017, with only 45% of farms finished the first rotation by 25 April. PastureBase Ireland data (2015 and 2016) show that for every 1% area grazed in February, an additional 14 kg DM/ha is grown by 10 April. This equates to an extra 140 kg DM/ha grown on farms which graze 20% of the grazing area in February compared to farms that graze 10% of the area. On a 40-ha farm this means that there is an additional 5600 kg DM available to the grazing animals. There is potential for many beef farms to finish the first rotation earlier than current practice. On an annual DM production basis, in 2016 farms that finished the first round before 10 April also grew 1250 kg DM/ha more grass (12.1 vs. 10.9 t DM/ha/annum) than farms that finished the first round after 10 April. This varies from farm-to-farm but the overriding aspect of grazing management is to make good use of spring grass. If turnout is too late and the first rotation is too long, pre-grazing yields will be too high, grass quality will deteriorate and achieving a post-grazing sward height of 4.0 cm will be difficult as utilisation and sward quality will be reduced. The positive effect of spring DM production on annual DM production has previously been shown, with spring DM production accounting for 43% of the variation in annual DM production, and with each additional kg of grass grown in spring resulting in an additional cumulative 6 kg DM/ha grown annually.

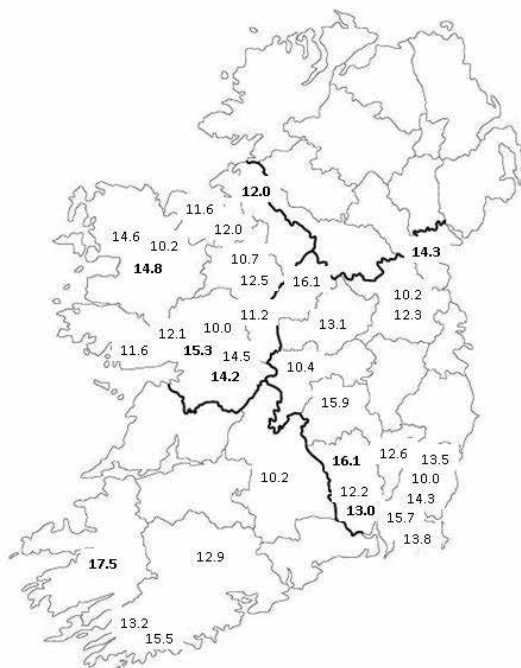


Figure 1. Grass dry matter production (t DM/ha) from PastureBase Ireland drystock farms across the country in 2017.

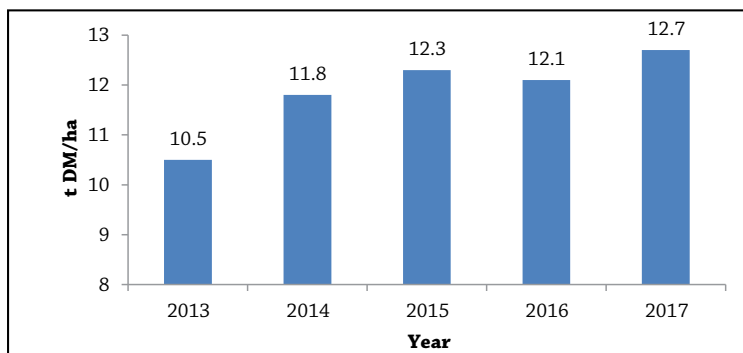


Figure 2. Annual grass DM production (t DM/ha) on drystock farms measuring farm cover on PastureBase Ireland (2013-2017)

Mid-season grazing management

The key to mid-season grazing management is to ensure a constant supply of high quality grass ahead of the grazing animals at all times. The 'grass wedge' or 'days ahead' is used in mid-season and is a visual representation of grass on your farm. During this period the farm needs to be walked weekly, farm covers recorded and necessary changes made promptly according to the number of days ahead (days ahead give a 'snapshot' of the amount of grass present on the farm on the day the farm walk is completed - target 12 to 14 days ahead between

April and August). High animal performance can be achieved from grass once the correct pre-grazing yield is obtained. Finishing the first rotation on time is critical for mid-season grass supply and quality. It will also ensure that grass will be more manageable in the second and subsequent rotations. Aim to have cattle graze grass with a pre-grazing sward height of 9.5 to 10.5 cm (1400 to 1600 kg DM/ha), while maintaining a rotation length of between 18 to 21 days. Farmers should aim to have a grazing utilisation of >85% in mid-season, grazing swards to between 4 to 4.5 cm post-grazing sward height. If higher pre-grazing sward heights are offered to the herd, grazing utilisation will be reduced to below 70%. If individual paddocks exceed the target pre-grazing cover (>1700 kg DM/ha [>12 cm]) the paddock should be removed as surplus silage to maintain good green leafy swards in front of the animals, as long as there is sufficient grass available on the rest of the farm. Beef farmers must adopt a policy of offering swards with high leaf content throughout the grazing season and ensuring that these swards are grazed to the target post-grazing sward height (4.0 to 4.5 cm). Poor grazing utilisation can often result in a paddock being topped; research has shown that topping can have a negative effect on grass growth with a reduction in subsequent re-growth of up to 20%, combined with a waste of the topped material.

Autumn grazing management

There is potential to make better use of autumn grass and to extend the length of the grazing season on beef farms. The objective of autumn-grazing is to ensure there is sufficient grass available to graze until housing (early to mid-November), and also that there is enough grass available for early-turnout the following spring for maximum LW gain. Generally rotation length should be extended from August 10 by approximately 10 days/month until mid-October when rotation length will reach 45 days. Similar to the SRP, a simple effective tool used to manage grass in the final rotation is the 'Autumn 60:40 planner'. The 60:40 planner is based on having proportions of the farm closed by certain dates. These dates can vary depending on soil type. The general rule of thumb is to start closing paddocks between the 5 and 10 October, and have 60% grazed by 7 November and 100% grazed by 1 December. In heavier soil types these dates can be at least 2 weeks earlier. Research has shown that every day delay in closing after 10 October reduced spring-grass supply by 15 kg DM/ha. At housing the average farm cover should be in the region of 600 to 700 kg DM/ha. If average farm cover is below this, the amount of grass available the following spring will be reduced leading to a requirement for greater levels of supplementation. If average farm cover is above this level > 800 kg DM/ha, lighter animals should remain outside to graze some of the heaviest covers to bring farm cover back in line with recommended targets (600 to 700 kg DM/ha).

Why white clover?

A number of experiments undertaken at Teagasc have shown the benefit of white clover inclusion in grassland in terms of savings in N fertiliser and increased animal performance. Currently there is increased interest in white clover as the cost of N fertiliser continues to rise. Clover fixes atmospheric N and makes it available for grass growth. Previous research has shown that clover can contribute up to 100 kg N/ha/yr through N fixation, resulting in a significant saving for farmers. White clover, however can also increase both animal and herbage production when compared to grass-only swards, particularly in the second half of the year when sward clover content is at its greatest (>25%). Clover growth is however very seasonal, and therefore its contribution to sward herbage DM mass varies across the year. Sward clover content is lowest in spring (<10%), peaking in late summer (>40%) and declining

during autumn. When included in grass swards it has been shown to increase overall annual herbage production by between 900 to 1500 kg DM/ha. The increase in farm performance has also increased interest in incorporating clover into the grazing system. The question arises as to how to get clover into your swards. Direct reseeding is a very successful method; however, this will take a number of years to establish clover over the entire grazing area. A simple and low-cost method of introducing white clover onto your farm is to stitch-in (over-sow) the seed in existing grass swards.

Stitching-in / Over-sowing

- When over-sowing, the clover seed can be broadcast onto the sward or stitched in using a suitable machine (Einbock pneumatic seeder).
- Best practice is to over-sow directly after grazing (≤ 4 cm post-grazing sward height) or after cutting the paddock for surplus bales – it is not recommended to over-sow clover into dedicated silage paddocks.
- A slightly higher seeding rate (3.5 to 5.0 kg/ha) is recommended for over-sowing compared to a full reseed, to overcome the issues with slugs and a lower germination rate.
- Sow with a fertiliser containing P as this will favour establishment particularly if soil fertility is poor.
- Soil contact post-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 22500 litres/ha (2000 gals/acre)
- Ideally over-sow on well-managed grassland – not suitable on old 'butty' swards with a low content of perennial ryegrass – if this is the case a full reseed is best practice

Management of grass-clover swards after over-sowing

Poor establishment has been obtained where the 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 white clover. The single most important recommendation, is tight grazing for the first 3 grazings post-sowing, both for direct reseeding and over-sowing, keeping pre-grazing herbage mass < 1200 kg DM and grazing swards to < 4 cm. Doing this 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. In general, highest rates of rainfall are recorded during the winter and lowest rainfall during May, June and July. To improve the chances of success on drier soils it is recommended that over-sowing is carried out in late-April or early-May. Ideal circumstances would be paddocks where surplus grass is removed as baled silage. By ensuring the above steps are carried out successfully, clover content in the sward can be $> 15\%$ of the sward composition the following year. The grazing management in subsequent years is also of critical importance to ensure the persistence of clover in the sward.

Conclusion

There is huge potential for increased grass DM production and increased profitability on Irish beef farms. All farms can grow more grass through improved grassland management regardless of location. Managing a farm to produce more grass requires attention to detail, improved soil fertility, grazing infrastructure and better grazing management. The farms that are currently undertaking some of the aspects outlined in this paper are more likely to improve grass production and increase farm profit irrespective of beef price.



Technology Village

Grass10

Teagasc grass and clover breeding programme

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Summary

- The national grass and clover breeding programme conducted by Teagasc ensures that varieties are bred in Ireland specifically for the needs of Irish farmers.
- Our mission is to support animal production from grassland in Ireland by breeding improved varieties of perennial ryegrass, white clover and red clover for Irish farm systems.
- Our ultimate breeding target is varieties that offer sufficient yield of high quality forage to match the animal feed demand curve over the entire grazing season plus provision of adequate winter feed as silage.
- To this end, the breeding programme has harnessed cutting edge methodologies with genomic selection now a routine part of the selection cycle.
- Current perennial ryegrass varieties include: Genesis, Carraig, Elysium, Kintyre, Solas, Solomon, Kerry, Glenveagh, Majestic and Glenroyal.
- Current white clover varieties include: Galway, Coolfin, Iona, Avoca, Buddy, Chieftain and Dublin.
- Teagasc has entered into a new partnership with Goldcrop Ltd. to support the programme and commercialise all new varieties.

Introduction

Grassland is Ireland's greatest renewable feed resource and provides the main feed for ruminant livestock. The competitiveness of Irish agriculture is based on grassland providing a cheap, high-quality feed source. The genetic improvement of forage grass and clover offers a cost-effective mechanism to increase the profitability and reduce the environmental cost of animal production from grassland. Forage grass and clover have been subjected to very little formal breeding. Genetic variation within and among populations is still extremely high, showing no signs of decreasing. There is no sign that the genetic progress achieved during the past 50 years of forage breeding will not continue for at least the next 50 years. Harnessing the power of modern technologies such as genomic selection may accelerate genetic improvement. The potential of forage breeding is limited only by human imagination, ingenuity and available funding.

History

The Teagasc forage breeding programme was initiated in the early 1960's at the Oakpark Research Centre, Carlow, Co. Carlow. In 2002, the molecular genetics programme was established at Oakpark in support of the breeding programme. The two programmes are now closely aligned. To date, the programme has bred and commercialised 27 perennial ryegrass

varieties and 11 white clover varieties. The programme is supported by Goldcrop Ltd., an Irish seed company with headquarters in Carrigtwohill, Co. Cork and DLF-Trifolium, a plant breeding and seed production company with headquarters in Denmark. Goldcrop have exclusive world-wide rights to commercialise and market all new varieties that emerge from the programme.

What is plant breeding?

Plant breeding is the science, art and business of improving plants for human benefit. It is human-directed evolution. Evolution, or the genetic change in a species over time, is a natural and on-going process. Man's involvement is necessitated by the fact that evolution is an exceedingly slow process and, the direction of evolution favoured by man and nature may be completely different. For example, nature favours traits that improve survival. This includes repeat heading in grass which is an undesirable trait for farmers as it contributes to poor mid-season herbage quality.

Benefits of plant breeding

Changing climate, pests, diseases and farming practices (as dictated by economic and national policy shifts, and new research findings) mean that the best variety 5 years ago may not be the best variety today. Therefore, new varieties are continually required in order to optimise the performance of our grassland. Breeding offers a low-cost means of improving grassland productivity and profitability. Sowing a new improved variety offers a permanent increase in performance over the lifetime of the variety. In contrast, a management scheme (e.g. extra nitrogen fertiliser) designed to improve crop performance must be continually re-applied each year, at a recurring cost. In terms of seed costs per hectare, there is usually little difference between new and older varieties, and the difference is negligible relative to the total cost of reseeding. The current rate of genetic gain in grass yield is ca. 0.4% per annum. This compares with a genetic improvement of 0.5% in wheat and 1.0% in maize yields per annum.

Forage breeding goals

Our goal is to increase the profitability and sustainability of animal production from grassland in Ireland by breeding improved varieties of perennial ryegrass, white clover and red clover for Irish farm systems. Teagasc varieties are bred and tested in Ireland under real-world (field) conditions using a combination of cutting and animal grazing over multiple years and site locations. The main traits for genetic improvement are: (i) spring and autumn growth, (ii) nutritive value, (iii) sward persistency and density, and (iv) disease resistance. The programme breeds diploid and tetraploid perennial ryegrass with emphasis on later-heading types, and small, medium and large leaf size white clover varieties. The red clover breeding programme is a new initiative, primarily targeted at extending the life span of red clover swards.

Breeding methods

The release of a new variety is the culmination of a 15-to-20 year process consisting of three main stages: (i) forage breeding (Teagasc), (ii) independent variety evaluation (Department of Agriculture, Food and the Marine - DAFM) and (iii) commercial seed production and release (Goldcrop).

The breeding process is a multistep and cyclic process, known as recurrent selection, where

the best plants (genotypes) are evaluated, selected and inter-crossed to produce a new variety. The generalized method consists of three parts: (i) development of a source population from which to begin selection, (ii) evaluation of individual plants from the source population and (iii) selection and inter-crossing of superior plants to form a new population. Most important forage traits are quantitative and controlled by the joint action of many genes. Recurrent selection increases the frequency of favourable alleles and superior plants in the population and can achieve in successive cycles of selection what would almost certainly never be achieved by non-recurrent selection.

The source population consists of varieties, elite families and introductions from gene banks. Selection is based on recurrent phenotypic, genotypic and genomic selection. Phenotypic selection is selection based on visual observation or physical measurement of the trait. Genotypic selection is selection based on progeny performance. Genomic selection is selection based on the DNA of the plants.

The Teagasc breeding programme uses among and within full-sib family selection and half-sib progeny test selection. The superior plants identified through one cycle of recurrent selection may become the starting point for the next cycle of recurrent selection or may be used to construct new synthetic varieties. A synthetic variety is defined as a population produced by crossing, in all possible combinations, a number of selected plants and which is thereafter maintained by random mating in isolation. The new variety is submitted to the DAFM for independent testing under cutting and grazing. The variety is added to the Ireland Recommended List if it is found to offer improved agronomic performance and its botanical characteristics are distinct from other varieties, uniform and stable (DUS). Commercial seed of Teagasc-bred varieties are produced and sold under license by Goldcrop or DLF-Trifolium.

Genomic selection

Genomic selection is a new breeding tool that uses information from a plant's DNA to predict its breeding value. In recent years there has been increased interest in the application of genomic selection in plant breeding. This has been driven mainly by a reduction in the cost of DNA sequencing, but also from the demonstrable success of genomic selection in animal breeding.

The huge advantage genomic selection offers grass and clover breeding is that it allows the breeding values of plants to be computed in one year using information from the DNA. This compares very favourably to traditional field-based phenotypic and genotypic selection, which can take up to five years per selection cycle. This means we can complete many more cycles of genomic selection in the same time it takes to complete a single cycle of field-based selection, resulting in greater genetic gain. Teagasc have been using genomic selection routinely in the commercial grass breeding programme since 2016 with a focus on delivering new varieties with greater on-farm profitability. Teagasc are currently evaluating the prospects of implementing genomic selection in white clover breeding with a view to deployment in the coming years. Genomic selection has the potential to treble the rate of genetic gain in grass breeding.

Varieties

In 2018, farmers may choose among 10 perennial ryegrass and seven white clover varieties bred by Teagasc for reseedling. All varieties are included on the Grass and Clover Recommended List Varieties for Ireland 2018.

Perennial ryegrass varieties:

- Early diploid: GENESIS
- Intermediate diploid: SOLOMON
- Intermediate tetraploid: CARRAIG and ELYSIUM
- Late diploid: KERRY, GLENVEAGH, MAJESTIC and GLENROYAL
- Late tetraploid: KINTYRE and SOLAS

ELYSIUM is a new intermediate tetraploid variety first released in 2018.

White clover varieties:

- Small leaf size: GALWAY and COOLFIN
- Medium leaf size: IONA, AVOCA, BUDDY and CHIEFTAIN
- Large leaf size: DUBLIN

Small leaf white clover varieties are especially suited for tight grazing and tend to be less aggressive than larger leaf varieties. Traditionally, small leaf varieties were lower yielding than medium and large leaf varieties. However, modern bred varieties may buck this trend. The small leaf variety COOLFIN out yields all medium leaf size varieties on the Ireland Recommended List.

DUBLIN is a new large leaf white clover variety first released in 2018. DUBLIN is suitable for inclusion in a seed mix for cattle grazing or silage production.

A number of other new Teagasc varieties are currently undergoing seed increase for future seed sales, including OAKPARK and SMILE late diploid perennial ryegrass varieties set for first release in 2019.

Conclusions

The Teagasc forage breeding programme continues to develop improved varieties of grass and clover for Irish farm systems. Farmers may currently choose among 10 perennial ryegrass and seven white clover varieties bred by Teagasc for reseeding. A number of other new varieties are currently undergoing seed increase for future release. Genomic selection, a powerful new genetic tool, is now a routine part of the breeding programme and will accelerate genetic gain.



Using the Pasture Profit Index (PPI)

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Summary

- The Pasture Profit Index (PPI) is a total merit economic index which ranks grass varieties on their economic value to a grassland farm.
- Key traits in the PPI are seasonal dry matter (DM) yield, grass quality, silage yield and persistency.
- The relative emphasis on each trait is as follows: grass DM yield (31%), grass quality (20%), silage yield (15%) and sward persistency (34%).
- There is a large range in PPI values (€/ha/year) between the highest (€225) and lowest (€61) varieties.
- Farmers will need to carefully choose varieties appropriate for their requirements when using the PPI.

Introduction

Food Wise 2025 has set a target to increase grass utilisation nationally by 2 tonnes dry matter (DM)/ha annually by 2025. This target will be difficult to achieve without an increase in reseeded to generate new more productive ryegrass/white clover swards. The Pasture Profit Index (PPI) was introduced to the Irish grassland industry in 2013, after many years of focussed research and refinements to Department of Agriculture, Food and the Marine evaluation protocols. The PPI sets out in economic terms, the agronomic differences between traits of grass varieties, to allow farmers to select the most appropriate varieties for their particular purposes. It is also essential that farmers and the industry only use or retail recommended listed material as this is the most reliable quality control for grass varieties.

Approach used

The use of the PPI enables the identification of grass varieties which provide the greatest economic contribution to a ruminant grazing system. The index ranks grass varieties based on their economic benefits and will ultimately result in an increase in the use of superior varieties, which means higher profitability for the industry.

The key traits in the PPI are seasonal DM yield (spring, summer and autumn), grass quality (DM digestibility, DMD), silage yield and persistency (Figure 1). These are referred to as sub-indices in the total index. The sub-indices identify the relative strengths and weaknesses of individual varieties. All varieties on the PPI Recommended List now have a minimum of two years agronomic data generated before the PPI is calculated. The range in PPI for varieties on the Recommended List in 2018 is from €225 to €61/ha/year (Table 1). Many of the lower ranked varieties have deficiencies in seasonal grass production and grass quality.

The data generated in the PPI is from the Department of Agriculture, Food and Marine evaluation protocols. The relative emphasis on each trait is as follows: grass DM yield (31%), grass quality (20%), silage yield (15%) and sward persistency (34%). The base values that are used are spring DM yield = 1.0 t DM/ha, mid-season DM yield = 6.1 t DM/ha and autumn DM yield = 1.9 t DM/ha. Base values for grass quality (i.e. DMD) are 853 (April), 856 (May), 826 (June), 816 g/kg (July), respectively. The base value for first-cut silage is 4.5 t DM/ha

and for second-cut silage is 3.5 t DM/ha. Persistency is based on ground score (GS) change (GSA). The economic merit for persistency was determined by dividing the cost of reseedling (assumed to be €672/ha) by the number of years a variety persists. Varieties surviving the yield threshold of 12 years or longer are assigned a value of 0 and less-persistent varieties are assigned a negative economic value. In so doing, the PPI rewards varieties with a low GSA and consistently high levels of DM production.

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

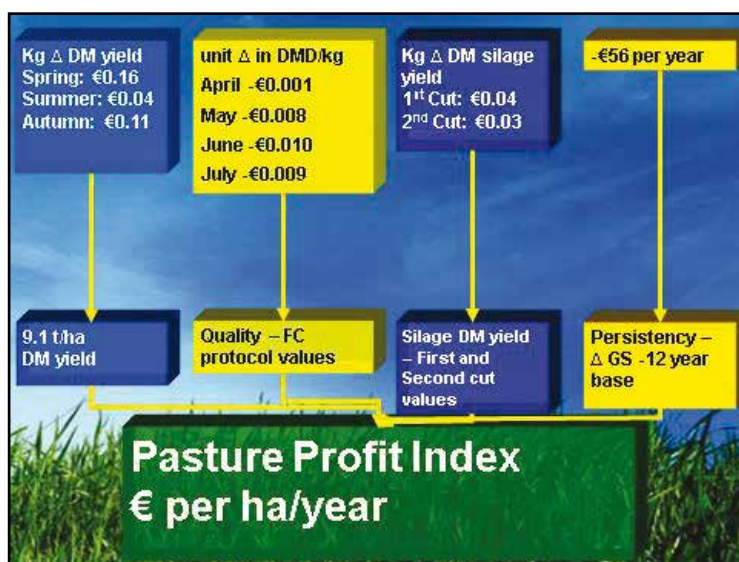


Figure 1. Economic values assigned to base values of the Pasture Profit Index 2018



Table 1. Pasture Profit Index values for recommended listed varieties in 2018

Variety	Ploidy	Heading date	Spring	Summer	Autumn	Silage	Quality	Persistence	Total €/ha/yr
AberClyde	T	May 25	57	48	37	28	55	0	225
AberMagic	D	May 29	48	50	71	17	30	0	217
Fintona	T	May 22	78	28	46	39	24	0	215
AberZeus	D	May-29	70	48	52	34	9	0	212
Nifty	D	May 27	81	52	60	26	-12	0	208
Moirra	D	May 25	121	26	52	27	-18	0	207
AberGreen	D	May 30	63	58	65	4	16	0	206
AberPlentiful	T	June 9	60	49	45	20	29	0	203
AberGain	T	June 05	32	43	45	30	60	-11	198
AberChoice	D	June 9	26	48	49	13	59	0	194
Meiduno	T	Jun 06	58	44	44	21	27	0	194
Dunluce	T	May 30	35	42	48	30	37	0	192
Elysium	T	May 26	75	34	29	20	31	0	189
AberWolf	D	May 31	68	37	36	21	25	0	188
Seagoe	T	May 28	44	39	46	42	14	0	185
Astonconqueror	D	May 26	81	31	36	24	7	0	180
AberBite	T	Jun 6	13	43	47	33	51	-11	175
Rosetta	D	May 24	88	28	43	20	-4	0	174
Solas	T	June 10	22	42	58	19	26	0	167
Kintyre	T	June 7	25	35	55	18	27	-5	156
Astonenergy	T	June 2	12	35	39	8	59	0	153
Xenon	T	June 11	22	36	33	19	40	0	150
Carraig	T	May 22	50	38	34	35	-16	0	140
Solomon	D	May 19	78	29	33	25	-28	0	137
Alfonso	T	June 4	10	35	37	7	45	0	134
Aspect	T	June 6	19	38	26	14	33	0	131
Navan	T	Jun 5	11	36	50	16	12	0	124

Variety	Ploidy	Heading date	Spring	Summer	Autumn	Silage	Quality	Persistence	Total €/ha/yr
Drumbo	D	June 7	28	31	35	0	39	-11	121
AberLee	D	Jun 12	-5	41	40	3	42	0	121
Kerry	D	June 1	33	39	41	11	5	0	119
Glenroyal	D	June 5	26	38	41	11	-3	0	112
Clanrye	D	June 6	35	38	18	20	-15	0	97
Majestic	D	June 2	38	31	39	5	-26	0	88
Glenveagh	D	June 2	18	29	23	12	-21	0	61



Fertiliser advice for grazing and silage in beef systems

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Summary

- Lime and fertiliser phosphorus (P) and potassium (K) use on most Irish livestock farms is too low.
- Soil test results indicate that 90% of soils have suboptimal fertility to maximise grass growth (target soil pH = 6.3 on mineral soils and 5.8 on peat soils, target soil P and K Index = 3).
- Low soil fertility (e.g. soil P or K at Index 1) equates to a loss of at least 1.5 t grass dry matter (DM)/ha per year, which is worth at least €125/ha per year on a beef farm.

5 Actions for soil fertility on your farm

- Soil test the whole farm to identify soil fertility levels in each field or paddock.
- Apply lime to acidic soils to increase the pH to the target level.
- Use the soil Index in each field to guide fertiliser P and K and slurry application.
- Apply slurry in spring to fields with high P and K requirements (low soil test P and K and/or cut for silage) to maximise its nutrient value.
- Use bagged fertilisers that are correctly balanced in nitrogen, P, K and sulphur and tailored to the needs of each field.

Introduction

Productive soils are the foundation of any successful farm. The demand within intensive grazing systems for high grass growth rates over an extended grazing season represents a continual demand on soil fertility reserves. The ability of soils to maintain a supply of nutrients in the appropriate quantities for grass growth is a key factor in determining how productive a field or farm can be. Fertiliser costs account for approximately 20% of the total variable costs on beef farms, but can provide good value for money when used correctly. However, fertiliser application rates that are either too low, too high, or not in balance with other soil fertility factors will give lower grass growth responses.

Soil fertility and fertiliser use on drystock farms

Soil phosphorus (P) and potassium (K) levels have declined on many beef farms in recent years, coinciding with a reduction in fertiliser usage (Figure 1). Of the drystock farm soil samples analysed by Teagasc in 2017 only 10% had optimal soil fertility levels as indicated by soil pH, P and K. 48% of soils sampled on drystock farms had soil pH at the optimal level > pH 6.2 for mineral soils. With up to 90% of soils currently deficient in at least one of these critical elements, poor soil fertility poses a significant threat to achieving increased productivity and profitability on beef farms.

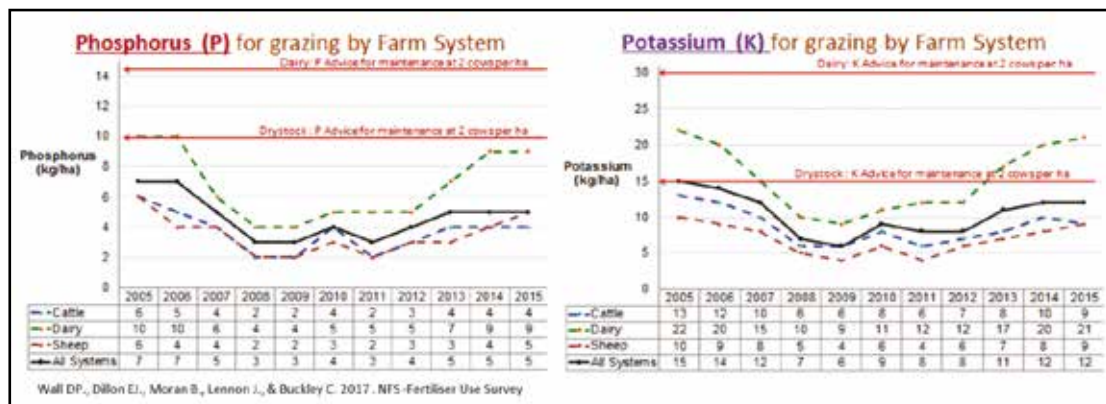


Figure 1. Phosphorus (P) and potassium (K) use on drystock farms, surveyed by Teagasc National Farm Survey. Typical P and K maintenance fertilizer rates for dairy and drystock are shown by the red horizontal lines

Soil fertility management – 5 steps to follow

1) Soil test

A soil test will indicate the background soil fertility levels regarding pH, P and K and also magnesium (Mg) and trace elements where required. Soil analysis is also a central requirement to implementation of the Nitrates regulations. However, the primary function of soil testing on the farm is to improve soil fertility information and to plan fertiliser applications in association with good farming practice. Soil sampling can be organised through your local Teagasc advisor at a cost of €25 per standard soil sample (pH, lime requirement, P and K). Unless you know what is in the soil, it is impossible to know how much fertiliser it needs. Using soil test results, the fertiliser programme can be tailored to the needs of the soil and the farm.

2) Apply lime

Soil pH is the first thing to get right. The release of nutrients from the soil and the response to applied fertilisers will be reduced where the soil pH is low (or too high). Apply lime as required based on the soil test result to increase soil pH up to the grassland target pH, which is 6.3 for mineral soils and 5.8 for peaty/organic soils. It is important not to apply more than 7.5 t lime/ha in a single application, as excessive application can adversely affect trace element availability in soils. Apply 7.5 t/ha immediately, and the remainder after two years where more than 7.5 t/ha is required.

3) Target Index 3 for P and K

Soil analysis is designed to estimate the P and K that is present in the soil in a plant-available form. Soil P and K should be in Index 3 in all fields where the objective is to produce high yields of quality grass. High fertility soils (Index 4) are a resource and should be utilised. Low fertility soils (Index 1 or 2) need to be nourished. For soils in Index 3 the fertiliser program should be designed to replace the nutrients being removed, thus maintaining the soil fertility level. Recommendations for P and K application rates for grassland on beef cattle farms are shown in Table 1. The P application rates should be adjusted to account for P applied in slurry or coming onto the farm in concentrate feeds.

Table 1. Simplified P and K requirements for grazed and cut swards in beef systems

Soil Index	Grazed Swards				Silage Swards ²	
	Farm Stocking Rate (LU/ha)				Cut Once	Cut Twice
	<1.0	1.0-1.5	1.5-2.0	>2.0		
P application rate (kg/ha)¹						
1	24	27	30	33	+20	+30
2	14	17	20	23	+20	+30
3	4	7	10	13	+20	+30
4	0	0	0	0	0	0
K application rate (kg/ha)³						
1	65	70	75	80	+125	+200
2	35	40	45	50	+125	+200
3	5	10	15	20	+125	+200
4	0	0	0	0	0	0

¹Assuming phosphorus build-up rates of 10 kg/ha P at Index 1 and 20 kg/ha P at Index 2.

²P and K rates specified for silage swards are to replace offtake only

³Typically no more than 90 kg/ha K should be applied at closing for silage with remainder of K applied after silage harvest

4) Organic Manures

Organic manures are an effective source of nitrogen (N), P and K, and can provide a large proportion of silage crop P and K requirements at relatively low cost. Table 2 shows the available N, P and K content for a range of organic manures. Cattle slurry is a valuable source of P and K and typically contains 0.6 kg P/m³ and 3.3 kg K/m³. For example 33 m³/ha (3,000 gallons per acre) of good quality cattle slurry (7% dry matter (DM)) will supply 24 kg/ha N (19 units N), 19 kg/ha P (15 units P) and 113 kg/ha K (90 units K) a large proportion of the P and K requirements for a grass silage crop.

Table 2. Available N, P and K values for a range of organic manures

Manure type	N	P	K
	kg/m³		
Cattle Slurry (7% DM) ¹	0.7	0.6	3.3
Dilute Cattle Slurry (3.5% DM) ¹	0.6	0.3	1.65
Pig Slurry (4% DM)	2.1	0.8	2.2
	kg/tonne		
Farmyard manure (FYM)	1.35	1.2	6
Spent mushroom compost (SMC)	1.6	1.5	8

¹ N, P and K value for cattle slurry.

To convert kg/ m³ to units/1,000 multiply by 9. To convert kg/tonne to units/ton multiply by 2.

Application of cattle slurry with trailing shoe / band spreader will increase N recovery by 0.4 kg/m³.

However, the P and K fertiliser values of slurry can be highly variable, usually due to dilution with water. While slurry can be more difficult to manage than chemical fertiliser, it can be a very cost-effective resource to increase fertility levels. Slurry application should be targeted

to fields that have high P and K requirements (fields with P and K Index 1 or 2). Apply in cool and moist weather conditions (e.g. in spring) to maximise N recovery. Many beef farms with lower stocking rates will be able to import manures and slurries from other farms. Cattle and pig slurry brought into the farm is a cost-effective way of increasing soil fertility and should be considered where possible. Cattle slurry contains N which needs to be deducted from the total N requirement for the crop/grass. Table 3 shows the recommended rates of N, P and K and suggested fertiliser application programmes at different soil P and K Indexes (1 to 4) required to grow 5 t grass DM per ha (~10 tonnes fresh grass / acre).

Table 3. Grass silage N, P and K requirements (5 t grass DM/ha) and suggested fertiliser application programmes

Soil Index	N kg/ha (units/ac)	P kg/ha (units/ac)	K kg/ha (units/ac)	Fertiliser options ^{3, 4}	
				No Slurry ¹	Cattle Slurry 3,000gal/ac
1 ¹	125 (100)	40 (32)	175 (140)	4.0 bags/ac 13-6-20 1.75 bags/ac CAN	3 bags/ac 27-2.5-5
2 ¹	125 (100)	30 (24)	155 (120)	3.5 bags/ac 13-6-20 2.0 bags/ac CAN	3 bags/ac 27-2.5-5
3 ¹	125 (100)	20 (16)	125 (100)	3.0 bags/ac 13-6-20 2.25 bags/ac CAN	3 bags/ac CAN
4 ²	125 (100)	0	0	4.0 bags/ac CAN	3 bags/ac CAN

¹Index 1, 2 and 3 soils apply P and K balance to restore soil P and K levels to after-grass

²Index 4 soils omit P for 2/3 years and retest, Index 4 soils omit K for 1 year and revert to Index 3 advice thereafter.

³Urea can replace CAN as main N source. Moderate rainfall (up to >10 mm) after application will reduce N losses from urea.

⁴For new / older swards with higher / lower yield potential reduce N, P and K by 25 kg N, 4 kg P and 25 kg K per tonne of grass DM,

5) Fertiliser products that give a balanced nutrient supply

Make sure the fertiliser compound is supplying nutrients in the correct balance for the crop, the soil, and to complement other fertilisers being applied. If one nutrient is deficient, no amount of another nutrient will overcome this. For example, if a field is deficient in K, then excess N applied will not be fully utilised. Consider straight K or N-K fertilisers where P usage is restricted. Other nutrients such as sulphur (S) can play a very important role in a balanced fertiliser programme and should also be applied on lighter soils that are free-draining and have lower organic matter reserves.

Conclusions

Trying to plan fertiliser application strategies without information on soil fertility levels is impossible. Therefore, soil test results for the whole farm are essential. Although it costs money to increase fertility levels to target levels, the returns in terms of grass production can be considerable, which can increase livestock carrying capacity, provision of winter feed (silage) and ultimately profitability. Implementing these simple steps for soil fertility management will go a long way to ensuring that the production potential of the farm is being realised, and that fertiliser inputs are being utilised as efficiently as possible.

Growing and utilising more grass in beef production systems

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Summary

- Profitable beef production in Ireland is based on the use of high quantities of quality grass to produce premium beef at a low-cost.
- Good paddock grazing infrastructure will allow a longer grazing season, and make grazing management easier at peak grass growth and during challenging weather and ground conditions.
- Grazing management factors that drive increased grass growth and utilisation include spring- and autumn-grazing management, rotation length, achieving the correct pre-grazing herbage mass and post-grazing sward height.

Introduction

Ireland's competitive advantage in beef production is based on the ability to produce and utilise grazed grass cheaply, and achieve high levels of animal performance from this low-cost forage. On average, the cost of producing a kilogram of live weight gain from grazed grass is considerably less when compared with a concentrate-based diet. Improving grass utilisation on a drystock farm is worth an additional €105/ha for every extra tonne of grass dry matter (DM) utilised. However, many Irish farms are only producing and utilising 50% of their grass growth potential. It is accepted that the foundation underpinning high grass production (and utilisation) is having adequate soil fertility and unimpeded drainage coupled with targeted application of fertiliser (see page 48). Additionally, large increases in grass production and utilisation can be achieved through utilising grazing infrastructure (paddock systems, roadways, water systems) and appropriate grazing management practices (target grass covers and days ahead, pre-grazing herbage mass, post-grazing sward height) throughout key periods of the year (spring, mid-season, autumn).

Grazing infrastructure: Paddock systems

Good grazing infrastructure allows more days at grass and permits better grassland management at times of peak grass growth and under difficult weather conditions. Current paddock residency time recommendations in rotational grazing systems for beef animals are 48-hours per paddock (Table 1). However, many drystock producers are implementing a 72-hour or greater residency time per paddock. Although, a longer residency time lessens the requirement to move livestock frequently and fewer paddocks are needed, it is difficult to optimise grass utilisation and maintain grass quality throughout the grazing season. Data from PastureBase Ireland has shown that the biggest driver of increasing total grass DM production on drystock farms is achieving more grazings per paddock during the grazing season. On a high proportion of drystock farms, the number of paddocks is not adequate,

which means large paddock sizes with longer residency periods (residency time is often up to two weeks and almost equivalent to 'set stocking' in some instances). As a result, livestock are grazing paddocks for too long thereby reducing the productivity of these paddocks. As grass re-growths are unprotected, continual re-grazing occurs, target residuals are not achieved and nitrogen fertiliser application is delayed. Data from PastureBase Ireland indicate that creating additional paddocks on a farm will increase total grass DM utilisation, thereby improving farm profitability.

Paddock size and shape

- Paddocks that are too large can lead to grass re-growths being grazed and can lead to poor grass quality. Using a strip wire to divide large paddocks into a more manageable area requires extra labour. However, strip-grazing and back-fencing large paddocks can limit damage and prevent the grazing of regrowths to the grazed area if large paddocks are already in place on-farm.
- Paddocks that are too small can lead to insufficient grass for a day's grazing which can impact on DM intake and animal performance. These paddocks also require more labour as animal movements are more frequent and also require additional water troughs.
- In terms of paddock shape, aim for a ratio of 2:1 so that paddocks are twice as long as they are wide. Long narrow paddocks result in too much walking to reach the end of the paddock; this can lead to poaching in difficult grazing conditions. The maximum depth of a paddock should be 250 metres (m) from the access roadway reducing to 100 m in wet areas more prone to poaching.

Table 1. Number of grazings per paddock in mid-season

Grazing/paddock	Advantages	Disadvantages	Best practice
12-hour grazing (1/2 day per paddock)	• Good grass utilisation • Protects re-growths • Better in wet weather • Identify surplus/deficit of grass easily • Limits sward damage	• More labour intensive • Animals could be underfed • More water troughs required	Only recommended if the farmer has excellent grass-budgeting skills
48-hour grazing (2 days per paddock)	• Protects re-growths • Animals less restricted • Animals more settled as less movement • Easier machinery access	• Can be difficult to manage in wet conditions	Most recommended as optimises grass utilisation and production, and labour efficiency
>72-hour grazing (3+ days per grazing)	• Fewer water troughs required • Fewer paddocks required • Re-growths affected • More difficult to graze out		Least recommended option

How to calculate paddock size (48-hour grazing):

- 1 Step 1: Minimise the number of grazing groups and increase number of cattle per group.
- 2 Step 2: Establish cattle number in the largest grazing group. This will determine paddock size on the farm.

- 3 Step 3: Establish daily grass demand, e.g. 40 spring-calving suckler cows with calves at foot need 14 kg DM/cow/day (700 kg live weight (LW) with an intake of 2% of total LW), which equates to 560 kg DM for 24 hours.
- 4 Step 4: Ideal pre-grazing grass yield is 1,400 kg DM/ha in mid-season (see Table 2)
- 5 Step 5: A daily grazing $560/1,400 = 0.4$ ha for 40 suckler cows (+ calves) in 24 hours
- 6 Step 6: Two days grazing $0.4 \text{ ha} \times 2 = 0.8$ ha for 40 suckler cows (+ calves) in 48 hours

Grazing management

How to ensure high grass utilisation and quality in spring

Spring grass is an ideal feedstuff for cattle as it is highly digestible, high in protein and reduces the need for concentrates. Ensuring optimum grass production and utilisation in spring depends on appropriate spring-grazing management. The aim in spring is to turn animals out to grass as early as possible (in order to maximise the proportion of low-cost grass in the diet, annually), while at the same time budgeting to provide enough grass until the start of the second grazing rotation. Under ideal grass growing conditions and on drier soils, the start of the second rotation would occur in early April; farms on heavier soils will have a later date. First rotation spring-grazing should start in February/March and continue until early April. This date can vary from farm-to-farm but the overriding aspect of grazing management is to make good use of spring grass. If turnout is too late on farms and the first rotation is too long, pre-grazing yields will be too high, grass quality will deteriorate and achieving a post-grazing residual of 4 cm will be difficult as utilisation will be reduced. Advantages of finishing the first rotation on time include:

- The first paddock grazed in the second rotation will have an adequate cover for grazing i.e. 8 to 9cm (1000 to 1200 kg DM/ha), and have the recommended 18 to 21 days of grass on the farm.
- A wedge of grass will be created, highest covers on paddocks grazed early in the spring and lower covers on paddocks grazed last in the rotation.
- Early spring grazing increases grass quality in the second, third and subsequent grazing rotations.

How to ensure optimum spring grazing management

- Farm cover at turnout should be 600 to 700 kg DM/ha.
- Have silage paddocks grazed by 6 April.
- Follow the spring rotation planner: on dry soils, aim to graze 20 to 30% of farm by 1 March and 50 to 60% by 17 March.
- Target a post-grazing sward height of 4 to 5cm during the first rotation to ensure good grass utilisation and good grass quality for subsequent rotations.
- Lighter stock, e.g. weanlings, do less damage in more challenging weather.
- Aim to finish the first rotation by 10 to 20 April (or 'magic day' – when grass growth equals grass demand; 10 to 14 days later on heavier soils).

How to ensure optimum mid-season grazing management

A key challenge during mid-season, when grass growth is at a peak is achieving high grass utilisation and maintaining grass quality.

- Rotation length should be 18 to 21 days.
- Target 12 to 14 days ahead during the mid-season
- Cattle should be eating grass only with no supplementary feed.

- Target pre-grazing herbage mass of 1400 to 1600 kg DM/ha (8 to 10 cm).
- Target a post-grazing sward height of 4.0 to 4.5 cm to ensure good grass utilisation and good grass quality.
- If grass supply exceeds demand, aim to remove surplus grass as round bale silage. Typically these paddocks will have a cover of at least 1700 kg DM/ha in the mid-season rotation.

How to ensure optimum autumn grazing management

The main objective of autumn grazing management is to finish the grazing season with the desired average farm cover (600 to 700 kg DM/ha) ensuring there will be sufficient grass for early-turnout the following spring.

- Rotation length in mid-September and mid-October should be 30 to 35 days and 45 days, respectively.
- Start closing the farm from the first week of October (5-10 October; 10 to 14 days earlier for heavy farms).
- Close the farm in rotation, every day delay in closing date reduces spring grass supply.
- Aim to have 60 to 65% closed/grazed by 7 November.
- Aim to have 100% closed/grazed by 1 December.

Weekly grassland measuring and budgeting are essential to ensure that these objectives are achieved. Usually from mid-August onwards, the entire farm is available for grazing. Building up grass covers to prolong the grazing season into October/November is necessary in order to maintain animals at grass in late autumn.

Table 2. Monthly grazing targets

	Pre-grazing height (cm)	Pre-grazing herbage mass (kg DM/ha)	Target days ahead
February/March	8 – 9	1000 – 1300	1st rotation 45
April	8 – 10	1300 – 1600	18 – 21
May	9 – 10	1300 – 1600	12 – 14
June/July	9 – 10	1300 – 1600	12 – 14
August	9 – 10	1300 – 1600	25 – 30
September	10 – 12	1500 – 2000	35 – 40
October/November/December	< 12	< 2000	Close paddocks from 5 to 10 October

Key elements to growing and utilising more grass on your farm

1. Grazing system and infrastructure: rotational grazing with adequate size paddocks.
2. Maximising utilisation in each season (spring, mid-season, autumn).
3. Know your grass covers and make weekly decisions.

Conclusion

Focusing on developing better grazing infrastructure and improving grazing management performance in spring, mid-season and autumn will deliver higher grass production, utilisation and animal output per hectare on drystock farms. These improvements will deliver higher profits in the short-to-long term.

Reseeding: benefits, methods and weed control

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Summary

- Reseeding can be one of the most cost-effective on-farm investments.
- There is little difference between reseeding methods in terms of long-term grass dry matter (DM) production.
- With spring reseeding there is no loss in grass DM production in the establishment year compared to permanent pasture.
- White clover can be established into existing swards by over-sowing.
- Management after reseeding/over-sowing is just as important as decisions made at sowing.

Introduction – the need for more reseeding

Reseeding levels in Ireland are low; less than 2% of our national grassland area is reseeded annually. As grass is our dominant feed during the main grazing season, and the primary source of winter forage in the form of grass silage, the low level of reseeding nationally must be addressed. Perennial ryegrass is a high quality feed and efficiently utilises applied nutrients such as nitrogen. Figure 1 shows the grass production across the grazing season of a sward containing 15% perennial ryegrass compared to a sward containing 100% perennial ryegrass. The majority of the difference (3 tonnes DM/ha/year) in grass production between the two swards occurs in the spring period, up to mid-May. Swards that have poor grass production in spring will not support early-spring grazing. It is recommended that pastures with less than 50% perennial ryegrass should be reseeded. Data from PastureBase Ireland shows that there is huge capacity on Irish farms to grow more grass.

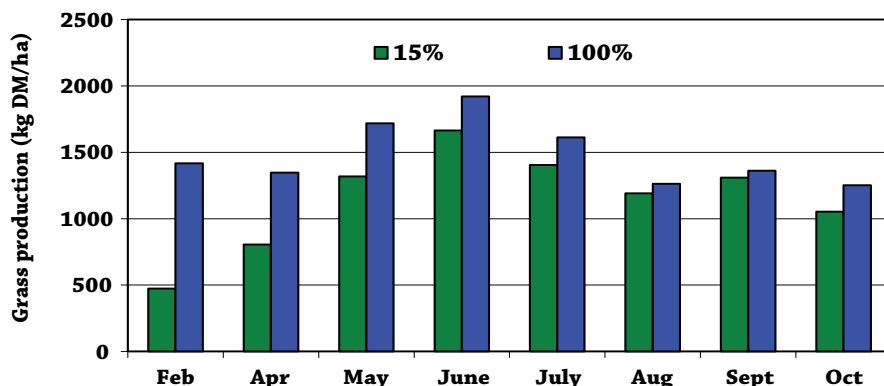


Figure 1. Grass production per month (February to October) in a sward containing 15% perennial ryegrass and 100% perennial ryegrass.

Economically, pastures with a low proportion of perennial ryegrass are costing farmers over €300/ha per year due to reduced DM production and nitrogen fertiliser use efficiency during the growing season. If the cost of reseeding is estimated at approximately €700/ha, the increased profitability of the reseeded pasture would potentially cover the initial reseeding cost in just over two years. This means reseeding can be one of the most cost-effective on-farm investments.

Soil fertility

Reseeding must be combined with the correction of soil fertility to successfully establish new swards. Reseeding can improve the productivity of a sward; however, for it to have maximum effect, soil fertility must be optimal. Getting soil fertility right is crucial if perennial ryegrass is to establish well and persist after reseeding. Soil testing gives an overview of the soil fertility status of a field or paddock, and appropriate applications of phosphorus (P), potassium (K) and lime (to correct soil pH) can be made to ensure adequate soil fertility for perennial ryegrass germination, establishment and production.

Cultivation techniques

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

Key points

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

Table 1. The Do's and Don'ts of different cultivation techniques

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

Timing of reseeding

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

Spring reseeding offers more flexibility. One of the most important aspects of spring reseeding is that the total annual grass production from a spring reseed is as much, if not more than, the old permanent pasture in the year of sowing, even allowing for the time the (new) sward is 'out of production' during establishment. Establishing clover in a spring reseed is more reliable than in autumn due to the stability of soil temperatures in late spring. Post-emergence spraying for weed control is usually very successful with spring reseeding due to favourable weather conditions in summer.

Whether reseeding in spring or autumn, it generally takes a sward around 11 months to fully establish and 'settle down', so good grazing management in that early-growth phase is very important.

Cultivar choice

Grass cultivars should be selected from the Irish (Republic or Northern) Recommended Lists. These varieties have been tested under Irish conditions. The Teagasc Pasture Profit Index is also a valuable tool to select the most suitable grass cultivars for your farm. Teagasc recommendations are to sow 35 kg seed/ha (14 kg/ac) to ensure good establishment of the sward. It is also advised to sow a minimum of 3 kg of each cultivar within a mixture, and no more than 3 or 4 cultivars per mix.

How to establish a white clover sward on your farm

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

1. Direct reseeding

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

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; therefore, there is a certain amount of risk associated with this approach.

Key steps involved with over-sowing white clover:

- The clover seed can be broadcast onto the sward or stitched in using a suitable machine (e.g. Einbock pneumatic seeder)
- It is best to over-sow directly after tight grazing (≤ 4 cm post-grazing sward height) or after cutting the paddock, such as for 'surplus' bales. It is not recommended to over-sow clover into dedicated silage paddocks.

- A slightly higher clover seeding rate (3.5 to 5 kg/ha) is recommended for over-sowing compared with a full reseed to overcome the issues with slugs and a lower germination rate.
 - Sow with a fertilizer that contains P, particularly if soil fertility is poor, e.g. 2.5 bag of 0-7-30 or 0-10-20 per ha.
 - If possible, reduce nitrogen fertiliser application after over-sowing.
- Roll or spread 5000 gallons/ha of 'watery' slurry on paddocks post-sowing to ensure good seed-soil contact.
- Ideally over-sow on well-managed grassland. If the sward is old with a low content of perennial ryegrass and a dense 'butt' a full reseed is best practice.

Management of reseeds

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

Care needs to be taken when grazing newly-reseeded swards. The sward should be grazed as soon as the roots of the new grass plants are strong enough to withstand grazing (i.e. root stays anchored in the ground when pulled). Early grazing is important to allow light to the base of the plant to encourage tillering and, where relevant, clover establishment. Grazing by lighter animals such as calves, weanlings or sheep is preferred as ground conditions may still be somewhat fragile, depending on the seedbed preparation method used. The first grazing of a new reseed can be completed at a pre-grazing yield of approximately 700 to 1,000 kg DM/ha. Frequent grazing of the reseeds at light pre-grazing yields (< 1,400 kg DM/ha or less than 8 cm) during the first year post-establishment will have a beneficial effect on the sward. The aim is to produce a uniform, well-tillered, dense sward. If possible, reseeded swards should not be harvested for silage in their first year of production as the shading effect of heavy covers of grass will inhibit tillering of the grass plant and clover establishment, resulting in an open sward which is liable to weed ingress.

Conclusion

The timing of reseeding will be influenced by feed budgets and weather conditions. There is little difference between reseeding methods once a firm seedbed is established and good seed-soil contact is achieved. White clover can be established in swards at reseeding or can be successfully incorporated into existing swards by over-sowing. Whether it is a full reseed or over-sowing, management after sowing has the biggest impact on the successful establishment and production potential of swards.

The benefit of white clover in beef systems

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Summary

- Clover has a positive influence on animal performance and herbage production.
- Clover can increase sward nutritive value significantly, which can increase animal performance from grazing.
- Clover inclusion increases the quantity of herbage removed from grazing swards leading to higher grass utilisation.
- Research is on-going in the Derrypatrick Herd at Teagasc Grange to quantify the benefits of clover inclusion on sward productivity and cattle performance.

Introduction

Clover has the potential to increase the productivity of Irish grass-based beef production systems as it can have a positive influence on animal performance and herbage production. In a perennial ryegrass sward, clover has been shown to increase animal dry matter (DM) intake at grazing which can lead to higher live weight gain. Additionally, clover has the ability to fix atmospheric nitrogen (N) and make it available for grass growth; this can supply between 50 and 150 kg N/ha per year to the sward. The proportion of clover in swards varies depending on the time of year and sward management. Generally, there are low levels of clover in swards in spring (less than 10%), increasing to a peak of up to 40 to 50% in late summer/early autumn. Clover has a lower growth rate than grass at temperatures below 10°C, which can lead to low sward clover content in spring. Clover growth continues to increase up to 24°C, whereas grass growth peaks at temperatures of 15 to 20°C. As a result of their different growth profiles, clover and grass growth patterns complement each other with grass growth peaking in May/June followed by a decline, while clover growth peaks in August/early September.

Establishment of clover

There are two ways of introducing clover into the sward – either by incorporating clover in the grass mix (2.5 to 5.0 kg/ha) at reseeding or over-sowing into an existing sward after silage harvesting or tight grazing. Incorporating clover in a reseed provides the best chance of establishment, and also provides the best opportunity for weed control. Reseeding is most effective when seeds are sown at soil temperatures of 8°C or greater. It is important that seed is not sown too deeply (> 1 cm) to ensure germination. The use of ‘clover safe’ post-emergence sprays 5 to 6 weeks after sowing provides the best opportunity to kill grassland weeds as they will be at the seedling stage. This is most important in a grass-cover sward as it can be difficult to control weeds after the post-emergence stage.

Grazing management of grass-clover swards

As with perennial ryegrass swards, excellent grazing management on grass-clover swards is critical to optimise both herbage production and its nutritive value. Spring time can

be a particularly challenging time for managing grass-clover swards. It is important that poaching on grass-clover swards is minimised as this will result in a loss of clover stolons and consequently, reduced herbage production. This can be difficult to manage as grass-clover swards can have a lower density of grass tillers, resulting in a more open sward, which is more susceptible to poaching. Fertiliser N application on grass-clover swards should be similar to grass-only swards in the spring, as their N requirements are similar at this time. Depending on soil indexes, phosphorus (P) and potassium (K) should also be applied at the appropriate rate as this will also promote clover growth. Tight grazing in the first rotation to 3.5 cm is critical; this allows light penetrate the base of the sward to reach the dormant clover plant, and thus promote stolon growth and production.

Mid-season grazing management of grass-clover swards is similar to that of grass-only swards. Pre-grazing yield should be maintained at 1300 to 1600 kg DM/ha and swards should be grazed to a post-grazing sward height of 4.0 cm. Rotation length should be between 18 and 24 days during the main grazing season. Nitrogen fertiliser applications should be maintained at similar levels to grass-only swards for April and May. From June onwards, when there is a high level of clover in the sward (>25%) and it is actively contributing N to the sward, N fertiliser applications may be reduced.

In the autumn, it is critical to graze paddocks out well (~4.0 cm) at the final grazing before closing while minimising poaching damage so that light can penetrate to the base of the clover plant to promote stolon survival and production over winter. The loss of stolons over the winter and the fact that clover growth in spring is very slow makes clover very vulnerable to competition from the grass in the sward in early spring.

Bloat

Bloat, excessive accumulation of gases in the rumen, can be a serious issue in grass-clover swards. Bloat can occur at any time of the year but particular risk times are April/May (due to lush, low DM swards) and from August onwards when sward clover content is highest.

High-risk conditions when bloat may occur include:

- High (>60%) clover content in the sward.
- Weather conditions (heavy persistent rainfall over a prolonged period leading to lower DM swards, or mornings where there is a heavy dew).
- Transitioning from grass-only to grass-clover swards.
- 'Hungry' cattle going into a paddock with high levels of clover.

Grazing management practices can be adapted to reduce the risk of bloat. Such practices include:

- Avoid switching from grass-only sward to mixed grass-clover swards (as much as possible).
- Ensure minimum post-grazing sward height is 4.0 cm, no lower. This will avoid hungry animals being turned into mixed grass-clover swards.
- Restrict access to a small grazing area for the first 2 to 3 hours after entry to the paddock, in order to limit animals preferentially selecting clover.
- Identify high-risk paddocks and monitor stock closely when grazing these.
- Check stock after initial turnout and regularly for the first three hours after entrance to a paddock during high-risk conditions.
- Provide a source of fibre such as hay or straw in the paddock to ensure animals have some fibre intake, particularly if close monitoring is difficult.

A routine preventative measure is to add bloat oil (an anti-bloating agent) to drinking water. Bloat oil can be added either directly to water troughs or dispensed through the water system, usually from June to September.

Recent and on-going research

A grazed plot experiment was undertaken at Teagasc Moorepark to examine the effect of N fertiliser application rate on herbage production and sward clover content from grass-only and grass clover swards. Treatments consisted of two swards (grass-only and grass clover) and five N fertiliser application rates (0, 60, 120, 196 and 240 kg N/ha per year). Measurements were made for a four-year period. Across the four years of the experiment, regardless of N fertiliser application rate, the quantity of herbage removed from the swards by grazing animals increased by 2,930 kg DM/ha when clover was included in the sward (Table 1). As N fertiliser application rate increased, average annual sward clover content declined from 33.3% when 0 kg N/ha was applied to 19.6% when 240 kg N/ha was applied.

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

	Nitrogen application rate (kg/ha/year)				
	0	60	120	196	240
Herbage removed (kg DM/ha/year)					
Grass-only	9080	9200	10980	11310	12630
Grass clover	13310	13050	13100	13760	14420
Sward clover content (% of DM)	33.3	30.6	27.0	21.7	19.6

At Teagasc Grange, clover was incorporated into half of the paddocks in the Derrypatrick Herd farm between 29 May and 20 July in 2017. The clover cultivars used were Aberherald and Chieftain (medium-leaved clover). Swards were over-sown either after silage was harvested or after tight grazing (<4 cm). Clover was sown at a rate of 5 kg/ha (2 kg/ac) using an Einbock pneumatic seeder. At sowing 0:7:30 was applied at a rate of 5 bags/ha. After sowing, paddocks were tightly grazed (<4 cm) at a pre-grazing herbage mass of 1,000 to 1,200 kg DM/ha, when possible. Herbage production, sward clover content and animal daily live weight gain will be measured over the coming years.

Clover inclusion in a sward can also increase the nutritive value of the sward, which will have a positive influence on animal performance. In the farm systems experiment undertaken at Clonakilty Agricultural College, swards that included clover had significantly higher crude protein concentration and organic matter digestibility than grass-only swards and lower fibre (neutral detergent fibre and acid detergent fibre) concentrations (Table 2). Higher animal live weight gains would be expected from animals grazing these types of grass-clover swards compared with the grass-only swards, when under the same management conditions.

Table 2. Comparison of sward nutritive values between grass-only swards and grass-clover swards in Clonakilty Agricultural College.

Average annual nutritive value 2014-2016	Grass-only	Grass-clover*
Crude protein (g/kg DM)	196	240
Organic matter digestibility (g/kg)	758	779
Neutral detergent fibre (g/kg DM)	455	408
Acid detergent fibre (g/kg DM)	264	247

*Annual sward clover content of 25%

Conclusion

White clover inclusion can increase herbage production. Additionally, clover inclusion in grass swards can increase sward nutritive value significantly which can increase animal performance from grazing. Research is on-going at Teagasc Grange (Derrypatrick Herd) to examine the effects of white clover inclusion in drystock enterprises.



PastureBase Ireland – Capturing grassland data on commercial Irish farms

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Summary

- Drystock farms recording farm cover regularly on PastureBase Ireland have on average grown between 11.8 and 12.7 t dry matter (DM)/ha/year over the past four years (2014-2017).
- There was large variation between farms for grass DM production ranging from 16.5 t DM/ha to 8.0 t DM/ha.
- Dividing the farm into suitable sized paddocks and rotational grazing is key for drystock farms to grow and utilise more grass.
- Weekly measurement of grass cover is key to achieving six grazing rotations during the mid-season period, as well as offering livestock high nutritive value grass.
- Autumn closing date of paddocks has a significant impact on the amount of grass available the following spring. For each week delay in closing in autumn, spring grass accumulation is reduced by 77 kg DM/ha.

Introduction

PastureBase Ireland (PBI) is an internet-based grassland management tool. In operation since 2013, it offers farmers 'grassland decision support' and stores a vast quantity of grassland data from dairy, beef and sheep farmers in a central national database. Within the last two years PBI and AgriNet Grass, owned by Progressive Genetics, have merged which will double the number of farms on the programme and will add significantly to the national database. The *Food Wise 2025* strategy has set ambitious targets for Irish agriculture, including a target relating to grass utilisation on all livestock farms. Specifically, it targets an increase in grass utilisation of 2 tonnes dry matter (DM)/ha annually by 2025. Significant changes will be required in how farmers manage and use grass if this target is to be achieved. What PBI is telling us is that farmers must have a good knowledge on current grass supply in order to manage grass well. If you do not know your farm cover, grass demand and grass growth, it is virtually impossible to operate a high-output grass-based production system. A key factor in the profitability of any beef farm is making use of the feed resource produced inside the farm gate. Relying on more costly imported feed increases financial exposure. Approximately, 10% of farms in PBI are drystock farms. The use of PBI can help beef farmers utilise more grass; one extra tonne of grass DM per hectare is worth €105 per hectare in extra profit in a drystock enterprise.

What are the advantages of PBI over other grassland programmes?

By using PBI you are adding to the world's first national grassland database. From this information grassland researchers in Teagasc can determine the level of grass production in any part of Ireland at any time. There is a lot of valuable data in the AgriNet Grass database

that can now be analysed from a national or industry point of view. Centralisation of grass-related data in PBI will help create improvements in terms of grass breeding, evaluation of new grass varieties and the management of grassland. The database stores all grassland measurements within a common structure. This permits the quantification of grass growth and DM production (total and seasonal) across different enterprises, grassland management systems, regions, and soil types using a common measurement protocol and methodology. Background data such as the number and size of paddocks, grass/clover varieties used, reseeding history, soil type and fertility, land drainage characteristics, fertiliser applications, and the land aspect and altitude are also recorded.

Grass DM production on drystock farms - PastureBase Ireland data (2014 - 2017)

Huge variation in grass DM production exists on farms. There are many reasons for this, including differences in stocking rate, soil fertility and grazing management practices. If soil fertility and grazing management can be improved, many farms can substantially increase their grass DM production. Relatively high grass DM production can be achieved on drystock farms with good grazing and soil fertility management in many locations. This is one of the key early findings that emerged from PastureBase Ireland in 2014.

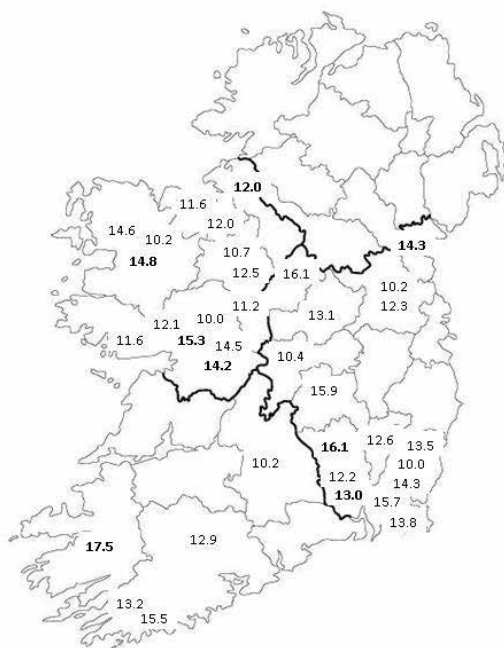


Figure 1. Grass dry matter production (t /ha) from PastureBase Ireland drystock farms in 2017

Figure 1 shows the annual DM production data from 55 drystock farms across the country in 2017. These farms have >25 weekly grass covers completed. In 2014, the same farms produced an average of 11.8 t DM/ha. This increased to 12.4 t DM/ha in 2015. The difference between the lowest and highest producing farms was 7.3 t DM/ha. The highest-producing

farms were growing >15.0 t DM/ha with little variation between paddocks, and the lower-producing farms had much greater variation between individual paddocks. In 2016, there was a decrease of 0.4 t DM/ha compared to 2015; on average drystock farms grew 12.0 t DM/ha. Much of this decrease in DM production was during the poor grass-growing spring in 2016 but growth recovered well in May. In 2017, drystock farmers produced an average of 12.7 t DM/ha.

2017 – Good year for grass growth on drystock farms

In 2017, drystock farms grew 700 kg more grass compared to 2016 (12.0 vs. 12.7 t DM/ha). Spring growth (1 January to 10 April) was up 30% in 2017 when compared with the same period in 2016. This was largely driven by the mild winter and favourable growing conditions especially in March. In the main grazing season (11 April to 10 August) growth in 2017 was 10% greater than in 2016. Autumn grass production (11 August to 31 December) in 2017 was down 12% than the year previous. The number of grazings achieved per paddock annually is a major driver of grass production; every extra grazing is worth 1,385 kg DM/ha. In 2016, drystock farms achieved 5.0 grazings per paddock, while in 2017 this increased to 5.4 grazings. These data were extracted from PBI drystock farms who contributed 25 measurements to PBI in 2016 and 2017. The pool of farmers in 2017 was bigger than 2016 (+15 farms); therefore, this needs to be borne in mind when interpreting the annual data presented.

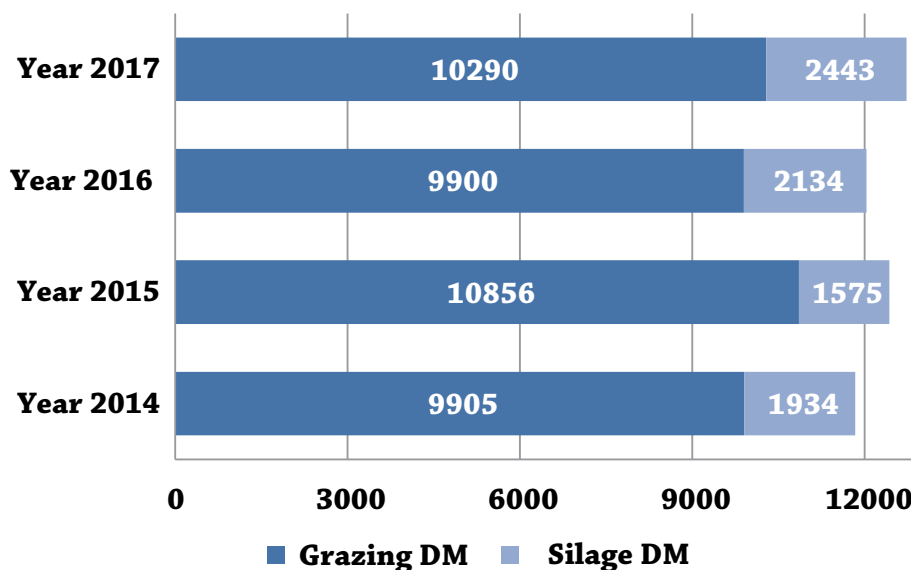


Figure 2. Annual grass dry matter production (kg DM/ha) on PBI drystock farms from 2014 to 2017

Grass DM production on drystock farms - PastureBase Ireland data (2014-2017)

Why and how does this amount of variation in grass production occur on farms? From the data in PBI over the last four years trends are beginning to emerge in growth rates which are directly related to grazing management. Achieving more grazings from each paddock during the season is a key driver to producing high quantities of grass. Reseeding low-producing

paddocks is also a key factor influencing grass production. On high grass-producing farms, variation in grass DM production between paddocks tends to be small. One of the strengths of PBI is that on-farm grass DM production can be quantified and classified into the different seasons for each paddock. This data enables farmers to target paddocks that have the greatest potential to increase grass growth.

Why are some drystock farms producing high quantities of grass?

1. Rotational grazing system – paddock system.
2. Good farm grazing infrastructure i.e. adequate size paddocks.
3. Maximising spring grazing – early turnout and finishing the first rotation on time.
4. Addressing soil fertility annually.
5. Recording farm cover weekly (>25 walks/year).
6. Making decisions weekly on the information generated after each farm cover assessment.
7. Achieving a high number of grazings per paddock per year – top farms achieving >8 grazings per paddock per year.

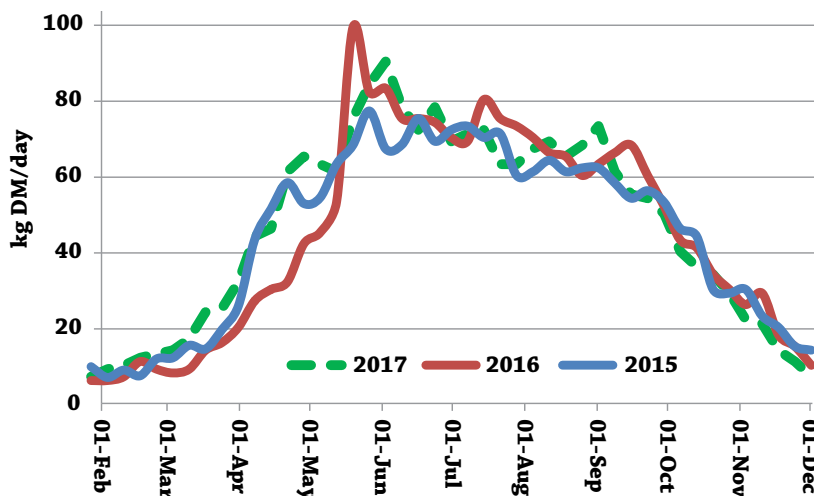


Figure 3. Mean daily grass growth rates (kg DM/ha) for PastureBase Ireland farms for 2015 to 2017.

Conclusions

It is clear that Ireland has incredible potential to increase annual DM production through a better focus on grazing management. PastureBase Ireland has highlighted that all farms need to focus more on early-spring grazing. Beef farms that graze early in the season will stimulate higher grass growth rates earlier (late-February/March) and will achieve higher annual DM production, increase liveweight gain and overall farm profitability.



Grass10 campaign

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Summary

- Ireland possesses the ability to grow large quantities of high quality grass and convert it through the grazing animal into high quality grass-based meat products.
- The objective of the Grass10 campaign is to achieve 10 grazings/paddock/year utilising 10 tonnes grass dry matter (DM)/ha.
- Maximising the number of grazings achieved on each paddock is a very effective method of increasing farm grass utilisation.

Introduction

Grazed grass is the cheapest and most available feed for beef production systems in Ireland. As an abundant natural resource, grass provides Irish farming with a significant competitive advantage for beef production. Grass enables low-cost animal production and promotes a sustainable, high quality green image of meat production across the world. Recent industry reports (*Food Harvest 2020* and *Food Wise 2025*) have highlighted the important role grass can play in an expanding meat production industry. Through a combination of climate and soil type, Ireland possesses the ability to grow large quantities of high nutritive value grass which can be converted through grazing animals into high quality grass-based meat products.



Our competitive advantage in meat production can be explained by the relative cost of grass, silage and concentrate feeds. Therefore, increased focus on grass production and efficient utilisation of that grass should be the main driver for profitability of the livestock sector. A recent financial analysis by Crosson et al. (2016) at Teagasc Grange demonstrated an increase in profit of €105/ha for every 1 tonne DM/ha increase in grass utilised. Additionally, environmental sustainability (carbon footprint, nutrient use efficiency, etc.) is also improved by increased grass utilisation.

Future profitability in grass-based meat production in Ireland will depend on an effective grass-based system. However, at present Irish farmers are not using grass to best effect and there is a need to (1) increase grass production and (2) ensure efficient utilisation of that grass.

Current grazing performance on drystock farms

Currently, it is estimated that about 5.6 tonnes grass DM/ha/year are utilised nationally on drystock farms (Teagasc National Farm Survey data). There are major improvements required in the areas of grass production and utilisation. Data from the best commercial grassland farms and research farms indicate that the current level of grass utilised on drystock farms can be increased significantly, to greater than 10 t DM/ha (i.e. 14 t DM/ha grown with a 75% utilisation rate).

It is important to recognise that improvements in soil fertility, grazing infrastructure and a level of re-seeding are required to achieve higher levels of grass production and utilisation. To achieve greater change in the amount of grass utilised, farmers will need to upskill their grazing management practices. This means regular measurement of grass supply/production.

Grass10 campaign

Grass10 is a four-year campaign launched by Teagasc in 2017 to promote sustainable grassland excellence. The Grass10 campaign will play an important part in increasing grass growth and utilisation on Irish grassland farms, thereby improving profitability at producer level and helping to ensure the long term sustainability of Irish beef, dairy and sheep production. The framework of the Grass10 campaign is outlined in Figure 1. Significantly, it can provide the platform or framework to enable various industry stakeholders to collaborate for collective action. Given the current performance in terms of grass growth and utilisation, the need for 'collective action' should be clear.

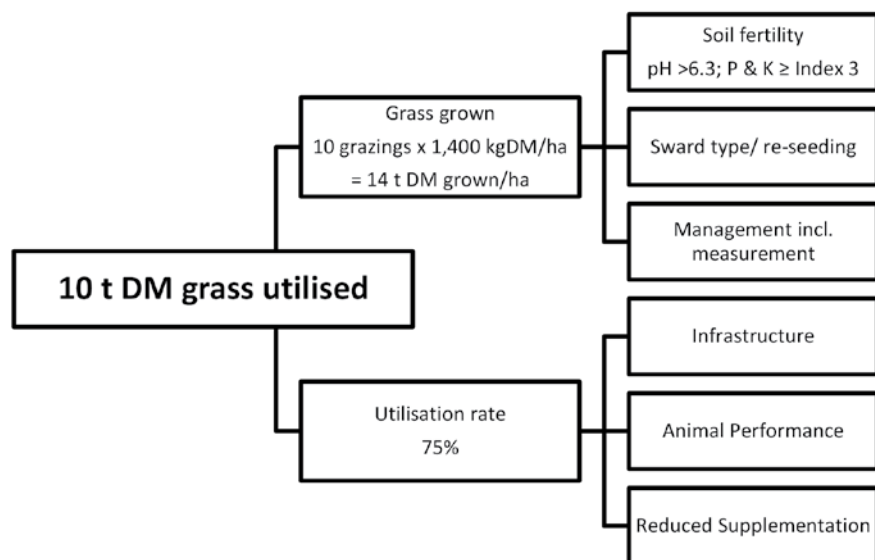


Figure 1. Schematic of Grass10 campaign

Objective

The objective of the campaign is to achieve 10 grazings/paddock/year utilising 10 tonnes grass DM/ha. In order to achieve this objective, significant changes in on-farm practices will be needed, specifically:

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

Every farm situation is unique with varying soil types, local climatic conditions, stocking rates and farmer management capabilities. However, many Irish farms are only producing 50% of their grass growth capability and therefore, grass production is limiting output on most farms. Large increases in grass production can be achieved. Increases in beef output must come from growing more high quality grass and not from importing supplementary feed.



Huge leaps forward have been made in developing decision support tools to improve farm efficiency, profitability and sustainability. The primary objective of most of these tools is to increase the information available to assist in farm-management decision making, as well as to collect and collate large amounts of data in a centralised database. Teagasc launched PastureBase Ireland (PBI) – an online grassland management decision support tool – in January 2013 and Grass10 will see the roll-out of the new PBI website as a key component of the campaign. Upon entering data from their own farm (e.g. grass measurements), the PBI platform provides real-time and customised grassland management advice to the farmer to assist their decision-making. Reports are developed in such a way that allows farmers to benchmark their individual farm with comparable farms in their discussion group or in their region. The data accumulated to date indicate that PBI participating farms have achieved improvements in grass DM production and grazing management.

PastureBase Ireland is informing us that farmers need to have control of current grass supply in order to manage grass well. Grass cannot be managed correctly without knowledge of farm cover, grass demand and grass growth. The crucial point on any farm is utilising the grass produced on the farm and minimizing the necessity to purchase feed.

Grassland performance on drystock farms using PastureBase Ireland.

The average annual grass DM production on drystock farms recorded on PBI over the last few years, is around 12 t DM/ha. Taking a more in-depth look of why some farms are able to produce high quantities of grass it is clear that achieving more grazings from each paddock during the season is the key driver of success. The average number of grazings achieved per paddock/year on drystock farms is less than 5. However, farms that produced more grass achieved 6 grazings per paddock annually.

On a high proportion of drystock farms the number of paddocks is insufficient leading to a small number of relatively large paddocks. The net result of this approach is long residency times (up to two weeks) and the productivity of these paddocks can be significantly reduced. A number of issues arise in these situations; regrowths are continually being regrazed, proper grazing heights are not achieved, nitrogen application is irregular and in many cases pre-grazing yields are too high, which results in swards needing to be topped on a number of occasions across the season.

There is a strong relationship between the number of paddocks per farm and the total number of grazings achieved per farm. PastureBase Ireland data have identified that creating one new paddock on a farm will give five extra grazings from the farm annually. The creation of additional paddocks not only increases grass production but makes management of

pasture more streamlined and leads to better control of grass, especially during periods of high growth. A key finding from the grazing performance of drystock farms recording on PBI is that the greater the number of grazings achieved, the greater the amount of grass DM produced. Every extra grazing achieved increased annual grass DM production by 1.5 t DM/ha.

Maximising the number of grazings achieved on each paddock is a very effective method of increasing farm grass utilisation. Paddock residency should be no longer than three or four days on drystock farms during the mid-season. It is critical that all drystock farms sub-divide existing paddocks into smaller areas with three or four day residency time. So, grow the grass in 3 weeks and graze it in 3 days.

Grassland Farmer of the Year competition

There is a proven link between increased grass utilisation and increased profitability in grass-based beef production systems. In addition, Teagasc research indicates that grass utilisation can be significantly increased on farms. With this background Grass10, in conjunction with the Department of Agriculture, Food and the Marine, launched a grassland competition to recognise those farmers who are achieving high levels of grass utilisation in a sustainable manner. Practises used by these farmers to increase grass production and utilisation, include soil fertility management, sward renewal, grassland measurement and improving grazing infrastructure.

The role of Stakeholders

Significant change is required in the grassland management practices of Irish livestock farmers to ensure that Irish grassland farming systems remain competitive and sustainable. Teagasc recognises that the co-operation and collaboration of a range of organisations and stakeholders is required to achieve the changes required right across the industry.

Acknowledgements

Grass10 wishes to acknowledge the support of our industry stakeholders in this new campaign.



An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine



Grassland AGRO



Technology Village

‘BETTER’ Beef Program / Suckler Beef Systems

Teagasc/Irish Farmers Journal BETTER Farm Beef Challenge: Phase III

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Summary

- The third phase of the Teagasc/Irish Farmers Journal BETTER Farm Beef Challenge commenced in February 2017 with 27 new farms.
- Profitability targets have increased to an average gross margin of €1250/ha across all farms and systems.
- The focus has now moved to farmers taking on a set of 3 'mandatory', and at least 3 'optional' challenges.
- The mandatory challenges cover health and safety on farms, farm finance and grassland management.
- Farm updates will be provided weekly through social media, The Irish Farmers Journal and Teagasc website. Open days and discussion groups will be held on farms.

Introduction

The third phase of the Teagasc/Irish Farmers Journal BETTER Farm Beef Challenge began in early 2017 with 27 new farmers. It's supported by ABP, Dawn Meats, FBD and Kepak. The third phase of the programme follows on from the success of the previous 2 phases, which showed increased levels of profitability associated with increased farm output and increased labour efficiency. Phase 3 of the programme now focuses on each farmer taking on 'challenges' across a broad range of areas. Each farmer has to undertake 3 'mandatory' challenges along with at least 3 more 'optional' challenges over the course of the programme. Each farmer, at the beginning of the programme has to complete a 3-year farm plan. Progress on farms is reported weekly through the Irish Farmers Journal along with regular updates on the Teagasc website, Beef Newsletters, Today's Farm magazine, and on social media.

The Challenges

Two tonne grass challenge (mandatory)

The target is to grow two tonnes (t) more grass dry matter (DM) per hectare (ha) annually from existing swards over the three-to-four year programme period. For farmers at a more advanced stage, the aim is to break the 10 t DM/ha/annum challenge; the programme average for 2017 was 7.9 t DM/ha.

Farmer Focus – John McSweeney, Lissarda, Co. Cork runs a 24 ha suckler and dairy calf-to-beef farm consisting mainly of dry, free-draining soil. John has increased his stocking rate

substantially in the last year, and is currently close to 3 livestock units (LU)/ha. To carry this stocking rate John needs to grow close to 16 t grass DM/ha/annum on his grazing block. In 2017, grass production was 13.9 t DM/ha, far in excess of the programme average. The farm has good soil fertility with the majority of land at soil Index 4 for phosphorus (P) and potassium (K) and a high proportion of reseeding was carried out. There is a good network of roadways and paddocks on the farm. John aims to try and get the first rotation started by mid-February and achieve 10 rotations during the main grazing season. Closing paddocks up early is essential for John to achieve early-turn out to pasture in spring and he aims to have the farm closed by November 1. Soil fertility will be maintained by applying required amounts of P and K fertiliser along with regular dressings of lime. Soil testing will be carried out every 3 years to assess if his fertiliser plan is working.

The farm finance challenge

The target is to keep 100% of the farm's direct payment and increase the farm's gross margin each year of the programme. All programme farmers will complete a Profit Monitor annually to monitor progress. The target gross margin across the programme farms is €1250/ha. The end-of-programme target gross margin varies between production systems, from €800/ha for suckler calf-to-weanling farms up to €1600/ha for suckler bull-finishing farms. In year 1 (2017) of the programme, mean gross margin across all BETTER Farms increased by 25%, from €525/ha to €721/ha, compared to 2016. This was associated with increases in stocking rate of 0.18 LU/ha, and in live weight output of 127 kg/ha. The suckler under-16 month bull system showed the highest increase in profitability (43%) with gross margins increasing from €909/ha to €1300/ha. Suckler calf-to-store and calf-to-weanling producers showed much more modest levels of profitability with gross margins increasing by only 2% compared to the previous year; store producers' gross margins increased from €611/ha to €625/ha, and weanling producers' gross margin increased from €307/ha to €312/ha.

Farmer Focus - Shane Gleeson farms 40 ha in Cappamore, Co. Limerick and operates a suckler calf-to-weanling enterprise. The plan is increase stocking rate by buying dairy-bred Hereford bull calves with a view to selling them live as forward stores. A 6-year business plan was completed for the farm which outlined projected stock sales and purchases along with required inputs and associated variable and fixed costs. The level of capital investment is to be kept to a minimum for the next number of years apart from investment in grazing infrastructure. Gross margin in 2016 was €124/ha, and in 2017 it increased to €267/ha. It is anticipated that gross margin will reach close to €1,000/ha by 2021.

The soil health challenge

The objective is to get programme farmers firstly identifying the fertility status of their soils and then to embark on a soil fertility plan. Soil types vary (e.g. mineral and peat) within, and especially across, the farms. The plan is that each farm paddock receives recommended applications of lime and nitrogen (N), P and K fertiliser during the first three years of the programme to improve soil pH levels to target of 6.3, and subsequently soil P and K levels to Index 3.

Farmer Focus - James Flaherty farms 41 ha near Castleisland, Co. Kerry and runs a suckler calf-to-weanling and dairy calf-to-beef enterprise. Approximately 50% of the total land area is soil Index 1 or 2 for P and K, and 30 to 40% of the farm has a lime requirement of 10 to 18 tonnes/ha. Lime will be applied over a number of years at a rate of 5 t/ha/annum. To increase soil P and K levels, James will focus on applying fertilisers such as 18-6-12 and 10-10-20

for grazing ground, whereas for silage ground, fertilisers such as 0-7-30 or cattle slurry will supply the P and K required, with Urea applied to supply the N requirement. Soil analysis will be carried out on an annual basis on this low-index land to monitor performance.

Farm safety challenge

The farm safety challenge is a mandatory challenge with all farmers required to complete a farm safety risk assessment on an annual basis, and to introduce two positive farm safety-related changes annually.

Farmer Focus - Tom Bolger and his son Ian have introduced a number of clever safety measures on his farm in recent years. One of the most useful innovations was the attachment of two angled mirrors onto the bonnet of the tractor, in order to provide a clear view of the road when exiting the yard or a field; this permitted the tractor to pull out safely onto the road. Prior to this, Tom would get down off the tractor to check if the road was clear and then quickly jump back in again before exiting. Another innovation was the design and manufacture of an adjustable dehorning calf crate that safely caters for different size animals, and can be operated by one person.

The greening challenge

Using research-based established methods, farmers must 'demonstrate' practical ways of incorporating clover into 20% of the farms grassland swards and disseminate best-practice advice on how to manage swards to ensure high establishment rates and necessary grazing practices to avoid issues such as bloat. Clover must be established in 50% of the farm by year two of the programme, with incorporation into the remaining half by year three.

Farmer Focus - Tommy Holmes farms 18 ha near Ballina, Co. Mayo in a suckler calf-to-finishing system. Over the past number of years Tommy has placed greater emphasis on soil pH along with P and K indexes. The farm grew 15.3 t grass DM/ha in 2016 and Tommy wants to grow and utilise even more grass going forward. Research has shown that white clover has the ability to fix N from the air and can supply 50 to 200 kg N/ha annually. Tommy is eager for clover to be included in all his swards to increase herbage production and quality.

The labour challenge

This challenge is to quantify the hours per week farmers work on-farm and, more importantly, the financial return for every hour worked (€/hr). Farmers will be tasked with recording labour hours for the first 7 days of every month.

Farmer Focus - John Dunne farms 119 ha outside Portarlinton, Co. Offaly and has one of the largest farms in the programme. Over the duration of the programme he hopes to increase his herd of 120 suckler cows, finishing all progeny under 24 months, and also rear 100 dairy-bred calves, bringing them through to slaughter. Spring is a very busy period on all farms but the workload on this particular farm at this time will inevitably be too much for one labour unit. To overcome this, John has employed an additional labour unit in the spring to help with machinery-related work.

Meet the markets challenge

Meet the markets is a challenge tailored towards farmers who are finishing cattle within the programme. The farm must be Quality Assured and aspiring to finish cattle that meet all the required specifications. Animal live weight must also be measured three times annually to monitor growth performance targets.

Farmer Focus - Sean Hayes farms on variable quality soil outside Tulla, Co. Clare. In 2017, Sean changed his production system from selling 'live' animals to producing 'finished' cattle for slaughter. The results were very positive as all stock had adequate fat covers and very acceptable carcass weights. The under-16 month old bulls averaged €1,626. Steers finished at 19 months averaged €1,467 and heifers finished at 21 months averaged €1,467. The biggest issue on farms that change production system in this manner is cash flow, as sales are delayed for a longer period.

The breeding challenge

Improving genetic merit of suckler cows will have a positive impact on herd output. A key component of the breeding challenge is to increase the average 'replacement' value of the herd by €20 over the duration of the programme. To achieve this major emphasis will be placed on improving the maternal traits, such as maternal calving difficulty, milk yield, cow maintenance costs, fertility and cow survival, all of which contribute to the makeup of the Replacement Index. Along with increasing the replacement value of the herd another key focus is achieving all the ICBF calving targets.

Farmer Focus - Garreth McCormack operates a 34 ha suckler calf-to-weanling system on heavy clay soils in Bailieborough, Co. Cavan. Garreth's herd comprising of predominately Saler 'type' cows had an average Replacement Index of €105, which is one of the highest indexes within the programme. The decision was made to use 100% AI in order to reach an average Replacement Index value of €125, which will put him in the top 10% nationally. His herd reproductive performance is impressive; calving interval of 371 days, 0.95 calves/cow/year, 0% calf mortality at birth, 4.4% mortality at 28 days, 63% of heifers calved at 22-26 months and a six-week spring-calving period.

The herd health challenge

The herd health challenge will evaluate veterinary bills to establish what categories of animal require antibiotic use on farm. Blueprints will be developed that favour targeted use of vaccines, and optimise herd/flock management and husbandry practices to reduce high-risk diseases, with the objective of reducing animal health costs by 20%.

Farmer Focus - Maurice Hearn is running 100 autumn-calving suckler cows on 60 ha near Dunmore East in Co. Waterford. In recent years, Maurice experienced some severe pneumonia outbreaks in calves and yearlings. Last summer a thorough herd health plan was put in place for the farm. The plan included modifications to an existing building to improve ventilation; ventilated sheeting was replaced with Yorkshire boarding and extra air outlets were put in the roof to improve air circulation. Additionally, a strict vaccination policy was introduced for the herd that targeted IBR and pneumonia.

The mixed-grazing challenge

The aim of this challenge is to establish a suitable blueprint for operating a mixed-grazing (cattle and sheep) system.

Farmer Focus - Martin Downes farms 104 ha, split in two blocks, near the village of Multyfarnham, Co. Westmeath. Along with 100 spring-calving suckler cows, there are 160 ewes on the farm, which lamb in February. Martin aims to have at least 60% of the farm closed by the end of October, and this is not grazed again until spring time. Sheep are grazed on beet tops for a month prior to housing at the end of November. Sheep are usually grazed with yearling bulls upon turnout to pasture in spring.

Newford suckler demonstration farm update

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Summary

- The Newford suckler demonstration farm was set up in Athenry to demonstrate best practice in sustainable suckler beef production.
- The 100-cow herd are Angus and Hereford crosses from the dairy herd.
- All cows are mated by AI to high Terminal Index sires to calve compactly over a 10-week period beginning in early February, close to turnout to grass in spring.
- All progeny are finished as steers or heifers, between 18 and 22 months of age.
- All the variable and fixed costs of the operation, and set-up of the farm, have to be funded by the farm with the exception of the land cost and the farm manager's salary; the farm has no Basic Payment Scheme (BPS).
- The farm is operated and managed by Mathew Murphy with student help in the spring, and all farm practices are designed to optimise labour efficiency.
- Despite excellent animal performance and technical efficiency, the farm has returned either a negative or very modest net profit to date.

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 McDonald's, 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-steer (and heifer) beef farm to generate a viable family farm income. The farm is laid out in three separate divisions. The main block of land (26 ha) in Newford is dry, good-quality grassland is used for grazing the suckler cows and calves. Two other blocks of land, approximately 13 ha each, are rented locally; this land is poorer quality with impeded soil drainage, and is used to produce silage and graze the yearling cattle.

The suckler cow type

The cow types at Newford are first-cross Aberdeen Angus and Hereford-cross-Friesian cows with an average live weight of 655 kg. They have good 'maternal milk' traits resulting in high pre-weaning live weight gain in the calves. The average Replacement Index of the cows is €110 with heifers averaging €143. Replacements for the herd are purchased as calves by selecting female progeny of high Replacement Index proven AI Hereford and Angus sires. These heifer calves are contract-reared until they arrive onto the farm at approximately 21 months of age in-calf to high Terminal Index AI sires (Table 1), which were selected by the Newford management team. All heifers are calved at 24 months of age.

Sire selection

Criteria for 'Terminal' sire selection are as follows:

- 5-Star Terminal Index
- > 80% reliability
- < 7% calving difficulty for mature cows
- > 30 kg predicted carcass weight for mature cows
- < 6% calving difficulty for the first- and second-calvers
- > 25 kg predicted carcass weight for first- and second-calvers
- Straw costs less than €15

Criteria for 'heifer replacement' sire selection are as follows:

- 5-star Replacement Index
- >80% reliability
- < 6% calving difficulty
- > 25 kg predicted carcass weight
- Above breed average for carcass growth and conformation

Table 1. AI Sires selected for 2018 breeding season

Code	Use	Breed	Terminal Index (€)	Calving Difficulty (%)	Reliability (%)	Carcass weight (kg)	Reliability (%)
FSZ	Mature cows	Charolais	157	6.6	99	39	99
ZGM	Mature cows	Limousin	142	4.9	98	26	97
LM 4093	Mature cows	Limousin	174	5.3	88	40	75
THZ	Heifers	Limousin	132	5.0	99	26	99

Table 2 shows the reproductive and 'maternal' performance of the herd to-date. The breeding season is kept short to ensure compact calving to grass and that the calving season is finished before breeding starts, which is very important for overall labour and management efficiency.

Table 2. Newford cow numbers and performance

	2015	2016	2017	2018
Cows	74	81	85	88
Heifers	24	15	22	22
Calving interval (days)	-	371	349	362
Breeding season (weeks)	12	10	10	10
Weaning weight (kg)	262	303	301	-
Calf mortality - 28 days (%)	4.5	5.2	0.9	4.5
% cows empty	-	6	6	-

All animals from Newford farm are finished prior to slaughter at between 18 and 22 months of age; slaughter data are shown in Table 3. The beef cross dairy cows are primarily O grade cows but when mated to high genetic merit terminal sires produce R grade progeny. The carcass

weight has been increasing gradually over the last 3 years due to a combination of selection of better sires and extending the grazing season. The target for the farm is to slaughter as many as possible of the progeny before the second winter; however, the autumn of 2017 was exceptionally wet and all finishing cattle had to be housed in September until slaughter. This significantly increased the requirement for purchased feed as can be seen from the profit monitor data in Table 4.

Table 3. Carcass weight, conformation and fat score and value of cattle slaughtered from Newford farm.

	2015	2016	2017
Steers			
Conformation score	R-	R=	R-
Fat score	3 =	3 =	3 +
Carcass weight (kg)	320	332	341
Value (€)	1,290	1,294	1,400
Heifers			
Conformation	R=	R+	R=
Fat score	3+	4-	4-
Carcass weight (kg)	280	296	291
Value (€)	1,172	1,177	1,167
Cull cows			
Conformation score	O=	O=	O=
Fat score	4-	4-	3+
Carcass weight (kg)	292	311	309
Value (€)	972	987	1,062

The farm achieves a high gross output due to a high overall stocking rate (2.9 livestock units/ha) but the high variable and fixed costs are approximately equal to total output (Table 4). The 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



during the initial conversion of the farm from a sheep farm. The farm is still at a relatively early stage in development and will continue to focus on reducing costs while maintaining or increasing output. 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 4. Profit monitor data for Newford farm for 2015 to 2017

	2015 €	2016 €	2017 €
Sales	44,072	107,861	171,893
Purchases	20,029	22,324	29,458
Inventory +/-	80,237	24,477	-14,099
Gross output	104,280	110,014	128,336
Gross output per hectare (ha)	1,869	1,972	2,005
Variable costs			
Purchased feed	22,293	15,784	22,518
Fertiliser	16,141	14,313	15,629
Veterinary	9,340	13,489	10,314
AI / Breeding	2,012	3,721	3,539
Contractor	17,945	23,522	16,963
Straw	4,512	8,160	3,584
Total variable costs	76,681	85,887	85,229
Variable costs per ha	1,374	1,539	1,332
Gross margin	27,599	24,127	43,107
Gross margin per ha	495	432	674
Fixed costs			
Hired labour	3,350	7,200	8,652
Machinery running	7,407	10,268	6,701
Loan interest	6,900	7,500	12,701
Depreciation Buildings	10,168	11,942	7,348
Other fixed cost	10,942	11,277	10,850
Total fixed costs	38,767	48,186	46,252
Fixed costs per ha	695	864	723
Net profit	-11,168	-24,059	-3,145
Net profit per ha	-200	-431	-49
Premia: BDGP	10,200	8,442	8,099
Net profit including BDGP	-968	-15,618	4,954
Net profit Incl. DBGP per ha	-17	-280	77

PLEASE NOTE:

**Newford farm will host an Open Day for all farmers
on Wednesday 5 September 2018**



Technology Village

Dairy Calf-to-Beef

How can beef sire selection play a role in a profitable dairy beef system?

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Summary

- The use of beef genetics on the dairy herd is increasing each year.
- Dairy beef carcass quality is decreasing on the quality payment system (QPS) grid.
- Choosing beef calves sired by high genetic merit beef bulls could be worth as much as €16,100 in a 100 head dairy beef production system.
- A sire evaluation trial, in conjunction with Anglo Beef Processors (ABP), is on-going to identify the most suitable beef genetics to use in dairy herds.

Introduction

The dairy beef sector in Ireland is an important and growing industry. Due to the growth in the national dairy cow population in the post-quota era (1.085 million in 2012 to 1.330 million in 2016 (AIMS, 2012; 2016)), there has been a proportional increase in the number of dairy calves available for beef production. Furthermore, the use of breeding tools, such as the Economic Breeding Index (EBI), is increasing the fertility of Irish dairy cows. Consequently, fewer cows need to be bred to dairy bulls to produce heifer replacements, leading to an increase in the proportion of dairy cows bred to beef breed sires (7% increase in the number of beef cross calves coming from the dairy herd from 2012 to 2016). The contribution of the calf enterprise to the profit of the dairy farm is generally considered small and therefore beef bull selection on dairy farms is often not considered a high priority. Results from a recent Teagasc survey found that 43% of dairy farmers valued easy-calving as the most important trait for selecting a beef bull. This was followed closely by short gestation (42%) and then by breed (15%). Due to the selection of beef bulls for the dairy herd for easy-calving short gestation, the trend in recent years is a reduction in carcass conformation on the quality payment system (QPS).

The Teagasc/ABP dairy beef programme

The Teagasc/ABP dairy beef programme began in 2014. For the first year, the main objective was to compare the performance of progeny from easy-calving short gestation sires with easy-calving average gestation sires using Angus, Hereford and Limousin bulls for important beef production traits. In total, 600 calves were purchased for this trial. From 2015 the programme evolved into a sire evaluation trial in conjunction with the ICBF Gene Ireland dairy beef programme. The programme has two primary objectives: 1) to identify the most suitable beef bull genetics for crossing on dairy herds and 2) to genetically improve the main breeds supplying beef bulls to the dairy herd. Six hundred and fifty calves are purchased directly from farms at two-to-four weeks of age. The calves are reared through the ABP Blade

dairy beef contract rearing programme and at 15 weeks of age, 350 calves are moved onto the ABP trial farm in Carlow until slaughter, while 250 are reared and finished at Teagasc, Johnstown Castle. Animal performance is measured throughout the production cycle and meat quality evaluations are made through collaboration with Meat Technology Ireland.

The ICBF dairy beef Gene Ireland programme

The dairy beef Gene Ireland programme was set up in 2015, in conjunction with Teagasc and ABP. As part of the programme, unproven, short gestation and easy-calving sires with high genetic merit for important terminal traits such as carcass weight, conformation and feed intake (determined using the Terminal Index) are identified by ICBF, AI companies and breed societies for use in the programme. Participating dairy farmers purchase the beef semen and record information such as calving difficulty, gestation length, calf quality and birth defects on each beef calf born. The ultimate aim is to identify sires with the highest performance for carcass weight and conformation, combined with relatively low feed intake for 'beef production', in addition to high meat quality for the 'consumer', without comprising calving difficulty or gestation length for the dairy cow. These high-performing bulls can then be used to improve the genetic merit of the pedigree beef herds which, in turn, will produce the next generation of beef bulls for the dairy herd.

Results of the Teagasc/ABP dairy beef programme

The results to date show large variations in progeny performance between individual sires for key economic carcass traits. For example, the Angus progeny from FPI had on average 43 kg heavier carcasses, with a 0.6% higher kill-out percentage than ZTP (Table 1). Similarly, progeny from the Hereford bull DPS had on average, 52 kg heavier carcasses than TGB (Table 2).

Table 1. The effects of Angus (AA) sire on carcass weight, carcass conformation, carcass fat, kill-out % and carcass value.

Sire	Breed	Carcass Weight (kg)	Conformation score (1-15)	Fat score (1-15)	Kill-out (%)	Carcass Value (€)*
JYK	AA	271	5.8 (O=)	7.4 (3+)	50.0	1122
ZTP	AA	281	6.0 (O+)	7.8 (3+)	50.4	1180
LZE	AA	287	5.6 (O=)	6.0 (3=)	50.0	1188
YRE	AA	296	5.6 (O=)	8.1(3+)	49.1	1225
ZHF	AA	299	5.8 (O=)	6.8(3=)	49.5	1238
MWG	AA	300	5.6 (O=)	7.0(3=)	49.5	1242
KYA	AA	300	5.9 (O=)	7.3 (3+)	50.3	1242
JGY	AA	301	6.0 (O+)	6.7(3=)	50.6	1264
GJB	AA	305	5.1 (O=)	6.5 (3=)	50.8	1263
RGZ	AA	309	6.2 (O+)	7.2 (3+)	50.3	1298
FPI	AA	324	5.9 (O=)	6.8 (3=)	51.0	1341

*Carcass value is based on a €4.00/kg base price on the QPS grid, €0.12/kg quality assurance payment and €0.20/kg breed bonus payment.

Table 2. The effects of Hereford (HE) sire on carcass weight, carcass conformation, carcass fat, kill-out % and carcass value.

Sire	Breed	Carcass Weight (kg)	Conformation score (1-15)	Fat score (1-15)	Kill-out (%)	Carcass Value (€)*
TGB	HE	287	6.0 (O+)	7.4 (3+)	50.3	1205
CRP	HE	293	5.6 (O=)	8.0 (3+)	49.4	1213
KKO	HE	301	6.1(O+)	7.9 (3+)	51.0	1264
CKVZ	HE	301	5.5 (O=)	7.8 (3+)	50.6	1246
FRZ	HE	301	5.3 (O=)	7.4(3+)	49.6	1246
SPL	HE	303	6.2 (O+)	6.7 (3=)	51.4	1273
KHO	HE	306	5.4 (O=)	9.0 (4=)	50.5	1267
S2150	HE	308	6.7 (O+)	7.2 (3+)	50.1	1294
HWP	HE	310	5.0 (O=)	7.3(3+)	49.5	1283
GZS	HE	311	6.4 (O+)	7.0 (3=)	50.3	1306
GPZ	HE	315	6.4 (O+)	7.4 (3+)	51.5	1323
LTX	HE	316	5.9 (O=)	7.5 (3+)	51.2	1308
KNL	HE	318	5.3 (O=)	7.3 (3+)	51.1	1317
S2122	HE	319	6.3(O+)	7.1 (3+)	51.1	1340
GGA	HE	326	7.0 (R-)	7.9 (3+)	50.8	1408
DPS	HE	339	6.6 (O+)	7.5 (3+)	49.9	1424

*Carcass value is based on a €4.00/kg base price on the QPS grid, €0.12/kg Quality Assurance payment and €0.20/kg breed bonus payment.

How much is the 'right' sire worth to a beef farmers dairy beef system?

As a beef farmer, selecting superior genetic merit animals, can have a considerable effect to farm profitability. Based on the results from Table 1, if a beef farmer purchases Angus calves from FPI rather than ZTP, there will be an increase in carcass weight per animal of 43 kg. The carcass conformation and fat score were similar for progeny from both sires. Based on a carcass base beef price of €4.00 /kg on the QPS, a €0.20 breeds bonus and Quality Assurance payment of €0.12; progeny from FPI would have an increased carcass value of €161 per head or €16,100 in a 100 head dairy beef herd. Based on the ICBF Terminal Index, FPI is a 5-star bull, whereas ZTP is only a 1-star bull. This example clearly shows that the Terminal Index works to identify the most profitable animals.

Conclusion

The use of bulls with higher genetic merit for beef traits can have a major impact on a dairy beef farmer's income through increased carcass sales, better carcass conformation, increased numbers of animals meeting the quality assurance and breed bonus specifications, shorter finishing periods and reduced feed costs. It is vital that beef farmers avoid selecting calves solely on their appearance at two-to-three weeks of age. Instead they should aim to purchase calves based on their genetic merit along, with the calves appearance and health status and, by doing this, calves of low genetic merit for beef will eventually be penalised in the market.

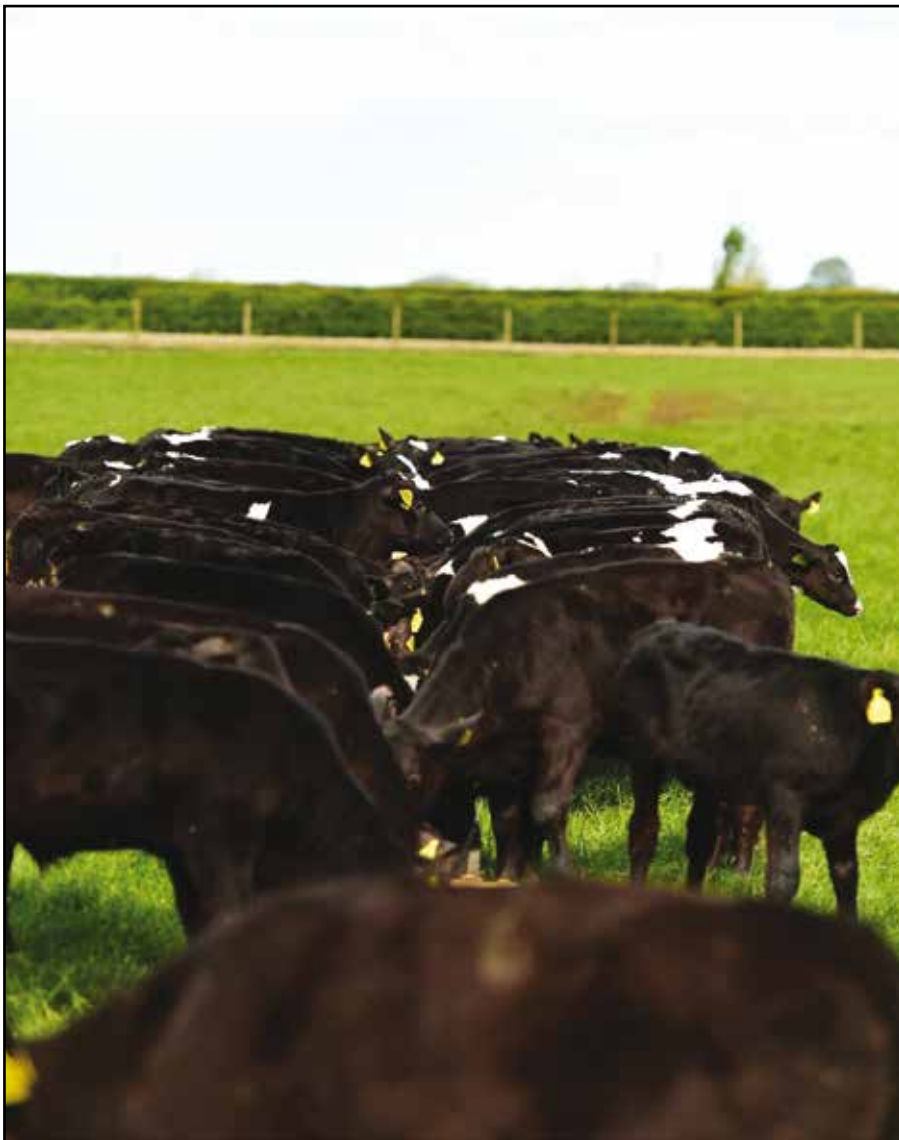
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Essentials of calf rearing

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Summary

- Good nutrition and hygiene are fundamental to calf health, welfare and productivity.
- Sustainable workloads ensure a good work-life balance but appropriate calf rearing facilities are essential as well as the implementation of labour saving techniques.
- Electrical water heaters will provide the best blend of low capital cost and moderately low running costs. Consider the cost-effectiveness, reliability, and safety of a water heating system before making an investment.

Introduction

Calf rearing is one of the most labour-intensive tasks on cattle farms. Poor hygiene and nutrition are some of the factors which can compromise calf health. This can cause disease outbreaks and underperforming calves resulting in increased labour requirements and costs. Being adequately prepared for the calf rearing season can pay dividends. This paper deals with some essential components of calf rearing:

1. Correct calf nutrition and hygiene practises which can help promote healthy calves, maintain optimal growth rates and minimise labour input.
2. Working 'smarter' not 'harder' – are there practises which can minimise the workload? Can the calf rearing facility be set up to reduce labour and facilitate high levels of hygiene?
3. Designing a cost-effective, safe and reliable water heating system.

1. Feeding the calf and hygiene

A number of experiments have been undertaken to compare whole milk and milk replacer and found little difference between the two once high-quality milk or milk replacer is fed. Consequently, there should be no differences in calf growth rates. Waste milk (i.e. milk from cows with a high somatic cell count or milk with antibiotic residues) should not be fed to calves.

How much milk or milk replacer should be fed?

Good nutrition is fundamental to animal health, welfare and productivity. Traditional milk feeding systems for dairy calves have been based on daily feeding rates of 8 to 10% of body weight (~4 litres/day). These 'restricted' feeding systems were intended to encourage the calf to eat a greater quantity of concentrate feed from an earlier age; however, they seriously limit growth potential as they only allow 20 to 30% of biologically 'normal' growth (0.2 to 0.3 kg/day) and are detrimental to calf health and welfare. A higher plane of nutrition facilitates physiologically 'appropriate' growth rates (0.6-0.7 kg/day), better immune function, and lower incidences of disease and mortality. In a recent Moorepark experiment calves were fed 4 litres (~10% of birth bodyweight) or 6 litres (~15% of birth bodyweight) of milk daily. Calves fed 4 litres of milk were lighter (~4 kg) at five weeks of age than those fed 6 litres and

this difference was still evident at weaning. At five weeks of age the reticulorumen is still underdeveloped and calves fed a restricted quantity of milk are not capable of increasing intake of starter concentrate and forage to a degree that can fully compensate for the lower supply of energy from milk. Feeding calves a greater volume of milk reduces the number of days taken to reach a target weaning weight. Furthermore, there was no difference in incidences of diarrhoea between calves fed 4 litres or 6 litres of milk. Weaning calves at a younger age is desirable from the farmer's point of view as this saves labour, time and feed costs.

Hygiene

Hygiene is a crucial component of healthy calf rearing systems. A recent Teagasc Moorepark study showed that less frequent cleaning of feeding equipment was associated with greater calf mortality. Infrequent cleaning of feeding equipment allows viruses, bacteria and other pathogens (i.e. rotavirus, salmonella, cryptosporidium etc.) to accumulate. Farmers who implement more rigorous milk feeding equipment cleaning regimes are more likely to have healthier calves with a higher growth rate. Both hot water and detergent should be used when cleaning; hot water (>70°C) has previously been shown to eliminate viruses and other pathogens. In general the majority of farmers do not have a sufficiently stringent cleaning policy. If feeding equipment is not cleaned frequently and thoroughly, pathogens will accumulate, and may become more difficult to remove, thus exposing calves to an increased risk of disease.

Straw is a good insulator when used as bedding, but if not removed or deep bedded regularly it can quickly become damp and dirty, thus having unfavourable consequences for calf health. Frequent cleaning of calf pens reduces pathogen build-up and calf exposure to infectious disease. The method of cleaning may also affect calf health. If pens are not washed or disinfected during cleaning, following product guidelines, the pathogenic load can accumulate and persist and the young calf can be exposed to a greater amount of bacteria compared to pens that are cleaned out, washed and disinfected. Calf pens should also be kept as dry as possible. Calves lie for approximately 70% of the day. If their bed is not cleaned out or refreshed regularly they are lying on a damp surface and more likely to suffer from ill-health. A simple test – 'the knee test' can be carried out. This can be completed by kneeling on one knee into the straw bed. When standing again the knee touching the straw should be dry. If not, the bedding needs to be changed (see Figure 1).



Figure 1. The knee test

2. Labour efficient work practices

Working long hours can lead to health and safety risks for everyone on the farm. Ensuring that farming involves a 'sustainable' workload is essential. A sustainable workload is one where work is organised and planned in advance and carried out with minimal stress for the farmer and animals. Having a sustainable workload ensures that a person can spend quality time with family, friends and at their other interests outside of farming. Having a good work-life balance will also help improve the image of farming and help attract more people into the

industry. Making changes to how work is done on the farm can save large amounts of time without any reduction in farm performance, and often with very little cost. The first step is to assess work practices to identify and remove unnecessary activities so that work requires less effort and capital and safety is improved.

Tips to reduce the labour demand associated with calf rearing

Labour demand can be reduced and total time caring for calves decreased by feeding milk to calves once-a-day from three weeks of age with no difference in calf performance or health compared to feeding calves twice-a-day. Once-a-day feeding before calves are 3 weeks old is not recommended as the abomasum does not have sufficient capacity to cope with the recommended volume (6 litres) of milk if given in one feed. Before feeding calves once daily it is important that calves are also consuming an alternative feed such as concentrate. If feeding once-a-day, calves still need to be checked thoroughly twice-a-day and fed concentrate at an alternative time to milk feeding. For example, feed calves milk in the morning and offer concentrates in the evening.

Another way to reduce labour demand is to rear calves outdoors. Recent research has shown that the most efficient farms turned the calves out to grass earlier, which reduced the labour input associated with bedding and cleaning pens. There was no difference in weaning weight between calves reared indoors or outdoors when well-managed. If rearing calves outdoors it is necessary to provide a shelter with a dry lie for calves. If calves cannot return to a house by night ensure they are 4 to 5 weeks of age before being turned out full-time, also try and ensure they are turned out during a week when the weather conditions are good and dry.

Facilities and organisation

Facilities have a major influence on labour efficiency. Calf rearing facilities tend to be the least modern on many farms, and this has very negative effects on labour efficiency as it increases the workload during the busiest time of the year. Being able to clean out the calf house mechanically by having doorways with access for a tractor and loader is essential to facilitate quick and easy cleaning. Group feeding calves in batches of 10+ and not having to carry milk long distances to calves all contribute to a sustainable workload.

Having a 'standard operating procedure' is a good idea as it documents the best currently known way of doing a particular task. It explains in detail the steps required to perform a particular task. These instructions should be visible to everyone and preferably posted where the task takes place. Well-written standard operating procedures simplify tasks, improve communication, reduce training time, and improve work consistency. The overall farm business benefits from consistent work performance and predictable results regardless of who is completing the task, giving the owner confidence in a job being done correctly.

A well-organised work place reduces time spent looking for tools and improves safety on the farm. Set up the calf shed to have all necessary equipment located in one place and required objects easily accessible. Any items or waste that is not required for calf rearing should be removed. With a clean and organised work environment, people's thinking capacity is not wasted searching for tools to carry out required tasks, instead time is spent on tasks that will create value to the business.

3. Key points for water heating systems on dairy calf-to-beef farms

An adequate and reliable supply of hot water is an essential element in the formulation of milk replacer as well as providing a means of sanitising milk feeding, mixing, and transporting

equipment on any dairy calf to beef farm. It is important to use a cost-effective, reliable and safe method of providing this hot water.

Cost effectiveness

On the majority of dairy calf-to-beef farms, electrical water heaters will provide the best blend of low capital and installation costs as well as moderately-low running costs. However, where demand for hot water is very high (e.g. above 500 litres per day), oil or gas-fired water heating systems may be an attractive option due to their ability to provide instant hot water without the necessity for storage. However, oil and gas systems are usually much more expensive to install. Regardless of the type of system used, it is recommended that hot water pipes and hot water storage tanks be insulated

Indicative running costs per 100 litre of water at 80°C are:

- Day rate electricity €2.00
- Night rate electricity €1.00
- Oil fired system €0.70
- Gas fired system €0.90

To keep running costs as low as possible, it is recommended that electrical water heating systems are operated on night rate electricity. Night rate is charged at approx. €0.08 per kWh and day rate is charged at approx. €0.16 per kWh; exact costs vary by the electricity supplier. Checking your pricing and tariff structure against the best available rates can also yield significant savings as the cheapest supplier could charge 20% less than the most expensive one. Night rate hours are from 11pm to 8am during winter time and 12 midnight to 9am during summer time. Note: There is no charge from ESB networks to install a night rate meter. The meter standing charges increase from approx. €0.46 per day to €0.60 per day after moving to night rate electricity. This means that a minimum of 1.5 units of electricity would need to be used each night to offset the extra charges. A typical dairy water heater uses approx. 1.5 units of electricity per hour and takes about 6 hours to reach full temperature.

Safety

Water heaters should be operated at 60°C at least, to prevent growth of Legionella bacteria, which cause Legionnaires disease. Legionnaires' disease is a potentially fatal type of pneumonia, contracted by inhaling airborne water droplets containing viable Legionella bacteria. The bacteria multiply where temperatures are between 20-45°C and nutrients are available. The bacteria are dormant below 20°C and do not survive above 60°C. Hence, water heaters should be operated at temperatures above 60°C. A thermostatically controlled mixing valve can then be used to mix the water to the desired temperature for calf feeding or washing, etc.

Reliability

The reliability and longevity of a given water heater is strongly influenced by the type of water supply on the farm. In particular, limescale formation on the element of electrical heaters and deposition of limescale in water storage tanks can significantly reduce the operating efficiency and lifespan of water heaters. Every farmer should have their water tested for hardness by a water testing laboratory. A water softener should be installed in areas of hard water, which will eliminate limescale build-up and extend the life of the water heater.

Performance targets of calves during their first season at pasture

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Summary

- Meeting performance targets for calves during the first season at grass is crucial to meeting final slaughter targets of dairy-beef cattle.
- Calves should gain 0.8 kg live weight/day during their first grazing season, reaching 190 to 230 kg at housing (birth date dependent).
- Good grassland management is vital to ensure optimal calf nutrition and health.
- An effective health programme involving parasite control is a key pillar to promoting calf performance at grass.

Introduction

From recent research at Teagasc Johnstown Castle, the optimal dairy-calf-to-beef production systems in terms of farm net profit for Holstein-Friesian (HF) and early-maturing breed cattle were 21-month and 26-month steer, and 19 and 21-month heifer systems, whereby cattle are finished off grass. Optimising calf performance during their first season at pasture is essential to ensuring that the targets set out in the production system blueprints are achieved. The critical aspects of calf performance during the first grazing season include; correct weaning procedure, maintaining an effective health protocol and optimal grassland management.

Live weight and average daily gain (ADG) targets for dairy calf-to-beef calves

The age of calves at turnout to grass is dependent on their birth date and the calf rearing system in place on the farm. Commonly, spring-born calves are turned out to grass shortly after weaning. Calves are weaned off milk at 8 weeks of age at a target live weight of 80 kg. At weaning, calves should be eating at least 1 kg of concentrate/head daily. Over the milk feeding period, calves should have gained 0.7 to 0.8 kg live weight per day. The target ADG of a calf (bulls and heifers) during their first grazing season is 0.80 kg (Table 1). The live weight target at housing for an early spring-born calf in November is 230 kg (Figure 1). For late-born (April/May) calves, this target is 190 kg at housing. [For farmers operating a 15-month bull production system, male dairy calves require an ADG of at least 0.90 kg during the first grazing season to ensure that they are approximately 250 kg at housing in November.]

Table 1. Average daily gain (ADG) targets for dairy calf-to-beef cattle.

Production system period	ADG (kg)
Rearing period (birth-12 weeks)	0.7-0.8
First season at grass	0.8
First winter	0.7
Second season at grass	0.9
Second winter (24-month steer system, finishing period)	1.0
Second winter (26-month steer)	0.5
Third season at grass (26-month steer, finishing period)	1.2

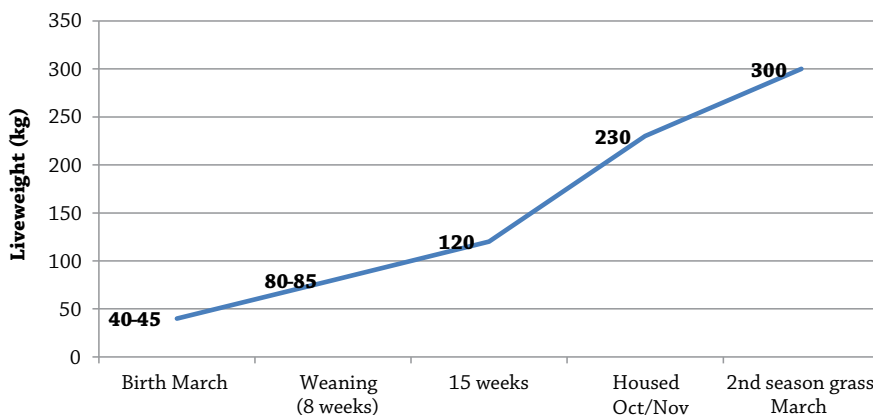


Figure 1. Target liveweights for a spring-born dairy beef calf

Concentrate supplementation

During the pre-weaning period, a good 'quality', highly-palatable coarse ration of 18% crude protein is recommended to encourage early feed intake and timely weaning of calves. If desired, calves can be gradually moved from the coarse ration onto a pellet after 3 to 4 weeks of age. Depending on the weather and on their birth date, calves may remain indoors for a number of weeks post-weaning where they will receive 2 to 4 kg of concentrate per day alongside hay or silage. Once the calves are fit, and weather is permissible, calves should be turned out to grass to help avoid disease issues, such as pneumonia. At grass, a concentrate ration of 16% crude protein is sufficient provided grass quality is good.

Early spring-born calves at grass

Upon turnout to grass, early-born (January to March) calves are typically supplemented with 1 to 2 kg of concentrate per head daily until mid-May. At this point, grass intake should be increasing and concentrate supplementation will cease. Calves remain on a pasture-only diet until early September when they will be supplemented once again with 1 kg concentrate daily until housing as grass supply and quality deteriorates.

Late spring-born calves at grass

Calves born in April/May will go to grass later in the summer. Unlike the early spring-born calves, these calves are fed 1 to 2 kg concentrate/day at grass for the entire grazing season.

Grassland management

It is critical that good pasture management is sustained throughout the season to ensure that optimum animal performance is achieved. Calves should have unrestricted access to leafy grass at all times. A leader-follower rotational grazing system is good for calves in terms of health and performance. This is because the calves graze ahead of older animals (Figure 2). This means that the calves get the choice pasture and are never forced to graze out a paddock. When silage after-grass becomes available, calves should graze it first.

Set stocking of calves is not recommended. Where a leader-follower system is not in place, farmers should aim for calves to enter paddocks with pre-grazing yields of 1100-1200 kg dry matter (DM)/ha as this helps to ensure that grass does not get ahead of the calves. Strip-

grazing is useful in these systems to optimise grass utilisation. If the final strip of a paddock has become too strong, the calves can be moved on and it can be grazed out by older cattle.

Health of calves at grass

Ill-thrift in young stock is defined as 'the failure for animals to grow as expected'. The major causes of ill-thrift in calves are malnutrition, parasitism and other chronic or long-standing disease.

1) Mineral deficiency

Alongside energy and protein for animal maintenance and growth, the diet must also provide small amounts of certain essential chemical elements (minerals or trace elements). Copper deficiency is the most mineral common deficiency of beef cattle in Ireland. An excess of soil molybdenum, iron or sulphur can interfere with the uptake of copper from the diet, thereby creating a deficiency in the animal. Other trace element deficiencies include cobalt and selenium. Copper can be supplemented in a variety of ways (feed, injections, long-acting boluses); however, only farms with a proven deficiency should supplement copper due to the risk of copper poisoning.

2) Parasitism

Parasitic infections are a potential problem in calves upon turnout to grass for their first grazing season. The three main parasites to be controlled are stomach worms, lungworms and liver fluke. Typical symptoms of gut worms include scour and faecal staining of the hindquarters and tail, while the main impact of lungworm is through clinical disease, such as hoose. The liver fluke depends on a snail to complete its life cycle and it will be more prevalent on poorly-drained land and during wet years.

Tactical management using 'targeted selective treatment' (TST) approaches are now recommended for the control and treatment of gutworms. These are based on good grazing practices, frequent monitoring of animals and only treating animals when necessary. Unlike gutworms and liver fluke, calves can be vaccinated for lungworm in advance of turnout.

- Grazing management. Calves should be turned onto 'clean' pasture, i.e. pasture not grazed by young cattle since midsummer/ autumn the previous year. Calves turned out to clean pasture will not require a worm drench before mid-summer.
- Monitor ADG. The ADG of calves 6 to 8 weeks after turnout is correlated with their level of exposure to parasitic worms. Therefore, careful monitoring of ADG can be useful for parasitic worm detection.
- Faecal Egg Counts (FEC). Fresh dung samples should be collected from calves approximately eight weeks after turnout and sent to a laboratory. FEC results will tell whether the calves have gut worm eggs, lungworm larvae, liver or rumen fluke eggs, along with coccidiosis oocytes. For gutworms, action is required where FEC >200 eggs per gram (epg) and when ADG <0.6 kg.
- Calves should be moved onto new pasture for four-to-seven days before treatment. During this period, the calves should be monitored closely. Ideally, treat only the calves with high

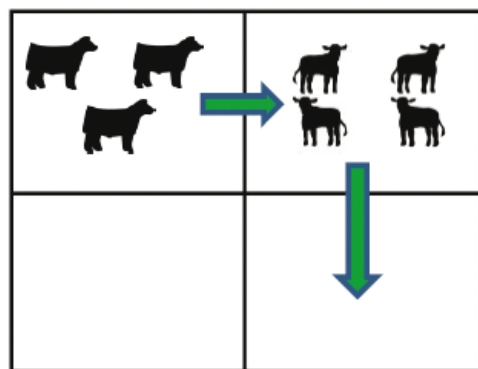


Figure 2. A leader/follower grazing system.

FEC and low ADG. If there is evidence of lungworm infection then all the calves may have to be treated. Animals are held on this pasture for 48 hours after dosing before being moved to 'clean' pasture.

- If clean grazing is not available, group treatment with an anthelmintic should be carried out with further monitoring after approximately eight weeks (dependent on the anthelmintic used).

3) *Other chronic disease*

Other chronic diseases that may affect calves during their first season at grass are respiratory disease, coccidiosis and clostridial diseases.

- Where calves suffered from respiratory disease during the rearing period, residual lung damage may continue to affect the performance of young animals after turnout. A vaccination programme for pneumonia should be implemented during the rearing period. Vaccines are available for calves from 4 days of age. Farmers should adhere to the 'booster' protocol for maximum effect.
- Coccidiosis is an increasing cause of scour in calves at grass. It is caused by a protozoa parasite infection whose lifecycle involves damage to the gut wall and eventually results in shedding of oocysts (resistant eggs). These oocysts can over-winter on pasture. Symptoms in infected animals include weight loss with dark diarrhoea and staining or streaks of blood on the tail. Most calves carry a low level of coccidia, but dirty, overcrowded conditions cause a rapid build-up of infection in the environment. Coccidiosis outbreaks can also be stress-related; for example, extremes of weather or management changes. A good preventive strategy will keep the level of infection balanced, keeping calves healthy while allowing immunity to develop. Preventive strategies for coccidiosis include:
 - Reducing stress.
 - Reducing infection risk. Keep feed and water troughs clean, raise troughs to avoid faecal contamination, rotate pastures, turn out onto clean pasture from the previous year and keep stocking density low.
 - Strategic use of in-feed medication. These require a veterinary prescription.
 - Strategic oral dosing with a coccidiostat. This should be timed to coincide with likely infection, which is usually ~14 days after exposure. Once sufficient exposure has occurred, immunity develops.
- Clostridial (bacterial) diseases are a significant cause of mortality in Irish cattle. Clostridial organisms cause a variety of diseases; however blackleg is one of the most common. A post-mortem examination should be carried out on suspected deaths to determine the specific clostridial bacteria responsible. This allows an appropriate vaccination programme to be put in place on farm. Where this information is absent, farmers can use a multivalent clostridial vaccine which should be given before calves go to pasture.

Conclusion

If farmers operate a successful programme, calves should reach the target weight of 190 to 230 kg at housing. Farmers must pay acute attention to calf health prior to and at grass, supplement calves with good quality concentrate and practice good grassland management.



On-going dairy-beef trial at Johnstown Castle

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Summary

- Recent research at Teagasc, Johnstown Castle has evaluated alternative production systems and finishing strategies for Holstein-Friesian bulls and steers, and early-maturing breed steers and heifers from the dairy herd.
- An on-going study at Johnstown Castle is evaluating the performance of Angus, Hereford and Limousin sired dairy heifers and steers under three stocking intensities.
- No statistically significant difference was observed in carcass weight, fat and conformation scores of dairy crossbred cattle at contrasting stocking rates.

Introduction

The most recent figures from the Central Statistics Office showed that the national dairy herd has increased to approximately 1.3 million cows. The majority of these cows (57%) are bred to dairy sires to generate replacement heifers for the dairy herd, 32% are bred to early-maturing breed sires (19% Angus and 13% Hereford, respectively) and approximately 10% are bred to 'continental' breeds (Limousin, Belgian Blue, Simmental and Charolais) (AIM, 2018). This highlights the focus dairy producers have on selecting breed types that are prominent for their calving ease and short gestation merits (Figure 1). Approximately 360,000 male dairy-bred calves will be born in 2018. Currently, steer beef dominates beef production in Ireland, while bull beef represents approximately 20% of the national male slaughter (Bord Bia, 2016). Given the low value of male dairy calves and in some instances, early-maturing breed dairy crossbred calves this spring, many beef producers are considering incorporating dairy calf-to-beef production into their beef enterprise.

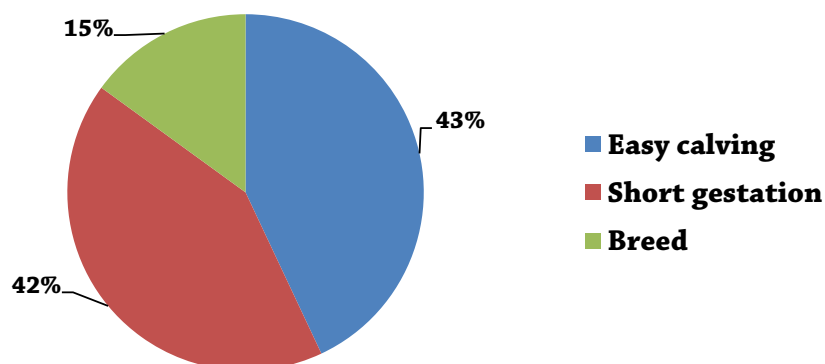


Figure 1. Beef sire selection by dairy farmers.

Research carried out at Teagasc Johnstown Castle has to date, focused on modifying/establishing production system blueprints for Holstein-Friesian (bull and steer systems) and early-maturing sired dairy crossbred calves (steer and heifer systems). Systems were focused on incorporating high levels of grazed pasture into the animals' annual feed budget. Carcass output per hectare was the main indicator of profitability in all beef production systems evaluated. Therefore, producers must maximise individual animal performance within a production system on their farm and subsequently exploit the available herbage to increase the stocking rate and make best use of the facilities available on farm.

Following on from this work, the current research focus is on evaluating the effects of stocking rate on the performance of dairy beef crossbred cattle. In conjunction with this, a sire evaluation trial in collaboration with ABP is on-going.

On-going dairy-beef trial at Johnstown Castle

A total of 216 dairy beef crossbred calves were purchased each spring since 2015 and were assigned to one of three stocking rate groups (72 animals per group). Each stocking rate group consisted of 36 heifers and 36 steers. All animals in the study were generated from Angus, Hereford or Limousin AI sires. All sires were commonly available in Ireland. Each stocking rate group has its own defined 'farmlet' (Figure 2). The objective of this study was to investigate the effects of contrasting stocking rates on performance of dairy beef crossbred cattle throughout the production cycle, live weight at slaughter, and carcass weight, fat and conformation scores. The dairy beef crossbred animals were allocated to three stocking rates; 2.8, 3.2 and 3.4 livestock units per hectare (LU/ha). Heifers born in 2015 were slaughtered at a fixed age at slaughter; 19 or 21 months of age while steers were slaughtered at either 21 months or 27 months of age. All animals were finished off grazed pasture and received 3 kg of concentrate dry matter (DM) for 60 days pre-slaughter.



Figure 2. Map of the farmlets at Johnstown Castle, low stocking rate = blue, medium stocking rate = green and high stocking rate = purple.

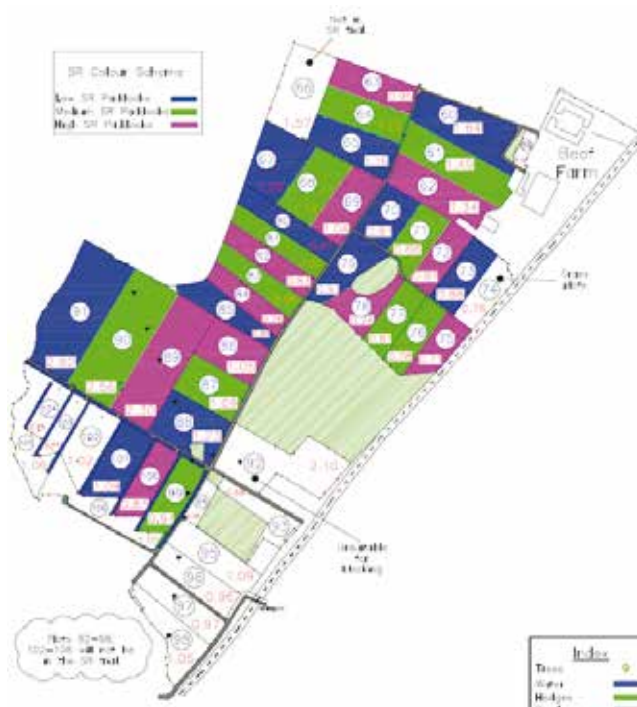


Figure 2a. Map of the farmlets at Johnstown Castle, low stocking rate = blue, medium stocking rate = green and high stocking rate = purple.

Results to date from the stocking rate trial at Johnstown Castle

Mean date of birth was 12 March for calves born in 2015. Animals were weighed once every three weeks from arrival to slaughter. Average daily gain of heifers and steers were similar for the high, medium and low stocking rate groups during the first season at pasture, first winter, second season at pasture and the second winter periods (Table 1). Average daily gain during the third season at pasture was lower for the steers in the high stocking rate treatment than the medium or low stocking rate groups. Carcass weight, conformation and fat scores were similar for heifers and steers in the three contrasting stocking rate groups. Due to the pre-determined slaughter dates for the animals, days to slaughter were similar for all stocking rate treatments.

In 2017 the protocol for selecting animals for slaughter was amended. Previously animals were assigned to a production system at 12 weeks of age as described above. In 2017, heifers were selected for slaughter on a target body condition score (BCS) of 3.50. Steers were carried through the 'second' winter on a grass silage ad-libitum diet only and will be slaughtered during the 'third' grazing season (summer of 2018). This will also determine if differences in days to slaughter exist between animals on contrasting stocking rates.

Table 1. Performance of heifers and steers in high, medium and low stocking rate groups.

Stocking rate	High	Medium	Low
Date of birth	12 March 2015	11 March 2015	12 March 2015
Average daily gain (kg)			
1st season at pasture (kg)	0.89	0.92	0.90
1st winter (kg)	0.48	0.49	0.50
2nd season at pasture (kg)	0.92	0.98	0.95
2nd winter	0.54	0.57	0.62
3rd season at pasture (kg)	1.07	1.13	1.15
Live weight at slaughter (kg)	511	522	524
Carcass weight (kg)	258	264	267
Fat score (1-15)	7.7 (3-)	7.6 (3-)	7.1 (3-)
Conformation score (1-15)	4.9 (O-)	5.2 (O=)	4.9 (O-)
Days to slaughter	654	655	654

Pasture utilisation

Dairy calf-to-beef production systems that finish animals before the second winter (predominately heifer systems) and indoor winter finishing systems have a low demand for grass in the spring. This is a consequence of the systems that are employed on the farm i.e. only yearling animals that are approximately 330 kg are turned out to pasture in March. In this instance it is beneficial to have older steers available to utilise the available (surplus) pasture in the early-spring. These animals can then be slaughtered in May/ June when beef price is at its highest. Although the stocking rate of the farm is reduced, results from Johnstown Castle have shown that slaughtering steers at 26 to 28 months of age is more profitable than indoor winter finishing at 23 months of age.

Conclusion

No significant difference in carcass weight, carcass fat and conformation scores were observed between Angus, Hereford and Limousin sired dairy crossbred cattle across contrasting stocking densities. To successfully maximise profit per hectare, beef farmers must ensure that increases in stocking rate are undertaken via improvements in pasture productivity and utilisation.

Acknowledgements

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New dairy calf-to-beef trial at Grange

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Summary

- A new dairy calf-to-beef trial was established at Grange in spring 2018.
- The objective of the study is to compare the performance of progeny from sires used on the dairy herd that are divergent in breeding value for carcass weight.
- Holstein-Friesian and Aberdeen Angus sires are used to represent the main calf breeds coming from the dairy herd.
- The new Grange dairy calf-to-beef herd is of fundamental importance to the industry and will provide direction and confidence to beef producers.

Introduction

With the increasing size of the Irish dairy herd, proportionately more calves for beef finishing will be produced from that source. Approximately 1.4 million calves will be born annually in the dairy herd with Holstein-Friesian (HF) sires accounting for almost half of these (AIM, 2016). As most HF heifer calves are retained as replacements for the dairy herd, the male HF calves are available for beef production. Thus, approximately 900,000 calves are available for beef production from the dairy herd. The early-maturing breeds, Aberdeen Angus (AA) and Hereford, are the most popular beef breeds used in the dairy herd (45% and 30%, respectively), with Limousin sires accounting for a further 11% of the crossbred calves. For dairy producers, short gestation, easy-calving beef sires are the preferred choice. The beef merits of such progeny need to be evaluated for the producer who wishes to finish these animals as beef. Generating progeny from the dairy herd with a high genetic merit for terminal traits, such as carcass weight and conformation score, will enhance the profitability of dairy calf-to-beef enterprises.

New dairy calf-to-beef trial at Grange

A new dairy calf-to-beef herd was established at Grange in spring 2018 to test whether genetic selection for carcass traits in sires used on dairy herds will deliver improved performance and profitability under intensive grass-based systems for dairy beef producers. Reflecting their use on dairy herds, HF and AA dairy crossbred male calves were selected and purchased from commercial dairy farms during spring 2018. Calves were generated from HF cows that were bred only between 27 March and 25 June 2017. The maximum calving difficulty for AA sires considered for the study was 3.5% with a minimum reliability in the overall Terminal Index for beef sires of 60%. Calves arrived at Grange at 3-weeks of age. Three distinct groups of male calves were established; 45 HIGH (high carcass weight AA calves from five sires) and 45 LOW (low carcass AA calves from six sires) and 45 HF calves (from four top EBI sires) were assembled. Average birth date for the HF, AA HIGH and AA LOW was 10 February, 19 February and 9 February, respectively. Average purchase weight (at approximately 3 weeks

of age) was 55 kg. All animals will be subjected to genomic testing. Details on sires used to generate the current groups of calves are presented in Tables 1, 2 and 3. The groups are being evaluated across seasonal pasture-based systems. The objective of the study is to compare the performance of progeny from sires that are divergent for carcass weight.

Table 1. Genetic evaluations (carcass sub-index, calving difficulty (CD), gestation length (GL) mortality (M), carcass weight (CW), carcass conformation (CC), carcass fat (CF) and feed intake (FI) traits of Holstein-Friesian sires.

AI Code	EBI (€)	Carcass Sub-index (€) (Rel, %)	CD (%)	GL (days)	M (%)	CW (kg)	CC (1-15)	CF (1-15)	FI (Kg DM/day)
FR4021	323	-9.17 (49)	2.4	-3.11	0.01	-3	-0.57	-0.15	-0.04
FR2385	319	-17.76 (51)	2.3	-4.55	-0.41	-8	-0.71	-0.27	-0.03
FR2239	316	-2.64 (53)	2.3	-5.34	-0.94	-1	-0.68	-0.53	0.09
FR2339	261	-22.18 (53)	2.0	-4.51	-0.75	-12	-0.73	-0.33	-0.04

Table 2. Aberdeen Angus sires used to generate crossbreed calves selected for HIGH and LOW carcass index dairy cross calves.

HIGH Bull	LOW Bull
AA2037	AA2123
AA4057	GZA
FPI	JGY
WZG	KYA
ZLT	SYT
	ZTP



Table 3. Beef production traits for the HIGH and LOW Aberdeen Angus sires.

	High		Low	
	Average	SD	Average	SD
Terminal (€)	91.80	12.36	49.00	19.72
Terminal Reliability (%)	77.60	13.58	88.00	11.83
Terminal Within-Breed Star	4.80	0.45	2.17	1.17
Terminal Across-Breed Star	2.80	0.45	1.67	0.52
Calving difficulty (%)	2.56	0.69	1.67	0.74
Gestation length (d)	-0.85	1.94	-2.09	1.83
Calf mortality (%)	-0.38	0.36	-0.26	0.33
Carcass weight (kg)	13.40	7.09	-3.00	7.16
Carcass conformation (1-15)	0.75	0.32	0.49	0.15
Carcass fat (1-15)	0.35	0.32	0.48	0.29
Feed intake (kg DM/day)	0.31	0.19	0.08	0.19
Docility (1-5)	0.07	0.05	0.00	0.05

Additional sires considered for 2018/19 season are summarised in Table 4.

Table 4. Potential Aberdeen Angus sire list for 2018/19.

HIGH Carcass	LOW Carcass
ZEP	VPH
FDH	ESH
RZI	JLS
AA2037	RHG
WZG	SYT
ZLT	ZTP
	AA2123
	GZA
	KYA

Animal management

Calves will be artificially-reared to a weaning weight target of ~85 kg. They will then be turned out to pasture for the first grazing season and strategically supplemented with concentrates (1.5 kg reducing to 1 kg) for the first month at pasture. Thereafter they will graze only pasture until mid-September when 1 kg of supplementary concentrates will be offered until housing in November. All calves will be castrated at 5 months of age. It is planned that the three divergent groups (HF, AA HIGH and AA LOW) will graze independently of each other. A leader-

follower grazing system will be practised when the dairy calf-to-beef unit is established. This approach will involve calves grazing ahead of the yearlings. During the first winter indoor period, calves will be offered high quality (dry matter digestibility) grass silage *ad-libitum* supplemented with 1.5 kg of concentrate per head/day. Yearling steers will be turned out to pasture in March and finally housed for winter finishing in late-October. It is planned to finish the steers on grass silage *ad-libitum* supplemented with 6 kg of concentrate per head/day. AA steers will be slaughtered at 23 months of age and HF steers will be slaughtered at 24 months of age. All inputs (milk powder, concentrates fed, veterinary, silage consumed etc.,) and outputs (live weighs and carcass weights, pasture production, etc.,) will be recorded for the systems.

Conclusion

The new dairy calf-to-beef herd is of fundamental importance to the industry and will provide direction and confidence to producers wishing to use dairy bred animals in their beef production systems. The herd will be a valuable resource for collecting new information on terminal traits of calves coming from the dairy herd.

Reference

AIM (2016). Animal identification movement system. Department of Agriculture, Food and the Marine.



Teagasc Green Acres Calf-to-Beef Programme

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Summary

- The Teagasc Green Acres Calf-to-Beef Programme has been running since 2015 with the aim of showing the technical efficiency that is needed to attain a worthwhile net margin per hectare.
- Output of beef liveweight produced per livestock unit farmed combined with a high stocking rate were the two key drivers of profitability on 10 calf-to-beef demonstration farms.
- The farms improved their average net margin from -€40 to €475 per hectare (excluding direct payments) over the three years of the programme.
- There are many different factors within the control of the farmer that have a large impact on profitability.
- A second three-year phase of the programme is beginning in 2018.

Introduction

The Teagasc Green Acres Calf-to-Beef Programme was set up in 2015 to demonstrate profitable dairy calf-to-beef systems on a whole-farm basis through a network of ten demonstration farms that all had significant calf-to-beef enterprises. The primary aim of the project was to demonstrate that where a high level of technical efficiency is achieved on beef farms, it is possible to attain a net margin (excluding premia) in excess of €500 per hectare. This programme was financially supported by Liffey Mills, Drummonds Ltd., Volac Ireland, MSD Animal Health and Grassland Agro. Through this funding a dedicated advisor was appointed to work with the demonstration farms and to disseminate the information that was generated in the programme. The first phase of the programme was completed in March 2018 after working with the demonstration farms for three years. In this period improvements were made in many different areas such as calf purchasing and rearing, grassland management, animal health, forage quality and overall farm financial performance.

10 Key Lessons Learned

1. Have a plan

When you buy your calves, you need to have a plan as to when these animals are going to be slaughtered. If there is no plan in place then there will be implications for housing facilities, slurry storage, not enough silage, mixed age groups creating issues for dosing, feeding concentrates for finishing and cash flow. Talk to your processor to know their requirements and ensure that all animals meet these market specifications to achieve bonuses, quality assurance payments etc. and decide on the numbers that you can supply at different times of the year to command the best price possible.

2. Producing high beef output

This is the kilograms of live weight produced per hectare. It is a combination of a high stocking rate and excellent individual animal performance. A target of 1250 kg live weight/ha should be produced. This can be achieved from a stocking rate of 2.5 livestock units per hectare and a performance of 500 kg live weight per livestock unit. Decide on a production system and stocking rate to suit your land type and housing facilities available. In calf-to-beef systems these targets are very achievable and higher levels can be reached.

3. Excellent calf rearing

Source a good quality calf. Buying an earlier born calf (before 17 March) will help increase output. These early-born calves will be weaned and at grass for a longer period in the first grazing season. Feed high levels of milk replacer; feeding up to 750 grams per day increases growth rates to weaning. Ensure good hygiene at feeding and in the calf pen. Consistency is key in relation to feeding of the calf; feed milk replacer at the same time, rate and temperature each day to avoid stressing the young animal.

4. Appropriate calf rearing facilities

Calf housing should be fit for purpose. Ensure a clean, warm, dry, well-ventilated shed for calf rearing. To ensure a dry bed have a 1:20 slope on the floor from back to front with a channel to remove seepage to an outside tank. Provide plenty of straw to ensure that the calf is kept warm at all times especially in cold conditions. Pen size should provide 2.2 m² (24 ft²) per calf. Ensure that there is no draught at calf level. There should be an outlet (5 to 6m² per 100 calves) which needs to be covered to prevent rain entering and wetting the calf bed. The inlet should be two-to-four times the size of the outlet to provide good ventilation. Good ventilation removes airborne pathogens, respiration, moisture, smells and reduces the risk of disease and sick calves.

5. Animal health plan

Having a health plan in place in conjunction with your vet is essential. With calves coming from numerous sources, having a vaccination programme in place is critical. The top performing farms vaccinate for pneumonia and IBR. A strategic dosing regime needs to be planned to control, worms, fluke, lice etc. throughout the grazing season and during housing.

6. Correct soil fertility

In order to produce high output from the system, high animal live weight gain from grazed grass is required. To ensure enough high-quality grass is available, soil fertility needs to be at its optimum. Ensure to correct the lime status of the soil firstly and then correct phosphorus (P) and potassium (K) levels to Index 3. Slurry and farmyard manure should be targeted at low soil index fields and the remainder corrected with compound fertilisers.

7. Grassland management

Having a paddock system in place to supply quality leafy grass at all times, thereby maximising weight gain from grass is essential. Target to have at least 240 days grazing in the second grazing season. To achieve this target, animals need to be turned out to pasture early in the spring; this will require excellent management in the autumn where paddocks are closed up early to ensure a supply of grass in the spring. Good management of the grazing programme in the spring to ensure you set the farm up for maximum productivity over the summer is critical to success.

8. Produce high quality silage

In a calf-to-beef system all animals are priority. Produce high-quality silage to ensure all animals meet the target average daily gain (ADG) of 0.6 kg /day over the first winter period. All silage produced should have a dry matter digestibility (DMD) greater than 70% to help reduce the concentrate level required to meet target daily gains. The financial difference between 62 and 72% DMD silage for 100 weanlings over a 140-day winter could be €7,000 or €70 per head.

9. Regular weighing of cattle

To ensure that performance is not compromised at any stage from purchase to slaughter it is essential that regular weighing of animals takes place throughout the year. At a minimum, animals should be weighed at turn-out to pasture, mid-season and at housing. Poor performing animals should be detected and a remedial action put in place. Animals for finishing can be grouped together, thereby increasing efficiencies as only the stock closest to target weights are fed to slaughter.

10. Review your plan regularly

Having a plan is important, but reviewing it on a regular basis is essential. Are key targets being met? If not, why not? What changes are needed to keep on target or does the plan need to change in some way? The objective must be to stick to the plan and to make the changes that are necessary so that it is achieved.

Physical and financial performance

Table 1 outlines the average physical and financial performance across the 10 Teagasc Green Acres farms for 2017. What is very noticeable from the results is that there is a huge variation across farms. This occurs due to many factors. All farmers started out with very different levels of profitability and over the course of the programme all have improved their margins substantially. Many of the farms are still increasing stocking rates and improving efficiencies while others are at, or close to, their planned levels. There are also a lot of different management styles between farms in a number of the key areas like calf rearing, animal health, grass management, soil fertility and financial/farm planning. Land type and stocking rate also have a huge bearing on profitability.

Table 1. Physical and financial performance of the 10 Teagasc Green Acres farms (2017)

	Average	Min.	Max.
Area (ha.)	66	26	119
Stocking rate (LU / ha.)	2.5	1.85	3.32
Output (kg / ha.)	1293	841	1845
Gross Output / ha	€2,424	€1,837	€3,329
Total Variable Costs / ha.	€1,366	€895	€1,768
Gross margin / ha.	€1,058	€566	€1,592
Fixed costs / ha.	€584	€331	€817
Net margin / ha.	€475	-€32	€897

Figure 1 highlights the main financial performance indicators from the year before the farmers entered the programme to the end of 2017. Gross output is the key driver of

profitability on the farms. It is the amount and value of beef sold and is a product of the stocking rate, performance of each animal and beef price received. Two of these are within the control of the farmer and need to be maximised by the farmer. The average gross output across the ten farmers was €2,424 per ha, with a range from €1,837 to €3,329. The maximum figure of €3,329 per ha clearly shows what is achievable. Gross output has steadily increased throughout the programme.

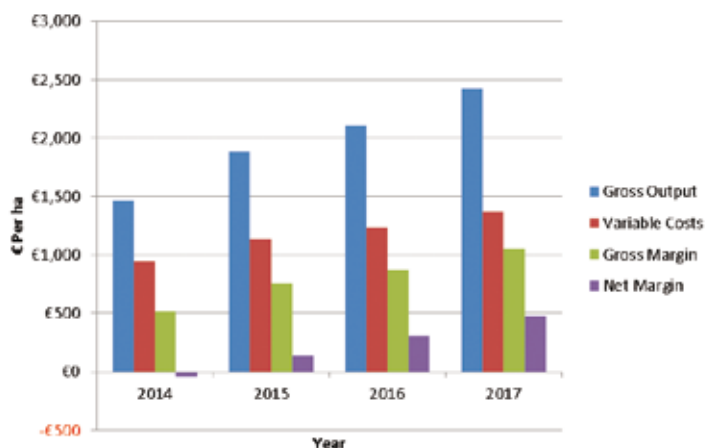


Figure 1. Average financial performance of the 10 Teagasc Green Acres farms (2014 – 2017)

Average variable costs across all the farms were €1,366 per ha in 2017, with a range of €895 to €1,768. Calf-to-beef production systems are high-cost systems and a high output is required to ‘carry’ these costs. The four highest variable costs on the farms were feed, fertiliser, veterinary and contractor. Direct feed costs typically make up approximately half of the variable costs. As can be seen from Figure 1, variable costs increased as output increased, but at a lower level. The variable costs as a percentage of output have decreased from 65% to 56% over the course of the programme.

Gross margin is the amount of money that is left to pay the fixed costs, tax, new farm developments and provide living expenses. The gross margin has increased steadily over the last three years rising from an average of €513 to €1,058 per ha. This was driven by the increase in beef output on the farms.

The average fixed costs on the farms was €584 per ha in 2017. This is very typical of non-breeding dry stock farms, which generally range from €450 to €650 per ha. Fixed costs rose slightly in 2015 to reflect on-farm developments.

The aim of the Teagasc Green Acres Calf-to-Beef Programme was to have a net margin of €500 per ha excluding all farm subsidies at the end of the programme. Having started with an average net margin of -€40 per ha in 2014 this moved to €136 in 2015, €308 in 2016, and €475 in 2017. This shows that the target is achievable.

Second Phase of Programme

A new three year phase of the Teagasc Green Acres Calf to Beef Programme has been agreed with financial support from six industry partners. These are Drummonds Ltd., Liffey Mills, MSD Animal Health, Volac, Munster Cattle Breeding Group and TP Whelehan. This programme will begin in 2018 focussing on disseminating information from 12 new calf-to-beef demonstration farmers to the wider farming audience.



Technology Village

Health / Breeding

Genomics of health traits in cattle

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Summary

- Variation exists between individual animals in the DNA sequence of genes controlling health traits. This variation is responsible for differences in susceptibility to diseases such as bovine respiratory disease (BRD), commonly known as pneumonia, and scour.
- Genomic research in Teagasc Grange aims to identify the differences in cattle DNA sequences that contribute to resistance to BRD.
- Identified DNA variants, following validation, will be added to the Irish single nucleotide polymorphism (SNP) chip and integrated into the national Genomic Selection breeding programme to evaluate their association with BRD.
- This will facilitate the selection of robust animals with superior genetic merit for resistance to BRD.

Introduction

Genomics is the study of the role of cellular DNA sequences present in chromosomes and how they are associated with phenotype or the expression of a trait. For cattle, one important current use of genome sequences is to predict genetic merit for economically-important traits such as health and resistance to disease, milk production, fertility and carcass quality. There are approximately 22,000 genes in the cattle genome. While all cattle contain the same genes, differences exist between individual animals in the DNA sequence of these genes. This variation in units of DNA (called nucleotides) between members of a species is called a single nucleotide polymorphism (or genetic markers), abbreviated to SNP (pronounced “snips”) and is responsible for differences in animal performance and traits of economic importance such as reproduction and resistance to diseases. Research in Teagasc Grange is focused on establishing the key genes controlling traits such as the immune response to BRD and identifying the genomic variants within regulatory regions of these genes which influence susceptibility to BRD.

Genomic selection

The ability to accurately identify elite animals at a young age without the requirement for progeny testing will both increase genetic gain as well as reduce the costs of a breeding programme. As DNA is responsible for some of the variation in performance among animals, is available from birth, and remains stable over the animal's life, it would be hugely beneficial to optimally exploit DNA-based information in breeding programmes.

The fundamental basis of genomic selection is to quantify the impact of thousands of SNPs on performance, including health traits, in cattle. Once identified, the DNA profile of a selection candidate (i.e. young test bulls) can be generated and the sum of all DNA variants for that individual animal obtained, resulting in an estimate of the genetic merit of that individual which can be made available at a very young age. Improving

genetic gain in animal health traits, such as resistance to BRD, using traditional selection approaches is often very slow for a number of reasons, including typical low heritability of the component health traits and difficulties in accurate measurement. However, the incorporation of genomic information into breeding programmes has the potential to significantly increase the rate of genetic gain in complex economically-important traits, including resistance to disease. Genomic selection has the ability to provide estimates of the genetic merit of an animal based solely on their DNA and this phenomenon has become a reality with the availability of commercial high density SNP chips.

The biggest impact of genomic selection to the cattle industry has been the increase in the reliability of breeding values without animal or progeny records, particularly for low heritability traits, and traits that are difficult to measure, such as reproductive and health traits. Genomic information is now included in both dairy and beef cattle breeding programs. Its inclusion has produced obvious benefits such as the simultaneous improvement of both fertility and production traits in the dairy herd. Platforms (referred to as “SNP chips”) have been developed to screen and quantify the variation among animals for tens of thousands of genetic markers, encompassing the entire bovine genome at the one time.

Irish dairy beef (IDB) custom SNP chip

In Ireland, a genomic selection breeding programme was established in 2009 for the dairy industry. A custom made SNP chip was initially developed in 2013 by a collaborative (Teagasc, Weatherby’s Ireland, Irish Cattle Breeding Federation and USDA) working group whose main task was to establish a custom SNP chip for dairy and beef cattle to aid implementation of genomic selection. Indeed, this resource is currently used for genetic evaluations, parentage testing, screening for lethal recessive genes, congenital disorders and other mutations with large effects on performance in cattle (IDB; www.icbf.com; Mullen *et al.*, 2013). The SNP chip has been designed using microarray technology so that thousands of genetic markers (SNPs) can be identified at the same time for each sample. These large numbers of SNPs are necessary for genomic evaluations with regard to particular traits in the livestock industry. Since 2013, the IDBv1 and more recently, IDBv2 and IDBv3, have been routinely used as part of the Irish genomic selection breeding programme. The chip is revised annually and a portion of the SNPs are reserved for variants relevant to research studies. The current version, IDBv4, includes over 50,000 genetic variants and is now employed in national genomics selection breeding programmes including the Beef Data and Genomics Programme (BDGP) (Figure 1). Biomarkers associated with variation in health, performance and reproductive potential, discovered through the Teagasc research programme are continuously being incorporated onto the IDB SNP platform for future validation, and therefore, readily exploitable by beef and dairy farmers.



Figure 1. Irish dairy beef custom SNP chip

Identification of SNPs associated with enhanced immunity in Irish dairy and beef calves

Health surveys were carried out and blood samples were collected from 1,392 beef and 2,090 dairy calves, from commercial farms in Ireland, during their first six months of life. A total of 2,400 calves with appropriate health phenotypic records were selected for genome wide association studies (GWAS) using the IDBV3 SNP chip to identify genetic variants associated with immunity and health related traits in these calves. The objective of this research was to apply the newly identified genetic variants (SNPs) to the genomic selection breeding programme to breed for improved health traits in Irish cattle.

A total of 413 significant SNPs were identified across 7 breeds, associated with overall disease occurrence, scour, pneumonia, joint disease, navel infection and immunoglobulin G (IgG) serum concentration. A SNP in the *CNTN1* gene was associated with BRD in Hereford calves, a SNP in the *PAX3* gene was associated with diarrhoea and pneumonia in Belgian Blue and Hereford calves, respectively, and a SNP in the *CAB39* gene was associated with an increased incidence of diarrhoea in Belgian Blue calves. Following further investigation and validation, these SNPs may be applied in future genomic breeding programmes to enhance the health status of cattle.

Current research on DNA based biomarkers of susceptibility to BRD

Bovine respiratory disease is the most economically important disease affecting cattle worldwide. It is multifactorial, involving infectious agents including both viral and bacteriological agents, host and environmental factors, and their interactions. Studies have found that neither immunisation nor antimicrobial therapies have significantly reduced the prevalence or severity of BRD, largely due to the lack of comprehensive information concerning the biological mechanisms controlling the host response and the underlying genetic basis of host resistance to BRD.

Cattle vary in their ability to resist BRD, and currently, there is a lack of information on the genetic basis of BRD resistance. Our research aims to fill knowledge gaps in this area through the identification of genetic variants associated with BRD resistance and diagnostic markers that are indicative of the disease and its severity. These variants may then be directly selected in cattle populations to reduce the prevalence of this multi-agent disease. This will be possible as BRD is moderately-to-lowly heritable and strong candidate areas of the genome for harbouring causative mutations and biologically meaningful candidate genes, including *PVRL1*, *DST*, *AZIN1*, and *SLIT3*, have already been identified by colleagues at the University of Missouri in the United States.

In collaboration with AFBI Stormont and the University of Missouri, we are performing two separate, controlled, viral challenge studies, one using bovine respiratory syncytial virus and the other using bovine herpes virus 1 (also known as infectious bovine rhinotracheitis (IBR)), in dairy calves (Figure 2). From these studies, we are examining the genes involved in the calves' immune responses to BRD. Subsequently we will use a cutting edge, novel technique (Assay for Transposase-Accessible Chromatin using sequencing, (ATAC-Seq)), to detect the active regulatory regions of the genome that are likely to regulate genes involved in the normal immune response to BRD. These key regulatory areas in the genome will be interrogated in the variant database for the 1000 Bull Genomes Project to identify genetic variants. The identified variants will be

added to the IDB custom SNP chip and integrated into the national Genomic Selection breeding programme to evaluate their association with BRD. This research will provide new insights into the genetic basis of BRD susceptibility and the molecular mechanisms underlying bovine immune responses to respiratory disease. It will also facilitate the selection and propagation of genetically superior, immunologically robust, animals and thus enhance the profitability of Irish cattle enterprises.



Figure 2. A calf being inoculated with bovine respiratory syncytial virus in a controlled challenge experiment

Conclusion

The incorporation of genomic information into breeding programmes has the potential to significantly increase the rate of genetic gain in a number of traits, including health traits such as BRD resistance, and is much faster and more reliable than traditional selective breeding methods. Increasing the abundance of certain favourable immune traits through the analysis of gene expression and the occurrence of SNPs linked with resistance to BRD, has massive potential benefits for both the beef and dairy industries.

Reference

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Acknowledgements

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Tests for failure of passive transfer of immunity and associations with health and performance in calves

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Summary

- Colostrum-derived passive immunity is central to the health, performance and welfare of neonatal calves.
- Calves with inadequate passive immunity are at greater risk of calfhood disease.
- The first step in evaluating a colostrum management programme is to assess the effectiveness of passive transfer of immunity to the calf.
- Passive immunity test results can be categorised for failure of passive transfer (FPT) using test-specific cut-off values.
- Farmers should consider implementing a testing programme to monitor calf passive immune status.
- There are still opportunities for improvement in colostrum management on Irish suckler and dairy farms.

Introduction

The first and most important feed provided to a newborn calf is maternal colostrum, which supplies immunoglobulins and other important nutrients. Immunoglobulins protect the calf against foreign agents, such as bacteria and viruses. As the calf is born without an active immune system, colostrum-derived passive immunity is essential in maintaining neonatal calf health, and thus, reducing morbidity and mortality. Failure of passive transfer (FPT) of immunity occurs when the calf does not absorb sufficient colostral immunoglobulins immediately after birth.

Assessing failure of passive transfer (FPT)

A number of laboratory or on-farm tests are available to assess passive transfer of immunity to the calf. Direct tests, such as the enzyme linked immunoassay (ELISA) test, measure immunoglobulin G (IgG) concentration in calf blood (serum), but these tests can be labour-intensive and expensive to perform. Other tests indirectly estimate IgG content by measuring protein levels (total protein, TP), proxy components in serum such as total solids percentage by Brix refractometer (Brix-TS %), or protein-related turbidity reactions (e.g. zinc sulphate turbidity test (ZST), which are indicative of immunoglobulin concentrations.

Passive immunity test results are generally categorised for FPT using test-specific cut-off values. For example, serum IgG and TP cut-off values most commonly used to classify dairy calves for FPT are 10 g/l and 5.2 g/dl, respectively. However, research examining associations between various test cut-offs for FPT with calf health outcomes, such as bovine respiratory disease (BRD) and mortality risk, has indicated that higher cut-off values for FPT in dairy

calves should be adopted. In beef calves, there is even less consensus on the cut-off values for FPT classification. Indeed, there is growing evidence that test cut-offs for FPT need to be reviewed, with more emphasis placed on deriving thresholds based on associations with key calf health and performance outcome measures.

The All-Island Animal Disease Surveillance Programme (Department of Agriculture, Food and the Marine and Agri-Food and Biosciences Institute, 2010-2015) has reported that between 38 and 66.5% of calf serum samples submitted annually to the regional veterinary laboratories in the Republic of Ireland and Northern Ireland have less than 20 ZST units (considered to be indicative of adequate IgG levels in circulation). Although these passive surveillance estimates on FPT may not truly reflect the overall national herd status, because they are drawn from voluntary submissions, often from clinically-ill calves or animals from herds with recurring calf health problems, nevertheless, it is evident that FPT is an issue on some Irish farms. There is no recent published information on the passive immune status or incidence of FPT in calves from modern 'genotypes' in commercial Irish dairy and beef farms. Additionally, research under Irish conditions was needed to validate test cut-off values, based on their relationships with key health and performance outcome measures, such as morbidity, mortality and growth.

Teagasc study

The primary aim of this study was to evaluate the diagnostic performance of passive immunity tests for FPT classification by identifying test cut-off values associated with increased risk of morbidity, mortality, or poor growth in calves. A secondary aim was to describe the epidemiology of morbidity and mortality in Irish suckler beef and dairy calves. A total of 1,392 calves from 111 suckler beef farms, and 2,090 calves from 84 dairy farms across Ireland, were enrolled in the study. Calves were born between July 2014 and June 2016, and monitored until 6 months of age. Each farm visit was scheduled to coincide with a time when calves would be available for blood sample collection and FPT assessment. Calves between 1 and 21 days of age were eligible for blood sampling. A maximum of 12 calves were blood sampled at each farm visit. The median age at blood sample collection for suckler beef and dairy calves was 10 and 9 days of age, respectively. Blood samples were collected by jugular venepuncture and serum was harvested. Serum was analysed for total IgG (by ELISA), globulin and TP by clinical analyser (TP-CA), ZST, Brix-TS %, and TP by digital refractometer (TP-DR). Farmers recorded information on disease events, health treatments, and calf mortality. Morbidity data were available for 1,192 suckler (n=84 farms) and 1,733 dairy calves (n=55 farms). Mortality data were available for all calves. Standardised 205-day body weight was determined for 450 suckler (n = 9 farms) and 480 dairy (n = 8 farms) calves.

Results

Suckler beef calves had lower mean values compared to dairy calves, across all of the tests for passive immunity (Table 1). This result was unexpected.

FPT test cut-offs for suckler beef calves

Optimal IgG ELISA cut-offs for classification of morbidity and mortality in suckler beef calves were 8 and 9 mg/ml, respectively (Table 2). Suckler beef calves with IgG ELISA values ≤ 8 mg/ml had greater odds of being treated for at least one disease event by 3 months of age or BRD in the first month of life compared to those calves with ELISA values > 8 mg/ml. The odds of suckler beef calves with ELISA values ≤ 9 mg/ml dying by 6 months of age were almost

threefold that of those with ELISA values > 9 mg/ml. Other test cut-offs that optimally classified suckler beef calves for health outcomes ranged from 56 to 61 g/l TP-CA, 26 to 40 g/l globulin, 12 to 18 ZST units, 8.4 % Brix-TS, and 5.3 to 6.3 g/dl TP-DR.

Table 1. Passive immunity test results for suckler beef (n = 1,392) and dairy (n = 2,090) calves

	Suckler calves		Dairy calves		Sig.
	Mean	Range	Mean	Range	
ELISA IgG (mg/ml)	12.0	(1.5 - 47.5)	14.0	(1.5 - 55.5)	*
Total protein – clinical analyser (g/l)	60.3	(36.7 - 87.7)	62.7	(39.8 - 93)	*
Globulin (g/l)	33.1	(12.4 - 67.1)	35.2	(13.9 - 68.5)	*
ZST (Units)	15.9	(0.3 - 52)	17.5	(0.5 - 51.4)	*
Brix - total solids (%)	8.8	(6 - 13.6)	9	(6 - 13.2)	*
Total protein –digital refractometer (g/dl)	5.9	(1.5 - 8.7)	6.2	(3.2 - 9.6)	*

*Significant difference; suckler beef calves compared with artificially-reared dairy calves

FPT test cut-offs for artificially-reared dairy calves

Cut-offs that optimised classification of dairy calves for subsequent health and performance ranged from 10 to 13 mg/ml for the ELISA direct test (Table 2). Dairy calves with ELISA values ≤ 10 mg/ml had greater odds of having reduced body weight post-weaning than those with ELISA values > 10 mg/ml. Dairy calves with ELISA values ≤ 12 mg/ml had greater odds of BRD treatment in the first 6 months of life than those with ELISA > 12 mg/ml. Conversely, dairy calves with ELISA values ≤ 13 mg/ml had 40% lower odds of diarrhoea from birth to 6 months of age than dairy calves with ELISA values > 13 mg/ml. Other test cut-offs that optimally classified dairy calves for health and growth outcomes ranged from 57 to 66 g/l TP-CA, 29 to 36 g/l globulin, 19 to 23 ZST units, 7.8 to 9.4 % Brix-TS, and 5.7 to 6.8 g/dl TP-DR.

Table 2. Test cut-offs that optimally classified suckler beef calves and dairy calves for health outcomes

FPT Variable measured	Test	Suckler beef calves	Dairy calves
ELISA IgG (mg/ml)	Lab-based	8 - 9	10 - 12
Total protein – clinical analyser (g/l)	Lab-based	56 - 61	57 - 60
Globulin (g/l)	Lab-based	26 - 40	29 - 34
ZST (Units)	Lab-based	12 - 18	19
Total solids (Brix %)	On-farm	8.4	7.8 - 8.4
Total protein - digital refractometer (g/dl)	On-farm	5.3 - 6.3	5.7 - 5.9

The ZST test is the most frequently used test in Ireland, with serum samples submitted to the regional veterinary laboratories being analysed using this test. In the Teagasc study, optimal ZST units for classification of health outcomes in suckler beef and dairy calves ranged from 12-to-18 units and 19 units, respectively. Thus, if FPT was defined based on the optimal ZST cut-offs, upwards of 64% of suckler beef and 65% of dairy calves would have been classified as having FPT. The most commonly applied cut-off for diagnosing FPT in calves is 20 ZST units. Hogan et al. (2015) recently reported that a ZST cut-off of 20 units is likely too high and they proposed a cut-off of 11 ZST units, which resulted in improved specificity for the test.

Results of the present study also suggest that a lower ZST cut-off is warranted. In the present study, 74 and 46% of suckler beef, and 68 and 54% of dairy calves had less than 20 and 15 ZST units, respectively. Thus, it is evident that there are still opportunities for improvement in colostrum management on Irish farms.

Measuring serum TP using a hand-held refractometer offers a convenient, simple, rapid and inexpensive on-farm tool by which producers and veterinarians can measure serum immunoglobulin concentrations, thereby allowing assessment of colostrum-feeding protocols. Compared to the gold-standard ELISA, Brix-TS values performed comparably to TP-DR values ($r = \text{ca. } 0.75$) for evaluating passive transfer.

Epidemiology of morbidity and mortality in Irish suckler beef and dairy calves

Overall, 20.4% of suckler beef calves and 14.8% of dairy calves were treated with antibiotics for disease by 6 months of age. The leading cause of morbidity from birth-to-6 months of age in the present study was diarrhoea, accounting for 44 and 77% of the disease events in suckler beef and dairy calves, respectively. The second and third most frequent causes of morbidity in calves during the first 6 months of life were BRD and navel infection, respectively. Suckler beef calves had greater odds of BRD, navel infection, and joint infection/lameness during the first 6 months of life compared to dairy calves. Conversely, the incidence rate of diarrhoea from birth-to-6 months of age was greater in dairy calves than suckler beef calves. Incidence rates of crude morbidity for suckler beef and dairy calves from birth to 6 months of age were 4.1 and 8.7 disease events per 100 calf-months at risk, respectively.

In total, 2.7% of suckler beef and 3.3% of dairy calves died in the first 6 months of life. Incidence rates of mortality from birth-to-6 month of age were 0.5 and 0.6 deaths per 100 calf-months at risk for suckler beef and dairy calves, respectively. The odds of mortality between 1 and 3 months of age tended to be 1.8-times greater in suckler beef vs. dairy calves. Suckler beef and dairy calves did not differ for cumulative incidence of mortality in any of the other age categories. Median age at death for suckler beef and dairy calves was 51 and 27 days, respectively. More than half of the dairy calf deaths occurred within the first 1 month of life; whereas, the majority of suckler beef calves died between 1 and 3 months of age. All suckler beef calf deaths occurred on the calves' home farm, whereas 23% (16/69) of dairy calf deaths occurred after they had left the home farm. Results of this study provide insight into the relationships between passive immunity, morbidity and mortality of suckler beef and dairy calves under field conditions in Ireland.

Overall, these findings provide further evidence that calves with lower passive immunity test results are at greater risk of experiencing a negative health event or poor growth performance. A risk factor analysis is being conducted to investigate which animal and herd-level factors potentially contributed to the differences in passive immunity between suckler beef and dairy calves in the present study.

Acknowledgements: Funding from the DAFM (Dr. B. Earley project leader) under the Stimulus Fund (11/S/131) is gratefully acknowledged. The authors also wish to acknowledge the participating farmers, their Teagasc advisors, Cynthia Todd and Olivia Butler with data collection, and the technical and administrative staff at Teagasc Grange for their support of this research.

Reference: Hogan, I., Doherty, M., Fagan, J., Kennedy, E., Conneely, M., Brady, P., Ryan, C., Lorenz, I., 2015. Comparison of rapid laboratory tests for failure of passive transfer in the bovine. *Ir. Vet. J.* 68, 18.

Bovine respiratory disease (BRD) diagnostics and vaccine responses

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Summary

- High calf morbidity and mortality associated with bovine respiratory disease (BRD) results in significant economic loss for farmers.
- Risk factors for BRD include the presence of infectious agents, management, environment and host genetics.
- Traditional diagnostic techniques for BRD-causing viruses and bacteria include culture and quantitative polymerase chain reaction (qPCR).
- Novel technologies being developed at Teagasc Grange include i) 16S ribosomal RNA amplicon sequencing for identification of bacteria and ii) Sequencing of viruses and/or bacteria using the Oxford Nanopore MinION.
- Vaccination of cows pre-partum against BRD-causing viruses can result in a protective antibody response in calves following colostrum feeding.

Introduction

The term bovine respiratory disease (BRD) encompasses pneumonias in cattle caused by a range of infectious agents and environmental factors, resulting in a complex range of pulmonary lesions. Animals with BRD characteristically show the following symptoms; an elevated rectal temperature (greater than 39.5°C), an increased respiratory rate, nasal and eye discharges, coughing, shortness of breath, a decreased appetite and being “off-form”. Internationally, and in Ireland, BRD represents the most significant cause of bovine morbidity and mortality in calves greater than 1 month of age. Furthermore, combined beef and dairy calf mortality due to BRD, in Ireland and Northern Ireland has risen by 8 and 11 percent, respectively, since 2014 (DAFM/AFBI, 2016). Consequently, BRD results in significant economic loss for producers and it presents a major challenge to efficient bovine livestock production and animal welfare. If calfhood diseases such as BRD are not promptly diagnosed, there can be prolonged use of antibiotics, high recurrence rates, and endemic herd health problems. Therefore, the early diagnosis of disease is essential to ensure good overall productivity and health in the herd and to reduce costs to the producer associated with treatment, calf mortality and reduced productivity. Improved diagnostics will also ensure targeted treatment of calves, and consequently, decrease dependence on broad spectrum antibiotics. This will in turn lead to a reduction in the development of antimicrobial resistance and the emergence of ‘superbugs’.

Risk factors for BRD

Bovine respiratory disease is multifactorial, involving infectious agents (both viral and bacterial), host factors, management practices, environmental stress factors and their interactions.

BRD infectious agents

The most commonly detected BRD viruses are bovine respiratory syncytial virus (BRSV), bovine parainfluenza 3 (BPI3) and bovine herpesvirus 1 (BoHV-1) (DAFM/AFBI, 2016). The most frequently detected bacterial causes of mortality due to BRD are *Mycoplasma bovis*, *Pasteurella multocida*, *Mannheimia haemolytica*, *Trueperella pyogenes* and *Histophilus somni* (DAFM/AFBI, 2016).

Management factors

Management-related predisposing conditions for development of BRD include: transportation, weaning, castration, dehorning, group housing, mixing unfamiliar calves in the same pen and mixing calves of varying ages together. Traditional temperate husbandry systems, such as prevalent in Ireland, are broadly focused on a grazing-based system of production from spring to autumn with winter housing.

1. Management factors for suckler beef production systems

Spring-born suckled calves are typically weaned in the early autumn at approximately 6-to-8 months of age and housed in the subsequent weeks. This husbandry practice can represent a significant sources of stress for these 'weanlings' which is occasionally exacerbated by other practices such as castration of male weanlings, housing or transportation and sale through markets. The form of BRD in beef weanlings is commonly referred to as 'shipping fever'.

2. Management factors for artificially-reared calf production systems

Enzootic pneumonia of artificially-reared dairy and beef calves is epidemiologically distinct from 'shipping fever', as it is typically recorded in younger (1 to 6 month old) calves. Management factors influencing this disease include failure of passive transfer of antibodies from colostrum, mixed housing of calves and dietary changes due to weaning. Environmental-related enzootic pneumonia predisposing factors include extreme and variable weather conditions, dust particles and inadequate ventilation.

Currently available diagnostics for BRD

Clinical assessment of individual calves (measurement of rectal temperature and observation of clinical signs and food intake) can be used to diagnose BRD on-farm. Nasal swabs can be sent to DAFM veterinary laboratories for identification of known BRD associated pathogenic bacteria and viruses. Similarly, in suspected fatal cases of calf BRD, known pathogenic agents can be identified in the post-mortem lung tissues using culture and quantitative (q) PCR diagnostic tests. Determination of the pathogens present in the respiratory tract of a BRD infected calf is important in order to develop a more effective treatment protocol.

Novel diagnostic tools for BRD in development at Teagasc Grange

Currently-used diagnostic tools for BRD, including culture and qPCR, will only identify known pathogens associated with BRD. The high incidence of vaccination failure for BRD may be due to the involvement of currently unknown pathogens. We have developed novel diagnostic assays for identification of bacteria (both known and unknown) associated with BRD in post-mortem tissue samples and for the discovery of both bacteria and viruses present in a clinical swab sample using two methods:

1. 16S ribosomal RNA amplicon sequencing
2. The Oxford Nanopore MinION

1. 16S ribosomal amplicon sequencing

As all bacteria contain the highly conserved 16S ribosomal (r) RNA gene, which contains both conserved and variable sequences within it, it is possible to identify different bacterial genera within a clinical sample, by comparing their 16S rRNA gene sequences. A novel, culture-free, bacterial 16S rRNA gene amplicon sequencing method was developed for BRD diagnostics in Grange. Using this approach, the microbiomes (microbial populations) of post-mortem cranial lung lobe and mediastinal lymph node tissues (Figure 1) collected from calves confirmed with BRD by veterinary laboratory pathologists in the regional veterinary laboratories (RVL) or collected from healthy calves, were characterised. A family of bacteria (*Leptotrichiaceae*) was identified, which contains a novel species member likely implicated in BRD. Additionally, both bacteria which are known causes of BRD (e.g. *Pasteurellaceae*, *Mycoplasma*), and bacteria which are not generally associated with BRD, were observed to be more abundant in post-mortem lung and lymph node samples from calves which died from BRD, relative to healthy calves. This assay has potential to accelerate BRD diagnosis and identify, as of yet, unknown bacteria, which may be key players in BRD development and progression.

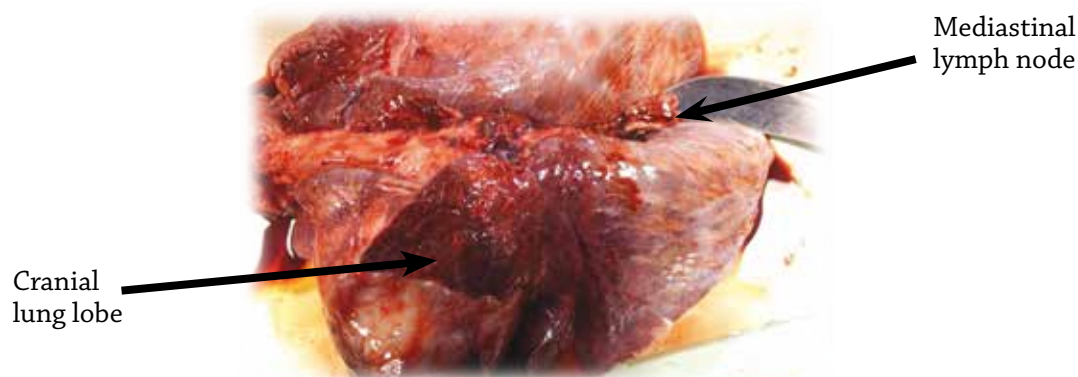


Figure 1. The cranial lung lobe and mediastinal lymph node in a pneumonic lung

2. The Oxford Nanopore MinION

The Oxford Nanopore MinION (Figure 2) is a portable 90g device that connects to the USB port on a computer (with an active internet connection) and sequences DNA directly at 450 bases/second; generating sequence reads in excess of 400 kilobases. We have used it to simultaneously detect three known BRD viruses (BRSV, BPI3 and BoHV-1) from nucleic acids extracted from foetal lung cell viral cultures. We have also used it to sequence nucleic acids extracted from a nasal swab taken from a calf displaying clinical symptoms of BRD on an Irish farm. This nasal swab sample was previously confirmed positive for BRSV at both a DAFM RVL and in Grange, by qPCR. The viral sequences generated from the Nanopore MinION were BRSV sequences. Therefore, we were successfully able to utilise the Oxford Nanopore MinION to identify a BRD virus present in a clinical swab sample from a BRD infected calf. This type of analysis will be optimised and refined and subsequently performed on future nasal swabs to simultaneously identify the viruses and bacteria present. As there have been recent advances in rapid nucleic acid extraction and sequencing preparation kits, there is potential for this to become a pen-side diagnostic tool for veterinarians.



Figure 2. The Oxford Nanopore MinION

3. Vaccination against BRD infectious agents

Vaccines are available for several known infectious causes of BRD, including BoHV-1, BPI3, BRSV, and *Mannheimia haemolytica*. Vaccines can be administered to calves via intramuscular or intranasal routes. Vaccination of young calves is complicated by the presence of colostral and neonatal hormonal factors, and significant levels of maternally derived antibodies, which may interfere with vaccine function. However, vaccination of the pregnant dam rather than the calf can overcome this problem. We have found a protective antibody response to BoHV-1 in calves, following colostrum feeding from their dams which were immunised against BoHV-1 with a primary vaccine (day -84), and a secondary vaccine (day -56) (Bovilis IBR marker inactivated (MSD Animal Health)), relative to the expected calving date (d 0) (Figure 3). In this study, two cow breeds and their calves were examined: Limousin × Friesian (LF) (n = 17) and Charolais × Limousin (CL) (n = 13). Blood samples were collected from calves immediately at birth, prior to colostrum feeding (0 h), at 12 h, 24 h, 72 h and 168 h after the initial feed of colostrum, and at d 7, 14, 28, 42, 56 and 84 post birth.

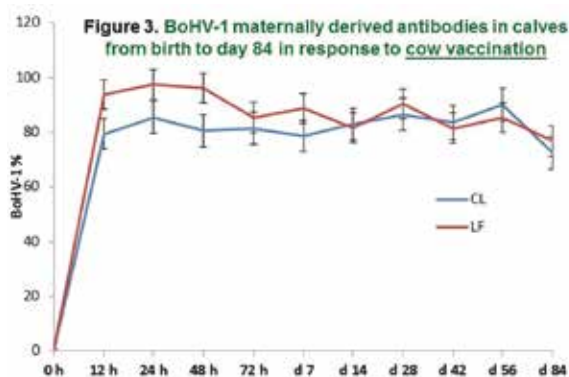


Figure 3. Protective antibody response in calves to BoHV-1 following IBR vaccination of cows pre-partum

Acknowledgements

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Antimicrobial drug usage in calves on commercial beef and dairy farms in Ireland – implications for antimicrobial resistance

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Summary

- Concern about the use of antimicrobials in food-producing animals is increasing. The present study offers a benchmark for antimicrobial use in Ireland. The following guidelines are recommended to maintain acceptable levels of antimicrobial usage on beef and dairy farms;
- Develop a herd health plan in consultation with your veterinarian and Teagasc advisor.
- Pay attention to colostrum feeding, animal nutrition and animal purchasing policies.
- Vaccinate animals to reduce the need for antimicrobials, and use alternatives to antimicrobials when available.
- Only give antimicrobials to animals under veterinary supervision.
- Do not use antimicrobials for growth promotion or to 'prevent' diseases in healthy animals.
- Improve biosecurity on farms, and prevent infections through improved hygiene and animal welfare.

What is antimicrobial resistance (AMR)?

Antimicrobial, derived from the Greek words *anti* (against), *mikros* (little) and *bios* (life), has a broader definition compared to just the term antibiotic and includes agents (both synthetic or natural), that act against bacteria, viruses, fungi and protozoa. In this paper antimicrobial is taken to mean antibiotics (and their chemical derivatives) with an antibacterial range of action. Antimicrobial resistance is the ability of bacteria (or microbes) to resist the effects of an antibiotic. Antimicrobial resistance is one of the leading health concerns in human and veterinary medicine worldwide. Antimicrobial resistance occurs when bacteria change in a way that reduces the effectiveness of drugs, chemicals, or other agents designed to cure or prevent infections. Antimicrobial resistance can be intrinsic or acquired. Intrinsic or natural resistance is a trait of all bacteria belonging to a specific subspecies, species, genus, family or even higher taxonomic rank. Acquired resistance to antimicrobial drugs can develop in bacteria in two ways: genes can mutate, or genes from other bacteria can be horizontally transferred to them. Antimicrobial resistance may cause treatment failure, both in humans and animals. This treatment failure results in a higher morbidity and mortality.

Monitoring antimicrobial usage

In Europe, various monitoring programs have summarised antimicrobial consumption for animals through annual antimicrobial sales data (DANMAP, 2013; ANMV, 2014; MARAN, 2015). These programs are structured to observe trends at the national level and for comparison of data between years and countries (ECDC/EFSA/EMA, 2015; EMA, 2015). However, a limiting factor of those programs is that they are unable to provide more precise information, such as usage at farm level, variability between farms, etc.

Teagasc study on antimicrobial drug usage in calves

The main objective of the study described below was to quantify antimicrobial drug usage in calves using health treatment records from Irish suckler beef and dairy farms. In this study, antimicrobial usage refers to the exposure of a given animal or group of animals over a period of time to the *active substance* in each antimicrobial that was administered.

Data source

Data were obtained from a large-scale study on herd-level factors associated with the health and survival of calves on Irish farms (hereafter referred to as the herd-level study). Farmers, enrolled in the herd-level study, recorded birth, disease and health treatment, and death information on their calves using standardised recording sheets. Case definitions were provided to the farmers to assist with the classification of disease. Farmers completed and submitted the project recording sheets on a monthly basis. All health treatment data were reviewed. Long-acting antimicrobials administered more than 7 days apart, or other medications administered more than 3 days apart, were classified as separate disease events. Crude morbidity was defined as calves being treated for at least one disease event, attributed to any cause, excluding injury. Calves treated for illnesses other than diarrhoea, pneumonia, navel infection, or joint infection/lameness were categorised as receiving treatment for 'other' disease events. The data collected were the antimicrobial trade name, the pharmaceutical form (oral solution, oral powder, parenteral solutions, tablets, bolus, etc.), the pack size (in L or mL for liquids, in g or kg for solids, in unit number for bolus or tablets, etc.), the total number of packages prescribed and dispensed to the farm, and the prescribed therapy (dose, administration frequency, duration).

Antimicrobial usage

Defined daily dose for animals (DDDvet) (mg/kg animal/day) and used daily dose (UDDvet) (mg/kg animal) were the technical units used to measure antimicrobial consumption. The DDDvet is defined as the average maintenance dose for the main indication in a specified species and it is provided by the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project for veterinary antimicrobial usage (European Medicines Agency), whereas the UDDvet is calculated as the amount of an antimicrobial drug administered during a given period (days) divided by the number of calves at risk and their average live weight at the beginning of a treatment. In this way the UDDvet reflects the dose, truly administered by the producer. Treatment incidence (TI) was the indicator used to quantify antimicrobial usage. The TI provides a standardized technical unit of measurement that quantifies how many animals out of a theoretical group of 1000 animals receive daily an antimicrobial treatment, and the calculations applied were:

$$\begin{aligned}
 TI_{\text{UDD VET}} &= \frac{\text{Total Active Substance Administered} \times 1000}{\text{UDDvet} \times \text{standard BW} \times \text{Total calf-days}} \\
 TI_{\text{DDD VET}} &= \frac{\text{Total Active Substance Administered} \times 1000}{\text{DDDvet} \times \text{Standard BW} \times \text{Total calf days}}
 \end{aligned}$$

The Population Correction Unit (PCU) is a measurement developed by the European Medicines Agency (EMA) and takes into account the animal population as well as the estimated weight of each particular animal at the time of treatment with antimicrobials. The milligrams (mg) of antimicrobial used per PCU was calculated.

Results

This study provides the first detailed information pertaining to on-farm usage of antimicrobials in suckler beef and artificially-reared dairy calves from birth-to-6 months of age, in Ireland. A total of 123 farms (79 beef and 44 dairy), comprising of 3,204 suckler beef calves and 5,358 dairy calves, representing 540,953 and 579,997 calf-days at risk, respectively, were included in the study. All calves were raised on farm of origin and most of the studied herds were closed herds. In this study, only animals showing signs of disease were treated with antimicrobials and no mass administration of antibiotics was practiced. On suckler beef farms overall, 12.7%, 5.7%, 2.9% and 20.4% of calves were treated with antimicrobials for disease from birth-to-1 month, 1-to-3 months, 3-to-6 months, and birth-to-6 months of age, respectively. The corresponding values on dairy farms overall for calves treated with antimicrobials were 10.2%, 5.3%, 1.9% and 14.8%. The highest risk period for disease in the present study was between birth and 1 month of age, with approximately two-thirds of all disease events occurring during this time period. This is reflected in the proportion of antimicrobials administered to calves at this time (Figure 1).

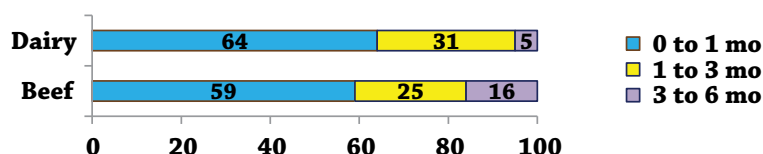


Figure 1. Proportion of antimicrobial treatments (%) for suckler beef and artificially reared dairy calves from birth to 6 months of age

The classes of antimicrobials most frequently prescribed for beef and dairy calves were; tetracyclines, amphenicols, penicillins, 1st and 2nd generation cephalosporins (GC), 3rd and 4th GC, sulfonamides, macrolides, lincosamines, fluoroquinolone, aminoglycosides and spectinomycin (Table 1).

Table 1. Antimicrobial drug classes administered to suckler beef (n=654) and artificially reared dairy calves (n=795) from birth to 6 mo of age.

Antimicrobial class	Number of antimicrobial treatments		Tlidd Mean		TluddMean	
	Beef	Dairy	Beef	Dairy	Beef	Dairy
Tetracyclines	97	160	0.70	0.60	4.46	28.9
Amphenicols	128	159	0.48	0.45	3.81	19.1
Penicillins	210	164	1.12	0.65	10.2	9.4
1st and 2nd GC1	0	1	0	0.02	0	15.3
3rd and 4th GC2	4	3	0.02	0.07	0.023	0.21
Sulfonamides	94	161	0.31	0.78	1.78	23.4
Macrolides	38	20	0.525	0.59	0.49	0.89
Lincosamines	2	0	0.002	0	0.014	0
Fluoroquinolones	202	181	0.93	1.29	13.13	26.5
Aminoglycosides	63	79	0.15	0.37	1.42	17.8
Spectinomycin	3	1	0.002	0	0.012	0.011

¹1st and 2nd generation cephalosporins; ²3rd and 4th generation cephalosporins

A total of 1,770 antimicrobial treatments were prescribed and administered to suckler beef (n = 841) and dairy (n = 929) calves between birth and 6 months of age. From birth-to-1 month of age the class of antimicrobial prescribed for most herds irrespective of type of farm, was penicillin (mostly amoxicillin) by the parenteral (non-oral) route (36.7 and 27.3%, beef and dairy, respectively). From 1-to-3 months of age, amphenicols (florfenicol) were the most prescribed class of antimicrobial for beef calves (17.7%) and tetracyclines (15.9%, mostly oxytetracycline) for dairy calves. Amphenicols (florfenicol) were prescribed more often in calves in the period from 3-to-6 months of age (11.4 and 16.0 % for beef and dairy, respectively). The antimicrobials most prescribed for beef calves during the whole period - from birth-to-6 months of age - were penicillins (mostly amoxicillin), tetracyclines (mostly oxytetracycline), amphenicols (florfenicol) and fluoroquinolones (enrofloxacin and marbofloxacin) (41.8, 30.4, 29.1 (13.9 and 25.2) %, respectively). From birth-to-6 months of age, penicillins (mostly amoxicillin), amphenicols (florfenicol), tetracyclines (mostly oxytetracycline) and fluoroquinolones (mostly enrofloxacin and marbofloxacin) were more frequently prescribed (34.1, 29.6, 22.7 (18.2 and 22.7) %, respectively) for dairy calves. Due to their special surveillance in the context of antimicrobial resistance, the 3rd and 4th generation cephalosporins were separated from other beta-lactams, and fluoroquinolones from other quinolones.

Fluoroquinolones were the most prescribed antimicrobials with 383 treatments, followed by penicillins (n=374), amphenicols (n = 287) and tetracyclines (n=257). The 3rd and 4th GC accounted for a total of 7 treatments (Table 1). In the present study the mg/PCU was 8.03, 2.70, 1.43 and 7.25 for suckler beef calves for the treatment periods from 0-to-1, 1-to-3, 3-to-6, and from birth-to-6 months of age, respectively. The corresponding values for dairy calves were 9.74, 3.72, 0.95, and 7.11 mg/PCU. The average cost of veterinary services was €41.25 and €43.37 per calf for beef and dairy calves, respectively; corresponding antimicrobial costs were €11.58 and €11.51 per calf.

Actions you can take to keep antimicrobials working

- Only give antimicrobials to animals under veterinary supervision.
- Always give the right dose, and the number of treatments, as prescribed by your vet.
- Do not use antimicrobials for growth 'promotion' / disease 'prevention' in healthy animals.
- Do not use antimicrobials to treat viral disease.
- Do not use a 'stronger' antimicrobial as first-line treatment.
- Vaccinate animals to reduce the need for antimicrobials and use alternatives to antimicrobials when available.
- Improve biosecurity on farms and prevent infections through improved hygiene and animal welfare.
- In the case of medicines used in food-producing animals, ensure that the Animal Remedies Record is updated on each occasion that a veterinary medicine is administered.

Acknowledgements: Funding from the DAFM (Dr. B. Earley project leader) under the Stimulus Fund (11/S/131) is gratefully acknowledged. The authors also wish to acknowledge the participating farmers, their Teagasc advisors, Cynthia Todd and Olivia Butler with data collection, and the administrative staff at Teagasc Grange for their support of this research.

Anthelmintic resistance on dairy calf-to-beef farms

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Summary

- Infection with gastrointestinal nematodes (gut worms) negatively affects the productivity of grazing calves.
- In intensive grazing systems good gut worm control depends on using effective wormers (anthelmintics).
- Gut worms develop resistance to the products used to control them. This is known as anthelmintic resistance.
- Resistance to benzimidazole anthelmintics (1-BZ: white wormers) was found on 75% of dairy calf-to-beef farms studied and resistance to macrocyclic lactone anthelmintics (3-ML: clear wormers) was found on 100% of such farms.
- Producers should implement sustainable worm control strategies that delay the further development of anthelmintic resistance.

Introduction

Irish beef production is predominantly pasture-based with grazing cattle naturally exposed to gut worms. A large number of different gut worm species can infect cattle but the most important are *Ostertagia ostertagi*, which is found in the abomasum and *Cooperia oncophora* which is found in the small intestine. *Ostertagia* is generally considered more pathogenic than *Cooperia* but *Cooperia* is more prolific and often the main contributor to worm eggs in faeces. In young stock during their first grazing season these worms can cause clinical disease including scour, ill-thrift and loss of appetite. As grazed grass forms a greater part of the diet, disease is generally a greater problem in the first grazing season for dairy calf-to-beef than suckler beef systems, and is more common in the second half of the grazing season due to the build-up of worm larvae on pasture over time. After their first grazing season cattle usually develop sufficient immunity to prevent clinical disease but nonetheless heavy infections can reduce performance.

Control of gut worms

Control of gut worms is usually achieved by the administration of broad-spectrum anthelmintics (wormers). There are currently 3 classes of wormers licenced in Ireland for the control of gut worms; benzimidazole (commonly known as white wormers (1-BZ) e.g. fenbendazole), levamisole (commonly known as yellow wormers (2-LV)) and macrocyclic lactones (commonly known as clear wormers (3-ML) e.g. ivermectin). In species such as sheep and horses the widespread use of wormers has resulted in the emergence of anthelmintic resistant worms. While anthelmintic resistance has been a problem in sheep production

for some time it has only recently been detected on cattle farms in Ireland. Anthelmintic resistance refers to the ability of worms to survive a dose that should kill them. Anthelmintic resistance is a genetically-determined trait that is heritable.

Emergence of anthelmintic resistance

The genes responsible for anthelmintic resistance are believed to be present in all worm populations but at very low levels. In the absence of anthelmintic treatment these genes confer no selective advantage on the worms. However, when animals are treated with an anthelmintic, this kills all the susceptible worms allowing only the resistant worms to survive. The surviving resistant worms output eggs with the dung onto pasture which results in resistant worms making up a much greater proportion of the worm population in subsequent generations. Anthelmintics from different classes (e.g. 1-BZ, 2-LV or 3-ML) have different modes of action. However, within the same class all products share the same mode of action and consequently when resistance develops to one product within a class all the products in the same class will be affected; this is referred to as 'side-resistance'. The development of anthelmintic resistance is generally considered inevitable over time. However, there are a number of factors that can influence the rate at which anthelmintic resistance develops. Risk factors for the development of anthelmintic resistance include dosing animals too frequently, dosing and moving animals to clean pasture immediately, and under-dosing animals. Animals can be under-dosed by using faulty or uncalibrated dosing equipment, underestimating the weight of the animals to be treated or dosing to the average weight of the animals instead of to the weight of the heaviest animal. Under-dosing can also occur if the dose is not correctly administered (i.e. drench should be placed over the back of the tongue) or applied incorrectly (wrong injection site or applying pour-on during adverse weather conditions). Bought-in stock may harbour anthelmintic resistant worms so it is important that purchased animals are treated immediately with an anthelmintic and isolated in a pen or shed for at least 48 hours before being turned out to pasture that has been recently grazed by cattle and is therefore contaminated with worm larvae.

Anthelmintic resistance diagnosis

The level of gut worm infection in a herd can be ascertained by counting the number of worm eggs per gram of faeces (faecal egg count or FEC). Anthelmintic resistance is diagnosed on-farm by a faecal egg count reduction test (FECRT). This involves collecting faecal samples from 10 to 20 randomly selected calves and determining the faecal egg count for each calf. Calves are then treated with the product to be tested. Faecal samples are collected from the same calves after treatment (7 days post-treatment for levamisole; 14 days post-treatment for benzimidazole and macrocyclic lactone) and the egg count is again determined for each calf. The reduction in the egg count after treatment is a measure of the effectiveness of the anthelmintic treatment. A fully effective anthelmintic dose reduces egg count to zero after administration. If the egg count reduction is less than 95%, then anthelmintic resistance is considered to be present.

Level of anthelmintic resistance in Ireland

A study was carried out on 16 dairy calf-to-beef farms in Ireland commencing in May 2017. The worm burden on each farm was monitored every 2 weeks by collecting 15 fresh faecal samples from a group of first-grazing season calves. A composite faecal sample was generated by combining an equal amount of faeces from each calf and the faecal egg

count determined. This provided an estimate of the worm burden of the herd. Once the herd faecal egg count exceeded 100 eggs per gram of faeces a FECRT was carried out. Forty calves from the grazing group were selected, weighed and faecal samples collected from each calf. The calves were then treated with the two anthelmintic products to be tested (benzimidazole and macrocyclic lactone). Twenty calves were treated with an oral benzimidazole product (fenbendazole 7.5 ml per 100 kg bodyweight) and 20 calves were treated with an injectable macrocyclic lactone (ivermectin, 1 ml per 50 kg bodyweight). Fourteen days after treatment faecal samples were again collected. Faecal egg count was determined for all samples and the reduction in egg count post-treatment calculated.

Table 1. Faecal egg count reduction (%) on 16 dairy calf-to-beef farms after treatment with benzimidazole (fenbendazole) and macrocyclic lactone (ivermectin) anthelmintics. A negative number indicates an increase in faecal egg count after treatment.

Farm	Fenbendazole (% reduction)	Ivermectin (% reduction)
1	69	-228
2	93	-3
3	49	25
4	98*	34
5	89	48
6	86	49
7	89	51
8	85	52
9	92	54
10	89	60
11	96*	60
12	63	66
13	99*	68
14	85	77
15	99*	78
16	15	89

*Farms which did not have resistance

On all 16 farms studied ivermectin resistance was present as treatment failed to reduce the faecal egg count by more than 95% (Table 1). On 2 of the farms the egg count actually increased after treatment. On one of these the increase in egg count was small (3%) but on the second there was a large increase in egg count (228%) after ivermectin treatment. On 12 of the 16 farms there was fenbendazole resistance. For these, the reductions in egg count varied between 15% and 93%. Only on 4 farms was fenbendazole effective in reducing egg counts >95%.

The species of worm that was resistant to fenbendazole and ivermectin was identified. On all farms *Cooperia* were resistant to ivermectin, whereas for 82% of the farms *Ostertagia*

were also resistant to ivermectin. On 36% of farms *Cooperia* were resistant to fenbendazole, whereas on 91% of farms *Ostertagia* were resistant to fenbendazole. Previous studies both in Ireland and overseas have identified ivermectin-resistant *Cooperia* but ivermectin resistance in *Ostertagia* was previously thought to be rare.

Strategies to manage gut worms

Given the evidence for widespread anthelmintic resistance on dairy calf-to-beef farms in Ireland it is important that beef producers implement sustainable strategies to manage gut worms and to delay the further development of anthelmintic resistance. Determining which anthelmintic classes are effective on the farm is a first step in designing an effective worm control plan. Monitoring for gut worms is important and should be an integral part of a herd health strategy. Young stock should be monitored for signs of clinical disease such as scour and reduced weight gain that may indicate a problem with gut worms. Worm burden can also be monitored using faecal egg counts. In calves, a faecal egg count of greater than 200 eggs per gram may have an impact on performance and may indicate a need to treat for gut worms. Treat only when necessary based on herd-level faecal egg count or based on reliable performance indicators such as average daily gain. It is important that the correct dosing technique is used and that the animals are treated according to the manufacturer's instructions and dose rates. Check that the dosing equipment is delivering the correct amount before you treat. If possible weigh the animals to be treated or select and weigh a few of the biggest animals in the group to determine the dose rate, and dose to the weight of the heaviest animal. If there is a large variation in live weight in the group then consider splitting the group based on weight and weigh the biggest animals in each group. Avoid the continual use of wormers from the same class and only use a combination anthelmintic product when it is necessary to treat for both fluke and worms. Where possible use grazing management to limit the exposure of young calves to gut worms. This can be done by grazing freshly reseeded pasture or forage crops in the spring or hay or silage aftermath in the second half of the grazing season when the worm challenge has built up on pasture. 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*. It is also important that animals are not moved to clean pasture immediately after dosing as this is highly selective for anthelmintic resistance. Animals should pick up a 'light' reinfection before moving to clean pasture. A good biosecurity protocol for all bought-in animals should be implemented. Animals should be treated with an anthelmintic and housed for 48 hours. They should then be turned out to contaminated pasture recently grazed by cattle.

Johne's disease-infected beef suckler herds

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Summary

- Johne's disease is caused by a bacterium called *Mycobacterium avium* subspecies *paratuberculosis* (MAP).
- Calves are the most susceptible animals in a herd and infection usually occurs within the first few weeks of life.
- By 6 to 12 months of age animals are considered relatively resistant to infection.
- Effective Johne's disease prevention is achieved where close attention is paid to herd biosecurity to exclude introduction of infection and break the cycle of spread within a herd.
- Aim to introduce as few animals as possible and to source these from high assurance herds (regularly test negative and with a biosecurity or herd health management plan in place).
- Test regularly and remove any infected animals which will otherwise continue to contaminate the environment while they remain in the herd.
- Calve heifers and young cows in their age groups and remove calves and their dams from the calving pen as quickly as possible to reduce exposure of the calf to a high-risk environment.

Introduction

Johne's disease is a bacterial disease of cattle and other ruminants for which there is no cure. It is caused by the bacterium *Mycobacterium avium* subspecies *paratuberculosis* (MAP). Animals are susceptible from birth and once they are infected, the disease progresses slowly and subtly. The disease has a long incubation period with infected animals only showing signs after a number of years. It is unusual to see clinical Johne's disease or record positive blood test results in animals younger than 2 years of age, although these may occur in heavily infected herds.

Johne's infection cycle on a farm

Johne's disease is usually introduced to a herd by an infected animal which appears healthy and may even have had a single negative test result. However, as such an animal matures it may start to shed MAP in its dung, contaminating pastures and the sheds where it is kept (Figure 1) leading to new infections in younger animals. This cycle continues until it is broken by an effective on-farm control programme which identifies and removes animals that are shedding bacteria and also prevents young susceptible stock from becoming infected from the environment.

Calves can become infected early in life by drinking or eating milk or food contaminated with MAP, which are shed in the dung or milk of infected adult cattle. On occasion, calves are born infected, with this being most common when their dam has advanced Johne's disease.

One infected cow, which contaminates a calving pen or shed housing cows and calves, can also infect a number of calves that come into contact with her dung. By 6 to 12 months of age, young stock are considered to be relatively resistant to infection.

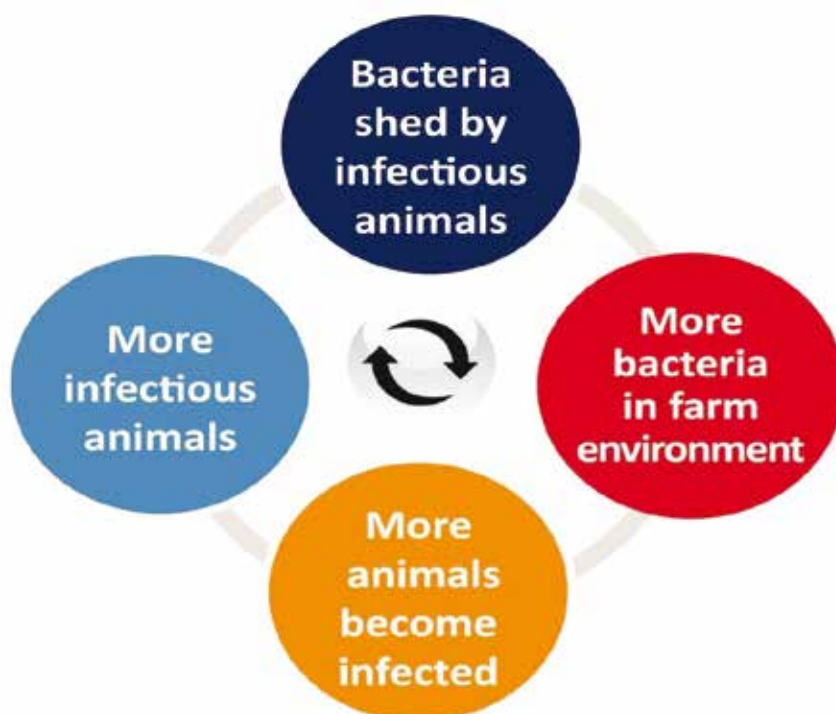


Figure 1. Infection cycle on a farm

The signs of disease that are displayed by an animal vary depending upon the stage of infection, how many bacteria the animal swallowed as a calf, how soon after birth this happened and how quickly the gut wall has become damaged. Infection progresses very gradually and the changes may not be readily detectable unless a herd owner is regularly body condition scoring or weighing animals.

The initial signs of disease relate to a reduced feed-conversion efficiency leading to loss of productivity characterised by weight loss, scour and ultimately emaciation and death. Some animals have a sub-clinical infection, with no obvious signs of disease, but these animals may also have reduced production, presenting as a reduced fertility, reduced slaughter weight and value, reduced milk production and increased susceptibility to other diseases.

For a suckler herd owner this means that a herd with uncontrolled Johne's disease will have a less than optimal fertility, and produce fewer, later-born calves. The associated increased culling rates of less-productive cows means the herd owner requires an increased supply of replacement heifers to maintain herd size. A Johne's disease-infected herd is also likely to experience challenges in finishing young cattle efficiently, since Johne's disease signs may start to emerge at a time when stock are approaching market weights.

How pre-calving and calving cows are managed can have a considerable impact on reducing the spread of Johne's disease in a herd. There are some challenges in managing Johne's disease in suckler beef cow breeding herds, since the options of early calf removal and hygienic calf rearing, which are available to dairy herdowners, are not practical for beef herds. However, the focus of Johne's disease prevention and control on biosecurity is both effective and available to every beef producer.

The keys to prevention and management of Johne's disease in a beef herd are:

- Minimise livestock introductions and limit these to animals from high assurance herds i.e. those herds which have been regularly tested negative and operate under a biosecurity or herd health management plan.
- Regular whole-herd testing, which can be carried out on the first day of the TB test. The test results for any animals which test positive should be interpreted by a veterinary practitioner with regard to the health and movement history of the herd.
- The development of a prevention and management plan which identifies potential risks for the introduction of infection into the herd, and the development of practices to minimise spread within the herd. As a first step in developing a herd prevention and management plan, talk to your veterinary practitioner to discuss disease control methods appropriate for your herd.

Timing is important in Johne's disease control so ideally a disease management plan should be in place prior to calving, and should identify areas on which to focus attention in the calving and cow-calf pens. These are the areas of greatest risk and calves are the most susceptible animals and at greatest risk of infection if exposed to infected animals.

Effectively reducing the spread of Johne's disease in a herd starts by including effective cow-calf hygiene in everyday farm management practices, and by reducing exposure of the calf to faecal contamination by keeping calves away from potentially infected cows and the environments in which they have been kept.

All owners of breeding herds should follow these steps to manage the risk of Johne's disease spread in the herd:

- Pre-calving, cows should be as clean as possible prior to calving, with udders and tails trimmed to minimise faecal contamination.
- The calving pens should be kept clean with bedding changed frequently, or topped up to limit a calf's exposure to dung.
- In an infected or test-positive herd, all test-positive cows should be calved as a separate group and ideally heifer progeny should not be retained for breeding or sold on for breeding purposes, since they may have been born infected or become infected shortly after birth.
- All beef herds should aim to keep calving heifers as a separate group since these animals are the group least likely to be shedding bacteria should infection be present. Calves born to heifers in a herd following this practice are considered lower risk than the progeny from older age groups, where bacterial shedding is more likely and heifer calves, reared in this manner, could be retained as future replacement animals.
- After calving, remove the dam and calf as soon as possible from the calving area, ideally within 15 minutes, to an area where the level of contamination build-up is reduced (for

example onto pasture). The sooner the calf is removed from the calving environment the shorter the exposure time to an environment potentially highly contaminated by other cows.

In suckler herds where Johne's disease has been present for some time and causing serious loss of production, a herd owner could consider developing a control plan that includes the establishment of a low-risk nucleus of replacement heifers, which can become the foundation of a higher assurance herd. This can be achieved by removing the heifer calves from younger dams straight after birth and raising them in isolation from the main herd, and only returning them to the main herd just prior to calving. If this practice is repeated in conjunction with regular annual whole-herd testing and the removal of test-positive cows, over several years the infection prevalence is likely to drop, and with commitment and perseverance the herd may gain effective control over Johne's disease.



Reproductive management of spring-calving suckler cow herds

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Summary

- Reproductive efficiency is central to economic and environmental sustainability of suckler cow herds and is influenced by a number of factors:
 - Age at puberty and age at first calving in heifers
 - Duration of the post-calving anoestrous interval, which is largely affected by cow-calf bonding and pre-calving nutrition
 - Heat detection efficiency where AI is used, or bull fertility in herds using natural service.
- Avoidance of fluctuations in feed supply during the breeding season and strategic manipulation of body condition (fat reserves) over the winter period will facilitate efficient reproductive performance of the herd.
- Management practices and biosecurity have an important role to play in prevention and control of infectious agents which could affect calving rate.

Introduction

Herd fertility is one of the predominant factors determining output and ultimately the financial sustainability of suckler cow herds. Despite this, national statistics from the Irish Cattle Breeding Federation (ICBF) suggest that, on average, only slightly over 8 calves are born to every 10 cows annually, with average inter-calving intervals in the region of 400 days overall and approximately 385 days for spring-calving herds alone. These statistics do not bode well for the future economic and environmental sustainability of the national suckler cow herd. While there is significant variation between herds and indeed between individual cows within a herd, this indicates that a large proportion of cows fail to achieve the key target of producing a calf every 365 days. Teagasc studies indicate that this inefficiency is costing Irish farmers in the region of €2 per cow (mainly in feed costs) for each day that the calving interval extends beyond the target of 365 days - equivalent to €100 per day for a 50-cow herd. Undoubtedly, while much of this inefficiency can be attributed to poor management practices, recent data from ICBF indicate a genetic dimension and is symptomatic, to some extent, of the emphasis for many years, on terminal rather than maternal traits within the national breeding programme. In this paper a number of the key elements of fertility management of spring-calving beef cow herds will be discussed as well as a brief update on some recent Teagasc research studies on this subject.

Reproductive targets for a beef herd

Suckler cow herds, like any livestock enterprise, must set, and aspire to achieve, key targets upon which performance can be benchmarked. The following are the reproductive and related production targets for a pasture-based spring-calving suckler cow herd: 1) 365 day calving-to-calving interval; 2) <5 % cows culled annually as barren; 3) >95% of cows that calve, wean

a calf; 4) heifers calving at 24 months of age; 5) compact calving with 80% of cows calved in 42 days; 6) replacement rate of 16 to 18%; 7) sustained genetic improvement of the cow herd for economically-important traits relating to reproduction, calving ability and calf weaning weight; and 8) close alignment of calving date with onset of pasture availability in the spring. There are three key events that must occur in a timely fashion in order to meet the above targets. These are:

- 1) Occurrence and timing of puberty and breeding of replacement heifers,
- 2) Resumption of oestrous cycles post calving,
- 3) Breeding and the establishment of pregnancy.

1. Occurrence and timing of puberty and breeding of replacement heifers

Calving heifers at two years of age is a key target for a reproductively efficient beef cow herd. However, only 20% of heifers meet this target in Irish herds in recent years (national average is 32.5 months). Significant costs are incurred during the rearing of replacement heifers and it is imperative that they become pregnant early in their first breeding season, encounter minimal dystocia, are successfully rebred to calve again within 365 days, and ultimately have long (at least 6) lactations and productive lives within the herd. Data from Grange studies clearly show that delaying first calving from two to three years of age decreases net margin per hectare by up to 50%, mainly as a result of increased feed costs. Additionally, within a two-year old calving system, heifers that conceive early during their initial breeding season have a greater probability of becoming pregnant as first-calving cows, have greater lifetime production (calf weaning weights), and tend to calve earlier in subsequent years compared to their contemporaries that conceived later as heifers. Hence, genetic predisposition to earlier onset of puberty in heifers, together with appropriate nutritional management will positively impact on the timing of conception in the first breeding season (Table 1) and ultimately lifetime productivity.

Table 1. Effect of puberty status at the start of the breeding season on pregnancy rate (%) after 6, 8, 10, and 12 weeks of breeding (artificial insemination) in crossbred beef heifers (Heslin *et al.*, 2018; unpublished)

		Week of breeding season			
Pubertal	No. heifers	6	8	10	12
Yes	68	68	82	90	94
No	243	55	70	78	86

Sexual development and onset of puberty in the heifer is regulated by a complex interplay of biochemical messages between reproductive and brain tissues, which can be influenced by factors including breed and nutritional status. Thus, growth and body composition, particularly fat, can influence the timing of puberty. However, there is little information on appropriate replacement heifer rearing strategies, to ensure early onset of breeding and calving at 24 months of age, for beef breed types in Ireland.

To address this issue, a two-year study was conducted at Grange to examine the effect of post-weaning nutritional management for different breed types on age at puberty and subsequent pregnancy rate. In total, 320 spring-born heifers purchased at 7-to-8 months of age from commercial herds, were used. The heifers were sired by either an Angus (early-maturing) or Limousin (late-maturing) bull and were the progeny of either dairy or beef cows. They were assigned to either a high or moderate plane of nutrition over the winter period in order to achieve average target growth rates of approximately 1.0 kg or 0.5 kg per

day, respectively. The heifers were subsequently bred using AI, while at pasture, over a 12-week breeding season.

Overall, dam type did not affect age at puberty or age at first breeding but pregnancy rate following breeding for either 6- or 12-weeks was higher for dairy-bred compared to suckler-bred heifers. Heifers sired by an early-maturing breed were younger at puberty and at first breeding, and had a higher pregnancy rate at 6-weeks compared to those sired by a late-maturing breed, but sire breed did not influence pregnancy rate following 12-weeks of breeding. While age at first breeding was advanced for heifers on a high winter feed allowance, plane of nutrition did not affect pregnancy rate following either 6- or 12-weeks of breeding. Currently the influence of nutrition during the calf rearing phase on sexual maturation in the heifer is under investigation and target pre-breeding growth rates are being formulated for the various breed types of interest.

2. Resumption of oestrous cycles post calving

The single most important factor influencing the reproductive efficiency of suckler cows is early onset of oestrous cyclicity (heat cycles) after calving. The main difference between a dairy cow which typically will resume cyclicity by one month after calving and a suckler cow, which can take anything from 40 to 100 days to resume normal heat cycles after calving, is the presence of the suckling calf. The bond between the cow and calf prevents the early onset of heat cycles after calving so any strategy to advance the opportunity to breed the cow again must consider this important factor. Indeed work conducted at Teagasc Belclare, in the past, shows that short-term restriction of suckling activity can significantly advance the onset of normal heat cycles in suckler cows. This latter strategy is being used on many autumn-calving and early spring-calving suckler farms with good success, where calves are restricted to once or twice daily access to suckle after they reach about 1 month of age. This can be achieved through locking calves out in a creep area thereby preventing constant access to the cows, or where facilities and weather conditions allow, turning calves out to a nearby sheltered paddock during the day. Where this is effectively practiced, the majority of cows will typically be seen on heat two to three weeks later. Additionally, once a cow is observed on heat, the suckling restriction can cease.

In addition to reducing the cow-calf bond, Teagasc studies have clearly established that energy intake of the cow in mid- to late-gestation, mediated through improved body condition score (BCS), has a positive effect on reducing the interval between calving and the onset of normal heat cycles. For example, calving the cow in moderate, as opposed to poor BCS, can advance the onset of cyclicity by 1 to 2 weeks. Overall, pre-calving nutrition has a much greater effect on the onset of heat cycles, through its effect on BCS and the general metabolic status of the cow, than level of feeding post-calving. In other words, if a cow is thin at calving, additional feeding after she calves will have limited impact on shortening the time until she has her first subsequent heat. The key objective is to calve cows in moderate-to-good condition but not overly fat. Target BCS for cows calving at different times of the year are outlined in Table 2. One BCS unit (0-5 scale, where 0 or 1 is emaciated and 5 is obese) is equivalent to approximately 70 kg of bodyweight in a moderate-sized cow.

Table 2. Target body condition score (BCS; 0-5 scale) at key reproductive events for spring and autumn calving sucker cows.

Calving season	Mating	Mid Pregnancy	Calving
Jan-Feb	2.5	3.0	3.0
March-May	2.5	3.0	2.75
Autumn	2.75	2.25	3.25

3. Breeding and the establishment of pregnancy.

In suckler, unlike dairy cows, there is no substantial evidence of a decline in conception rate, with rates of 60 to 70% typically achievable to either AI or natural service, unless there are problems with semen quality, AI technique or bull fertility. Conception rates reach a normal level in cows bred at 60 or more days after calving though performance of first-calvers is often lower compared to mature cows, reflecting the increased nutritional demands of the former for growth in addition to maintenance and lactation. Where AI is used, fertility is highest following insemination at 12 to 18 hours after heat onset but is not greatly reduced following early insemination. However, late insemination, at 24 hours or later, after onset of standing heat, should be avoided. While the majority of Irish herds use natural service, farmers need to avoid becoming complacent in relation to fertility of their stock bulls, even for mature animals. On-going vigilance for mating ability and fertility is recommended for all bulls but in particular for young bulls recently joining the herd. There is little doubt that there are significant differences in fertility amongst individual bulls. While the reported incidence of sterility is generally low (<4%), subfertility, at a consistent level of 20-25%, is much more common in breeding bulls. To this end, Teagasc is currently leading a large research project, funded by Science Foundation Ireland, where the biological basis for differences in fertility amongst bulls will be examined. The contribution of genetics as well as nutrition of young bulls, on the age at onset of puberty and subsequent fertility will also be studied. As an aid to the identification of both infertile and potentially sub-fertile natural service bulls, a breeding soundness evaluation can be carried out before the onset of the breeding season by a trained veterinary surgeon. This can be backed up by early pregnancy scanning of mated females.

Infectious disease and trace element status - 'BeefCow' project

Various endemic pathogens are frequently cited as mediators of poor fertility in beef cattle; however, there are little data available to quantify their impact on either productive and/or reproductive efficiency. To address this, almost 6000 cows from 169 spring-calving suckler cow herds were blood sampled during the breeding season and the sero-prevalence (presence of antibodies) of bovine viral diarrhoea virus (BVDV), bovine herpes virus (BHV-1), leptospirosis (*L.hardjo* and *Neospora caninum*) was established. The work was led by Teagasc and funded by the Department of Agriculture Food and the Marine. A sero-prevalence rate of 71, 78, 44 and 5% for leptospirosis, BVDV, IBR and neosporosis, respectively, in non-vaccinating herds was observed. Analysis of reproduction and calf performance data supplied by ICBF for these herds showed that these pathogens had no negative impact on pregnancy rate at the end of the breeding season, subsequent calving interval, and calf mortality or live weight performance up to 225 days. However, importantly, sero-prevalence for all pathogens measured was negatively associated with the subsequent calving rate of cows diagnosed as pregnant at the end of the breeding season, suggesting a potential, though modest negative effect on foetal mortality.

Trace elements play an important role in the health and performance of cattle and deficiencies are often suspected in cases of poor reproductive performance, though again, there are little data to substantiate this. As part of the aforementioned epidemiological study, blood samples were also analysed for selected trace elements. Preliminary findings indicate that 15, 79 and 82% of cows were below limits considered acceptable for copper, iodine and selenium, respectively. Analyses are on-going to determine the association of these trace elements, if any, with various reproductive, health and animal performance traits.

The Maternal Herd at Teagasc Grange

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Summary

- The purpose of the establishment of the Maternal Herd at Grange was to validate the Euro-star Replacement Index and determine the effectiveness of the index in selecting animals suitable for breeding replacements.
- Results to date showed no significant differences between high and low Replacement Index beef x dairy cows; however, within beef crossbred cows, high Replacement Index animals had greater milk yields, superior fertility overall, lower calf mortality and subsequently greater longevity within the herd than low Replacement Index animals.
- Beef x dairy cows calved earlier and had a greater milk yield than beef cows; however, no difference was found in progeny performance at slaughter.
- Phase 2 of the Maternal Herd project will compare ELITE (top 10% within the Replacement Index; 5-star; >€120) to the national average (3-star; €55-€73) within beef crossbred animals, with beef x dairy animals used as a 'control' group.

Introduction

Profitable suckler beef production systems require a cow that will efficiently produce a weanling with good weight-for-age from a pasture-based system and deliver a live calf every 365 days. Profitability in suckler beef systems is also driven by stocking rate, mean calving date, age at first calving, number of live calves per cow per year and slaughter age of progeny. These drivers of profitability depend on appropriately matching the cow type to the prevailing environment. Herd genetic improvement plays an important role in farm profit by facilitating optimal breeding decisions that increase long-term animal productivity. Current industry statistics show that, on average, Irish suckler cows have calving intervals of 400 days; produce 0.85 calves per cow per year and only 24% of heifers calve for the first time between 22 to 26 months of age (ICBF, 2018). This performance highlights the current inefficiencies of the suckler herd and the scope for improvement that is achievable. In this context the Euro-star Replacement Index (RI) was implemented nationally in 2012 to select/breed animals superior for maternal traits. This led to a greater emphasis being placed on the key maternal traits which are proven to underpin farm profitability. In order to ensure continued accurate genetic evaluations the profit traits included in the index together with their respective economic weighting must be regularly reviewed.

Design and establishment of the Maternal Herd

The *Maternal Herd* was assembled in 2012 with the purchase of maiden heifers (weanlings) from commercial farms throughout the country. Heifers were selected from two main sources: 1) beef crossbred heifers generated from dairy cows and 2) beef heifers sourced from suckler herds (Figure 1). Only heifers from sires with high reliability (>70%) for RI were considered for selection, with particular emphasis on breeding values for the key maternal profit indicator traits (i.e. age at first calving, calving interval, maternal weaning weight and

maternal calving difficulty). Heifers were sourced to represent two divergent categories of animal – either high or low RI. Additionally, within dam type (dairy *v* beef cows); heifers were sired by either Angus (early-maturing breed) or Limousin (late-maturing breed) bulls. Genomic testing was conducted to verify the sire of all heifers purchased. Heifers calved for the first time in spring 2014 and approximately 30 replacement heifers have been introduced into the herd each spring thereafter. Since its establishment in 2012, lactating heifers from 67 sires were represented in the study.

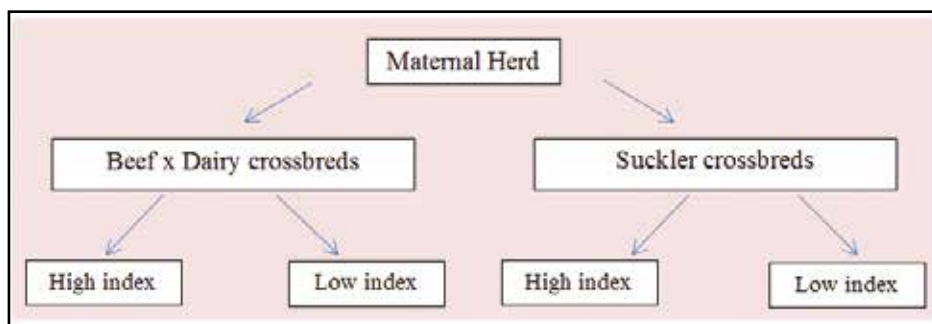


Figure 1: Summary of the composition of the *Maternal Herd*.

Expected performance differences

The RI value is comprised of a multitude of traits including cow weight, calf weaning weight, age at first calving, calving difficulty, gestation length, cow survival, feed intake, carcass traits etc. Table 1 details the RI of each of the four groups as well as the economic indexes ascribed to maternal cow traits and maternal progeny traits. The expected performance differences for key traits based on the genetic values are also highlighted in Table 1. Due to the influence of milk and fertility within the RI, the difference between high and low beef $\times$ dairy cows (BDX) was 1 star (5 and 4 stars, respectively) or €56. However, the high and low RI beef cows (Beef) were in the 5 and 2 star categories, respectively. Detailed measurements of key maternal performance traits such as: age at onset of puberty, milk production, reproductive efficiency, weaning weight, body weight change and body condition score (BCS), as well as feed intake at pasture and energy balance measurements were recorded for all cows.

Table 1. Descriptive statistics for the *Maternal Herd*.

Replacement Index	Beef $\times$ Dairy		Diff	Beef		Diff
	High	Low		High	Low	
Replacement Index (€)	134	78	56	101	36	65
Maternal cow traits (€)	524	259	265	284	-10	294
Maternal progeny traits (€)	143	130	13	221	192	29
Calving difficulty score (%)	2.8	4.0	1.2	4.2	5.7	1.5
Cow weight (kg)	5	9	4	17	19	2
Gestation length (days)	-0.29	0.92	1.2	1.6	2.3	0.7
Age at first calving (days)	-16	-5	11	-17	-9	8
Maternal weaning weight (kg)	15.4	9.9	5.5	6.5	2.6	3.9
Direct carcase weight (kg)	3.2	4.7	1.5	12.6	14.7	2.1

Results

Production performance of the cows is presented in Table 2. Age at first calving, calving interval, and most reproductive variables investigated were similar for both high and low RI groups across both replacement strategies. However, overall pregnancy rate was greater for high RI beef cows compared to low RI beef cows. The BDX cows had an earlier age at first calving, were lighter, had a lower body condition score (BCS) at breeding and calved approximately one week earlier than beef cows. Calving interval and all other reproductive variables investigated were similar between beef and BDX cows.

Table 2: Effect of Replacement Index and cow origin on reproductive performance.

Replacement Index	Beef × Dairy		Beef	
	High	Low	High	Low
Body weight (kg)	562	569	634	622
Age at first calving (d)	757	756	764	762
BCS at breeding	2.64	2.66	2.87	2.89
Calving to service interval (d)	63	60	62	64
Pregnancy to first service (%)	47	55	46	54
Pregnancy rate (%)	84	88	86	77
Calving to conception interval (days)	80	79	78	79
No. of services per cow (n)	1.73	1.63	1.76	1.56
Actual calving interval (days)	363	361	362	359
Mean calving date	15 March	16 March	21 March	23 March

High RI beef cows produced 0.7 kg more milk per day than low RI beef cows, which resulted in an additional 0.04 kg live weight gain/calf/day (Table 3). Low RI beef cows had greater overall calf mortality than high RI beef cows. Replacement Index did not influence calf birth weight, weaning weight or calf value. No differences were found between high and low RI BDX cows for any of the calf performance traits investigated. Results to date indicated that BDX cows had a greater milk yield than beef crossbreds. Calf birth weight, and calf average daily gain, and consequently weaning weight, did not differ significantly between both groups. Calf value at weaning was greater for calves from BDX cows compared to beef cows, but no difference was found in price per kg live weight.

Table 3: Effect of Replacement Index and cow origin on calf performance.

Replacement Index	Beef × Dairy		Beef	
	High	Low	High	Low
Milk yield (kg/d)	8.9	8.4	7.3	6.6
Calf birth weight (kg)	42	44	44	45
Total calf mortality (%)	11.9	7.8	7.0	16.3
Weaning weight (kg)	287	290	281	271
Calf ADG ¹ (kg)	1.12	1.13	1.10	1.06
Calf value (€)	705	734	696	689

¹ADG= average daily gain

Preliminary carcass data (2 years of progeny performance) showed no differences between RI or beef and BDX progeny. Thus, selecting for maternal traits had no negative impact on carcass performance of progeny, with progeny across all groups achieving acceptable carcass conformation and fat scores.

Table 4: Effect of Replacement Index and cow origin on progeny carcass performance – Preliminary Results.

Replacement Index	Beef × Dairy		Beef	
	High	Low	High	Low
Live weight at slaughter (kg)	603	603	607	588
Carcass weight (kg)	322	327	330	324
Carcass conformation (1-15)	6.7	7.0	7.6	7.6
Carcass fat (1-15)	8.7	8.7	8.5	7.9

Future plans

Phase 2 of the *Maternal Herd* has commenced with the purchase of 74 maiden beef heifers. These heifers were sourced on the basis of their own genetic index using genomic information thereby increasing the RI reliability for individual heifers. In addition, all heifers were generated using AI sires. Phase 2 aims to compare ELITE (top 10% within the RI; 5 star; >€120) to national ‘average’ beef heifers (3 star; €55-€73), with BDX heifers being used as a ‘control’ group. Within the ELITE group heifers ranked in the top 10% for key maternal traits of age at first calving, calving interval, milk and survival. The objective of Phase 2 is to demonstrate if intense selection within the Index, with a focus on key maternal traits, will translate into more divergent physical performance compared to the existing national average performance. The breeding season commenced on the 30 April 2018. Similar to previous years, heifers will be artificially inseminated for thirteen weeks. Vasectomised ‘teaser’ bulls and tail paint are used as heat detection aids. Heifers are being bred to an easy-calving terminal Charolais bull that has a high reliability for calving ease (4.1%).

Conclusion

The *Maternal Herd* is a valuable resource for collecting detailed information pertinent to maternal traits in suckler cows. Results to date have shown that no significant differences were found in BDX cows, possibly due to a lack of divergence for the RI. However, some differences between high and low RI beef cows were evident. Phase 2 of the *Maternal Herd* project aims to build on these results, with more specific selection criteria, to determine if active selection for specific traits will translate into physical performance of the cow.



The Derrypatrick research demonstration Herd, Grange

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Summary

- The Teagasc Derrypatrick Herd, Grange is a 100-cow suckler calf-to-beef research demonstration herd on 65 hectares.
- Two research studies, a grazing experiment, in which white clover incorporation into the grass sward is evaluated, and a sire genetic merit experiment, which compares the Replacement and Terminal breeding indices, have commenced.
- The Derrypatrick Herd gross margin for 2017 was €1285/ha.

Herd profile

The Teagasc Derrypatrick Herd, Grange is a 100-cow suckler calf-to-beef research demonstration herd on 65 ha with a stocking rate of 2.7 livestock units (LU)/ha. The soils range from moderately drained to imperfectly-poorly drained clay loam, with some parts composed of poorly-to-very poorly drained gleys. The primary objective of this herd is to evaluate alternative suckler calf-to-beef production systems. The cow herd consists of Limousin × Friesian and $\frac{3}{4}$ beef breed Simmental and Limousin sired animals. Over the previous 3 years, these cows have been bred to either Angus (early-maturing; EM) or Limousin/Charolais (late-maturing; LM) bulls. Progeny have been finished as 16-month bulls, 20-month heifers and 24-month steers. As of 2018, all male progeny will be slaughtered as steers, to coincide with a grazing study, which will result in a higher stocking rate (3 LU/ha). Grazing and animal (sire) genetic merit research projects will commence in 2018 and details are outlined below.

New research

Grazing study

White clover (Chieftain and Aberherald) was incorporated into half the farm (every second paddock) during 2017 with the aim of evaluating the effect of white clover inclusion into perennial ryegrass swards on herbage dry matter (DM) production, utilisation, clover persistency and animal performance. Clover was over-sown into existing pastures at a rate of 5 kg/ha (2kg/ac) using an Einbock pneumatic seeder after a tight grazing (3.5/ 4.0 cm) or silage harvest. Fertiliser (0:7:30) was spread at sowing at a rate of 5 bags/ha (2 bags/ac). To aid clover establishment, pre-grazing herbage yields were typically less than 1,300 kg DM/ha for the subsequent 3 to 4 grazings. Half of the cow herd and their progeny will graze perennial ryegrass-only swards, whereas the remaining animals will graze mixed swards consisting of white clover and perennial ryegrass.

Sire genetic merit study

A comparison of high Replacement Index vs. high Terminal Index sires commenced during the breeding season of 2017. Sires were selected based on high 'maternal' traits or high 'terminal' traits. Two high and two low sires each from the Charolais, Limousin and Simmental breeds were used on second and greater parity cows, while two high and two low Aberdeen Angus

sires were used on replacement heifers. The calves from these sires will be managed to slaughter in a 20-month heifer or 24-month steer production system. The aim of this study is to determine the effect of selecting high Replacement Index sires in comparison to high Terminal Index sires on animal performance and carcass output. Within the Replacement Index, sires were selected on the following (maternal) traits: milk yield, calving interval, cow contribution to the Replacement Index, calving difficulty, while maintaining a 'balanced' Terminal Index. Within the Terminal Index, sires were selected on the following traits: carcass weight, overall Terminal Index and calving difficulty. Additionally, it was ensured that breeding value 'reliability' was high. Maximum sire calving difficulty used on the cow herd was 8%. All heifers were bred to Angus sires using high Replacement and high Terminal Index for that breed.

Grassland management

The Derrypatrick 2018 grazing season started on the 18 April; difficult ground conditions prevented earlier turnout to grass. Sixty six cows and calves, and all (99) yearlings were turned out to grass on 18 April with the remaining cows and calves were turned out on the 20 April. Paddock pre-grazing cover (herbage mass) was 1350 kg DM/ha for the cows and calves, and 1440 kg DM/ha for the yearlings. There are eight groups of cattle in total - four groups of cows and calves, and four groups of yearlings. This number of groups is to facilitate the evaluation of white clover inclusion on animal performance and output as well as herbage production and composition (described above). Target pre-grazing cover and post-grazing sward height is 1300 to 1500 kg DM/ha and 4.0 cm, respectively. Once this post-grazing sward height is reached, groups are moved to the next paddock. The second rotation started on 14 May.

Calving

A summary of calving performance in 2018 is presented in Table 1. A post-breeding pregnancy scan carried out in September 2017 revealed 100 animals in-calf. However, during the indoor winter period three cows aborted and one heifer proved not in calf. The first calf was born 10 February, and the last calf was born 14 May. A total of 96 cows calved, producing 97 calves. Cow live-weight and body condition score (BCS) at calving were on average, 657 kg and 2.75 (scale 0-5), respectively.

Table 1. Calving performance 2018

Start date	10/02/18
End date	14/05/18
Mean calving date	28/03/17
Number calving	96
Calves born alive	97
Average calf birth weight, kg	47
Cow live weight at calving, kg	657
Cow body condition score at calving, (0-5)	2.75

Breeding

The sires used in the Derrypatrick sire genetic merit study are a mixture of Charolais, Limousin, Simmental (used on cows) and Aberdeen Angus (used on heifers). More specifically, (AI codes) the Replacement Index sires used in 2017 were, VMO, CH2218, JSS, CWI, QCD, SI2152, ZLL

and RGZ, and the Terminal Index sires used in 2017 were, FSZ, FWO, LM4050, GWO, RWV, CQA, TPX and AA2037. In 2018, VMO, CH2218, JSS, CWI, QCD, SI2152, ZLL and RGZ were selected as the Replacement Index sires, and FSZ, SNZ, LM4050, LM4093, RWV, CQA, ZEP and GJB were selected as the Terminal Index sires. The 2018 breeding season began on 2 May and will continue for 12 weeks. Breeding is 100% AI and is implemented using the 'AM:PM rule', where cows observed in heat in the morning are inseminated in the afternoon, and cows observed in heat in the afternoon are inseminated the next morning. Cows are bred to 1 of 12 (4 from each breed) Charolais, Limousin and Simmental sires, whereas heifers are bred to 1 of 4 Angus sires. Aids to heat detection included teaser bulls with chin-ball, tail paint and visual observation 4 times daily.

Animal performance

Calf performance in 2017 is summarised in Table 2. Male calves were castrated in mid-September. Gradual weaning began on 10 October; this was carried out by housing one third of the cows from each grazing group every 3 days. Hence, weaning was completed over a 10-day period. Due to poor weather conditions, cows remained housed following weaning. Calves were offered 1 kg of a barley-based concentrate ration/head/day from 10 days pre-weaning until housing, 4 weeks after weaning. Unfortunately, a weanling heifer had to be put-down under veterinary advice following a leg fracture; this was the only mortality encountered following calving. Cow live-weight and BCS at weaning were on average 668 kg and 3.0, respectively.

Table 2. Calf performance 2017

	Birth weight kg	Wean weight, kg	Wean age, d	Daily live weight gain birth-wean, kg	Housing weight, kg	Value at housing €
Heifers	41	275	213	1.11	285	725
Bulls	45	295	210	1.21	311	781

Dung samples were collected on 24 July and analysis indicated a low worm burden. Dung samples taken again on 21 August revealed a worm count (~200 eggs per gram) that required treatment. All calves received a Levamisole-based anthelmintic. This was the only worm control calves received until housing. Shortly after housing, all calves received triclabendazole and ivermectin-based products for fluke and worm control, respectively. Weanlings were housed on 16 November and were valued by an independent evaluator: on average, heifers were valued at €725 and steers at €781 each.

Slaughter performance for animals born in 2016 is summarised in Table 3. When housed (11 November 2016), bulls were offered first-cut grass silage (72% DM digestibility - DMD) *ad-libitum* plus 2 kg concentrate/head daily. Concentrate allowance was gradually increased such that all bulls received concentrates *ad-libitum* by early January. Bulls were slaughtered in mid-June 2017 at 16 months of age. Lifetime average daily gain (ADG) was 1.35 kg and overall concentrate input was ca. 1.3 tonnes per head. Finishing heifers and steers were offered a barley-based concentrate from 1 September and the allowance was increased gradually over a 2-week period to 4 kg/head daily. The aim was to finish heifers from grass at 20 months

and steers before the second winter. In total, 16 heifers and 12 steers were slaughtered from pasture (+ supplementation). Due to poor weather conditions, the remaining animals (17 heifers and 8 steers) were housed on 1 November for a final finishing period indoors on high quality grass silage and 5 kg concentrates. Some animals were drafted for slaughter on 16 November, whereas the remainder were slaughtered on 7 December. In 2017, a total of 28 cows were culled, with chronic lameness and poor performance being the main factors for culling.

Table 3. Live weight, growth, slaughter and carcass traits of early-maturing (EM) and late-maturing (LM) breed progeny in 2017¹

	No	BW (kg)	WW (kg)	SW (kg)	ADG (kg)	CW, (kg)	CS	FS	KO (%)	Age (Mth)
16m Bulls										
EM	11	44	375	703	1.40	395	R+	3-	56	16
LM	9	53	352	682	1.30	403	U-	2+	59	16
Heifers										
EM	21	41	320	578	0.94	308	R=	4=	53	19
LM	19	51	326	601	0.92	334	U-	3-	56	20
Steers										
EM	10	46	364	651	1.00	354	R-	3+	54	20
LM	9	53	350	688	1.04	392	U-	3-	57	21
Cows	28	N/A	N/A	751	N/A	391	R-	3+	52	N/A

¹No = number, BW = live weight, WW = weaning weight, SW = slaughter weight, ADG = lifetime average daily gain, CW = carcass weight, CS = carcass conformation score, FS = carcass fat score, KO = kill-out.

EM = Early-maturing breed, LM = Late-maturing breed

Economic performance 2017

The Derrypatrick herd gross margin for 2017 was €1285/ha compared to €1054/ha in 2016. Despite purchasing 18 in-calf cows (to replace 18 cows not in-calf in 2016), gross output was higher in 2017 than 2016 aided by a positive inventory change in cow numbers. In comparison to 2016, fertiliser costs were €65/ha greater and purchased feed costs were €146/ha lower, resulting in overall direct costs being €59/ha lower in 2017. Increased fertiliser costs were due to investment in soil fertility by using more compound fertiliser. Lower feed costs were due to shorter finishing periods for cull cows, heifers and steers.



Technology Village

Feeding / Meat Quality

Securing enough quality grass silage for beef production systems

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Summary

- Grass silage less than 68% dry matter digestibility (DMD) is suitable only for dry suckler cows in good body condition.
- To achieve good performance on silage-based diets, growing/finishing cattle and lactating suckler cows require silage of at least 72% DMD.
- Consider grass silage 'quality' (DMD) and quantity together in feed plans.
- Delaying first-cut silage until mid-June to achieve one bulky crop has become common practice; however, this often leads to poor digestibility first-cut silage, and much-reduced second-cut yields.
- Soil fertility, reseeded swards, tight grazing pre-closing, correct nitrogen (N) fertiliser application, and cutting at the correct growth stage, are the key elements to maximizing silage quality and quantity across the season.

Introduction

Grass silage accounts for up to 25-30% of total feed dry matter (DM) consumed on a typical drystock farm. As a standalone feed it can be quite expensive to produce (€130 to €170 per tonne DM); however, when used as part of an integrated grazing system, well-managed grass silage is competitive relative to concentrates and alternative forages. In recent years, difficult spring weather conditions have highlighted the importance of having adequate reserves of quality silage on hand. To achieve this, flexibility in grass management is required, along with good knowledge of both grass growth capacity and feed demand on the farm. The principal challenge for beef producers is to balance the dual objectives of having an adequate supply of silage while also 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 for first-cut silage are 4.8 t DM/ha and (up to) 6.2 t DM/ha for swards harvested in mid-May and early-June, respectively.
2. *Appropriate feed quality* for the class 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% of nitrogen), and lactic acid (target over 8% of DM) content. High DMD (leafy) swards can be well-preserved with good management.

First-cut silage: Does quantity rule over quality?

Grass DM yield at harvest remains the single most important factor determining the cost per tonne of silage in the pit. Fixed costs per hectare (e.g. land charges, contractor 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. In addition, the drive to secure adequate feed stocks for winter has meant that many beef farms have largely abandoned any consideration of feed quality when planning first-cut silage crops. This is borne out by results of grass silage analysis for Teagasc beef clients over recent years (2012-17), which consistently show average DMD in the 64-67% range. Dry suckler cows can be adequately fed on 67-68% DMD grass silage. However, for growing/finishing cattle (and suckler cows in early lactation) the target is to have silage at 72-74% DMD or higher. This is illustrated very well by results of a study carried out at Teagasc Grange, where a good quality 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 gains were 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 live weight gain. In fact, it took less than half the amount of silage DM to achieve 1 kg carcass gain with the 75% compared to the 60% DMD silage.

Table 1. Effect of silage quality on silage intake and daily weight gain in growing cattle

DMD %	First-cut silage quality			
	75	70	65	60
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 (DM intake/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. Ironically, 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 during the subsequent grazing season to achieve a target carcass weight, which reduces the area available for silage cutting.

A valid concern with targeting quality silage for first-cut is potential reduction in silage yield, which may contribute to silage shortages later. On this point, it is vital to consider the yield of forage DM across the year as a whole, not just from a single-cut. Figure 1 shows the effect of different first-cut dates on total grass silage DM and forage energy (UFL) yield per ha, in a two-cut system with a fixed second-cut harvest date in late July.

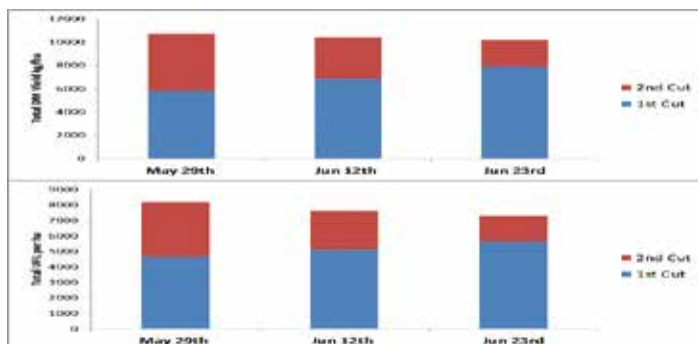


Figure 1. Effect of first-cut harvestdate on silage DM and UFL yield in a 2-cut system

There was no advantage in total DM production to delaying first-cut due to poor yield at second harvest. In addition, first-cut silage was lower in DMD and not suitable for growing cattle or lactating suckler cows. Delaying second-cut further for the later first-cut swards would have reduced availability of autumn after-grass and negated any silage yield benefit. In fact, many farms who delayed first-cut silage in 2017 experienced great difficulty in salvaging second-cut crops in late-August and September; this contributed to the silage shortage issue. Low soil fertility may exacerbate this problem due to slower recovery and increased delay to second-cuts. From a cost-perspective, delaying first-cut would not result in significant dilution of land charge (due to similar total DM yield per ha), while contractor costs would be similar (particularly on a bale silage system). Management decisions around first-cut silage yield should therefore be made on the basis of meeting DMD targets and improving annual grass tonnage per hectare, rather than focussing solely on the bulk of an individual cut.

Finding the right balance between yield and quality

While growing cattle require grass 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. It is clear that beef farms with a mix of stock types (e.g. dry suckler cows, weanlings and finishing cattle) must plan for making silage of varying DMD. Differences in silage DMD can be created by varying the cutting date within a well-managed grass sward. High DMD silage is produced by cutting in mid-May when grass has high leaf content, while lower DMD silage is produced by delaying harvesting 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 and 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, spring-calving suckler calf-to-beef farms may take an early-cut of high-DMD silage in mid-May on 40-50% of the silage area for feeding to weanlings and finishing cattle, with the remainder of the first-cut taken in early-June (67-68% DMD) for feeding to dry cows.

Management guidelines for cost-effective grass silage production

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 (<4.5cm) with young stock in late-autumn. Swards with yellow/dead material at the base must be grazed off, otherwise silage DMD may be reduced by up to 6-7 percentage points. Re-seeded swards should be grazed at least twice before closing for silage.

Fertiliser plan: The first step to improving silage yield and quality on most beef farms is to take soil samples and develop a field-by-field fertiliser plan based on the phosphorus (P), potassium (K) and lime requirements (Table 2). Treat P and K separately as silage fields may

be adequate for one nutrient but lacking in the other. Reduce N application rate by 20 to 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 application for 3 to 4 months before silage cutting as it may adversely affect silage fermentation.

Table 2. 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)			

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 fertiliser N application and closing is important. A useful rule-of-thumb 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.

Achieving good preservation: Good preservation occurs when bacteria present on the grass crop ferment available sugars to lactic acid. This causes a decline in pH which preserves the value of the stored feed. High available sugars, low buffering capacity and air-free (anaerobic) conditions are necessary for achieving good preservation. Grass sugar 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 sugar readings are low. Under good ensiling conditions, there is no consistent benefit to using additives. 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% within 24 hours 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 left for more than 36 hours will lose sugars, and may become too dry (>40% DM) for pit silage if tedded out. There is no advantage to wilting beyond 32% DM.

Reseeding: Old permanent pasture is less responsive to fertiliser than perennial ryegrass, leading to delayed silage harvest and poorer DMD. Lower sugar content also makes preservation more difficult. The decision to reseed should be based on sward composition and yield potential. Silage ground should be reseeded every 8 to 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 will only be successful if soil fertility, weed control, and post-emergence management to promote tillering are adequate.

Managing DM losses: Reducing DM losses at ensiling and feed-out is often overlooked as a means of improving efficiency. These losses range from 15 to 30% of standing crop DM, which can significantly increase the requirement for purchased feed. The main sources of DM loss are poor aerobic stability, failure to seal and maintain pits/bales fully, and excessive exposure to air across the silage pit face.

Concentrate feeding and feed ingredients for growing-finishing cattle

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Summary

- Small improvements in feed efficiency, especially during indoor 'winter' feeding periods, can have a relatively large influence on farm profitability.
- Increasing the level of concentrates in the diet reduces forage intake and increases live weight and carcass weight gains, although at a diminishing rate.
- Subsequent compensatory growth at pasture diminishes the advantage of concentrate supplementation of young cattle.
- High digestibility grass silage with moderate concentrate supplementation can sustain a large proportion of the cattle performance achieved on high-concentrate diets.
- Feeding management is more important when feeding concentrates ad libitum than as a supplement.
- The relative nutritive (and economic) value of by-product feed ingredients depends on their inclusion level in the ration, and the amount of concentrates fed.

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. Due to the considerably lower comparative cost of grazed grass as a feedstuff, beef production systems should aim to increase animal output from grazed pasture. However, the seasonality of grass growth and inclement grazing conditions means that an indoor 'winter' period, of varying duration, is inevitable on all Irish farms and the main feed costs on beef farms relate to this period, and especially when feeding finishing cattle. For example, even in grass-based, suckler calf-to-steer beef systems on research farms, grazed grass, grass silage and concentrate account for 65%, 27% and 8%, respectively, of feed dry matter (DM) intake annually. Yet when this feed consumption is expressed in terms of cost (land charge included), the outcome is very different: grazed grass, silage and concentrate account for 44%, 39% and 17% of the total annual feed costs, respectively (see Figure 1).

Annual Feed Budgets (/cow unit)

Suckler calf-to-beef system: 24 mth steer

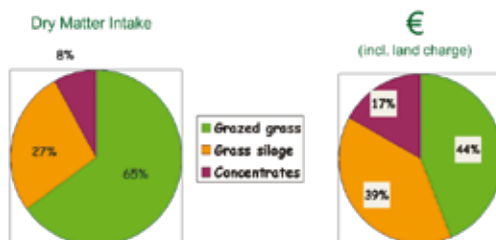


Figure 1. Annual feed budget for a grass-based suckler calf-to-beef steer system expressed on a DM intake and cost-basis

Clearly, in other production systems, such as weanling-to-finish and 'winter-finishing', the proportional cost associated with concentrate feeding will be even higher. Consequently, enhanced feed-cost efficiency during the more expensive indoor feeding periods has a comparatively greater financial impact than during the grazing season. Economic and environmental sustainability of beef production systems therefore depends on optimising the contribution of grazed grass to the lifetime intake of feed, and on providing silage and concentrate as efficiently and at as low a cost as feasible.

Feeding concentrates: Key principles

The role of concentrates is to make up the deficit in nutrient supply from forages in order for cattle to 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) values on a 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 influencing the nutritive value of forage and consequently, the performance of forage-cattle. Low DMD forage means that higher levels of concentrate supplementation have to be used to achieve the same growth rate or performance (Table 1).
- Increasing the level of concentrates in the diet reduces forage intake ("substitution") and increases live and carcass weight gains, although at a diminishing rate.
- Animal production response to concentrate supplementation is higher with forages of lower DMD.
- 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 the older, lighter, slower-growing Holstein-Friesian steers 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.
- Animal response to concentrate supplementation at pasture primarily depends on the availability and quality of pasture and level of supplementation.
- Increasing the level of concentrate supplementation reduces the importance of forage nutritional value, especially when feeding concentrates *ad libitum* (to appetite).
- 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.

Concentrate feeding: Indoors

Weanling Cattle:

To minimise feed costs and exploit subsequent compensatory ("catch-up") growth at pasture during the following grazing season, a live weight gain of 0.5-0.6 kg/day through the first winter is acceptable for steers, heifers (and suckler bulls). Due to compensatory growth, there is little point in over-feeding weanlings during the first winter. However, cattle growing too slowly (<0.5kg/day) during winter will not reach target weights. This target animal performance level can be achieved on grass silage supplemented with concentrates as outlined in Table 1.

Finishing Cattle:

Efficiency of feed utilisation by finishing cattle primarily depends on weight of 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 finishing period. 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 1 unit decline in DMD of grass silage requires an additional ~0.33 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, for finishing heifers (lower growth potential) daily supplementation 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.

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.

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

Concentrate feed ingredients

Although cereals (barley, maize, wheat and to a much less extent, oats) usually predominate, by-product feeds, also known as co-products, are widely available and used extensively in beef rations. They are secondary products mainly from the food processing industry and the biofuel/ethanol industry. Key by-products include soya hulls, corn gluten feed, maize dried distillers grains, wheat dried distillers grains, palm kernel expeller meal and citrus pulp. By-products generally have little value as a foodstuff for humans, but many are suitable as a feed for cattle due to the ability of cattle to digest fibrous, plant cell-wall material. Indoor feed costs could be reduced through utilisation of alternative, 'cheaper' concentrate feed ingredients in beef rations. 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 is liable to change over time as the primary manufacturing processes evolve and become more efficient. This means that periodic re-evaluation of the nutritive value of by-products is required for accurate formulation of rations for beef cattle.

In this context, a series of recent DAFM-funded experiments carried out at Teagasc Grange, has evaluated a number of key cereal and by-product feed ingredients in beef cattle diets. The 'control' concentrate offered in all these studies was a barley/soyabean meal-based ration (ca. 862g rolled barley, 60g soya bean meal, 50g molasses, 28g minerals and vitamins/kg); all other rations were compared against this. The optimum inclusion level of a number of by-product feeds was evaluated by replacing rolled barley (and some, or all, of the soyabean meal

depending on the protein content of the test feed ingredient) in the ration. All concentrates were prepared as coarse mixtures. Key findings are as follows:

- Carcass weight was heavier and feed efficiency was better in bulls offered a high-concentrate diet where half of the rolled barley in the control ration was replaced with *maize meal*, but not *flaked-toasted maize*; maize inclusion in the ration did not enhance carcass fat deposition.
- Rolled *oats* can replace rolled barley in a concentrate supplement (ca. 5.0 kg/day) to high-digestibility grass silage without negatively affecting performance of finishing beef cattle; feeding oats had no effect on carcass fat score.
- For growing 'weanling' cattle, *soya hulls* and *citrus pulp* can replace rolled barley in concentrate rations offered at relatively low levels (ca. 2 kg/day), as a supplement to high digestibility grass silage, without negatively affecting performance.
- For finishing cattle diets, *citrus pulp* can replace rolled barley in the ration at inclusion rates up to 400g/kg without negatively affecting performance when offered ca. 5.0 kg concentrate/day as a supplement to high-digestibility (ca. 75% DMD) grass silage.
- For growing cattle offered ca. 3.5 kg/day of concentrate as a supplement to moderate digestibility grass (ca. 65% DMD) silage, and finishing cattle offered ad libitum concentrates, the optimum inclusion level of *soya hulls* in a barley-based concentrate was ca. 200g/kg.
- Dried *corn gluten feed* had a feeding value comparable to that of rolled barley/soya bean meal when offered as a supplement (ca. 5.0 kg/day) to high-digestibility grass silage.
- *Maize dried distillers grains* had a superior feeding value (based on dietary feed conversion ratio) to *wheat dried distillers grains* when the ration was offered as a supplement (3.5 kg/day) to grass silage or ad libitum. The optimal inclusion level of maize and wheat dried distillers grains in the concentrate was about 800g/kg when the concentrate ration was offered as a supplement to moderate-digestibility grass silage and, about 400g/kg for maize, and 200g/kg for wheat, dried distillers when the ration was offered ad libitum.
- *Palm kernel expeller meal* can be included in a barley-based concentrate at up to 400 g/kg when offered as a supplement to moderate digestibility grass silage and up to 100 g/kg when offered ad libitum.

Overall it is concluded that, due to 'associative effects', the relative nutritive (and economic) value of by-product feed ingredients depends on concentrate feeding practices; i.e. inclusion level in the ration; whether the ration is offered as a supplement to grass silage or to appetite with restricted grass silage.

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, recent research at Grange showed a significant, but small, response to protein supplementation. However, all 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, especially weanling cattle.

Concentrate feeding: Grazing

Studies at Teagasc, Grange have shown that at adequate (ca. 20 g DM/kg live weight) grass allowances in autumn, feeding ca. 0.50 to 0.75 kg of concentrate ration per 100 kg live weight resulted in carcass growth responses in steers between 30 and 110 g carcass per kg concentrate. The low growth response to supplementation was associated with grazing very high nutritive value grass herbage. Recent Grange research has shown that concentrate supplementation is a strategy for 'pasture-finishing' (achieving adequate carcass fat score) of cattle in autumn, especially late-maturing breed types.

Grass-based suckler weanling-to-beef production systems

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Summary

- Target age at slaughter and carcass weight for suckler-bred animals should be 24 months and 400 kg for steers, and 22 months and 310 kg for heifers.
- For weanling cattle returning to pasture, target first-winter daily live weight gain is 0.5 to 0.7 kg.
- The economics of concentrate supplementation at pasture are questionable, especially where good grassland management is practiced.
- Bulls have better production efficiencies than comparable steers.
- In *grass/grass silage-only* systems, late-maturing breed type steers need a short 'third' grazing season to be adequately 'finished'; early-maturing breed types can be slaughtered at ca. 20 months of age from pasture when grazing conditions are good.

Introduction

The typical suckler cow in Ireland is a late-maturing crossbred with Limousin, Charolais and Simmental breeds dominant in the breed makeup. Likewise, late-maturing breed terminal sires predominate in the suckler herd with the resulting progeny having well-conformed, lean carcasses suitable for many EU beef markets. Suckler herd progeny account for almost half of the national beef kill. The national suckler herd is generally spring-calving, coinciding with the beginning of the grass growing season. Nationally, most suckler calves are traded after weaning. As grazed pastures are invariably the cheapest feed resource for livestock production, attention has focused on ways of improving animal performance at pasture, and maximising grass utilisation, either grazed or conserved (grass silage), within suckler beef systems. In this context, recent research at Teagasc Grange evaluating suckler weanling-to-beef production systems is summarised below.

Targets for suckler beef progeny

Nationally, average steer slaughter age is approximately 28 months. For suckler bred-cattle, steer progeny from late-maturing breed suckler cows bred to late-maturing sire breeds were one-month older (i.e. 29 months) at slaughter, but had carcasses which were 43 kg heavier, than progeny from cows bred to early-maturing breed sires. Likewise, progeny from early-maturing breed suckler cows, whether bred to early- or late-maturing breed sires had a similar slaughter age (29 months), but carcasses of progeny from late-maturing breed sires were 44 kg heavier than those from early-maturing breed sires.

In integrated spring-calving suckler calf-to-beef systems, as operate in the Derrypatrick Herd at Grange, steers are typically slaughtered at under-24 months of age. In such systems progeny spend the first season at pasture with their dam, are weaned in the autumn, and housed for a first-winter 'store' period. During this time they are fed high 'quality' (dry matter

digestibility, DMD) grass silage *ad libitum* and supplemented with 1 to 2 kg concentrates/head/day. They (yearlings) return to pasture for a second grazing season and, in the case of steers, are housed for finishing - grass silage supplemented with 4 to 5 kg of concentrates per head daily - to slaughter at about 24 months of age. In the case of heifer progeny, the finishing diet may be offered indoors i.e. grass silage supplemented with 3 to 4 concentrates per head daily or, depending on grass supply and grazing conditions, heifers may remain at pasture and receive the same concentrate supplementation; in both situations the slaughter age is ca. 20 months of age. In the production systems described, target carcass weights are 400 kg and 310 kg, for steers and heifers, respectively.

Optimising first-winter growth performance

A number of studies using suckler (and dairy) beef weanlings have been conducted at Grange to assess the effects of weanling winter growth rates on subsequent performance at pasture and during finishing. In a recent study, spring-born late-maturing breed weaned suckled bulls were offered grass silage *ad libitum* (DMD 731 g/kg) and either 2, 4 or 6 kg concentrates daily. At the end of winter, bulls were turned out to pasture for ~100 days. At turn out, animals supplemented with 4 kg concentrates were 26 kg heavier, while those supplemented with 6 kg concentrates were 65 kg heavier than those that received 2 kg concentrates. At pasture, average daily live weight gain was greatest for animals that received 2 kg concentrates during the winter, lowest for animals which received the 6 kg concentrates, with the 4 kg concentrates group being intermediate (i.e. compensatory growth occurred). At housing, there was no difference in live weight between the 2 and 4 kg concentrates supplemented groups but the 6 kg concentrates group was still 32 kg heavier giving a live weight response (relative to 2 kg concentrates) of ~15:1. When slaughtered after a 100 day finishing period during which they were offered a high-concentrate diet *ad libitum*, there were no significant differences in carcass weight, kill-out proportion, or carcass fat score. These data for suckler-bred bulls confirm data for steers and heifers that where it is planned to return weanling cattle to pasture after the first-winter (or 'store' period), due to subsequent compensatory growth, the optimum winter daily live weight gain is 0.5 to 0.7 kg.

Performance at pasture and concentrate supplementation

A study was undertaken where, after the first indoor-winter store period, suckler yearlings were returned to pasture for 100 days and offered either zero, 2.7 kg or 5.3 kg concentrates/head/day. At the end of the grazing period animals were housed and finished on an *ad libitum* barley-based concentrate diet. After 100 days at pasture, the animals that received zero concentrates were 17 kg and 36 kg lighter than the groups that received 2.7 kg and 5.3 kg, respectively. During the finishing phase, highest growth rates were seen in the animals that were unsupplemented at pasture (i.e. compensatory growth was again observed). At slaughter, no significant differences were observed for carcass weight, slaughter weight, kill-out proportions, carcass conformation and fat scores.

In a further study, 17-month old autumn-born bulls (554 kg live weight) were turned out to pasture in spring and for 90 days received a daily supplement of either, zero, 3 kg or 6 kg concentrate per head before slaughter. The corresponding live weight gains were 0.90, 1.02 and 1.10 kg/day. Feeding 270 kg of concentrates (3 kg/day for 90 days) resulted in no additional carcass weight (367 vs. 367 kg). Where 540 kg of concentrates were fed (i.e. 6 kg/day for 90 days), an additional 20 kg of carcass (387 kg) was achieved compared with the pasture-only animals. Carcass fatness was only marginally improved by concentrates

supplementation. It is concluded, based on the conditions of these experiments, that the economics of concentrate supplementation at pasture are marginal. Other studies have drawn broadly similar conclusions.

Some markets require bulls to be under-16 months of age at slaughter. When spring-born suckler-bred yearling bulls were returned to pasture after the first indoor-winter store period and slaughtered at 16 months of age, they failed to meet the carcass fatness specification, even when offered 5 kg of supplementary concentrates per head daily whilst grazing. Comparable animals indoors, offered an *ad libitum* high-concentrate diet or grass silage *ad libitum* and 5 kg concentrates daily achieved the carcass fatness specification suggesting that grazing is not an option for this production system.

Bulls and steers compared

When bulls and steers of similar breed and age, reared under similar management and offered the same diet and slaughtered at the same age are compared, on average, live weight gain is higher (8-10%), carcass weight is heavier (10-15%), feed conversion efficiency is better (10-15%) and lean meat yield is greater (20%) for bulls than steers, and invariably bulls have higher carcass conformation and lower fat scores. Differences in favour of bulls are generally more pronounced at higher feeding/feed energy levels and with increasing slaughter weight. In a recent study at Grange, weaned spring-born late-maturing breed suckler bulls and steers *ca.* 8 months old (363 kg at start) were compared in two contrasting production systems. Animals were offered grass silage *ad libitum* plus 3 kg concentrate daily for the first winter, targeting a growth rate of $\sim$ *ca.* 0.6 to 0.7 kg live weight/day. At the end of the 127 day first-winter one group of bulls and one group of steers remained indoors and were offered *ad libitum* concentrates, while another group of bulls and another group of steers were turned out to pasture for 98 days and then finished on an *ad libitum* barley-based concentrate diet. Animals were slaughtered at 19 months of age. Apart from live weight at the end of the first winter, where bulls were only marginally ahead of the steers, and fatness at slaughter, where steers were fatter, bulls significantly out-performed steers for all other variables measured. At pasture, bulls grew at *ca.* 0.2 kg live weight gain per day faster than steers, and had a similar advantage when finishing indoors. On the 15-point scale, bulls were one score leaner and one score better in conformation than steers.

Grass-fed beef

Developing beef production systems based on *grass-only* where high-nutritive value grass, either grazed or conserved, is used (no concentrates) should reduce production costs. However, a key challenge is 'finishing' late-maturing breeds of cattle on grass forage-only diets, and achieving the carcass fat score required by some markets. The performance, growth and carcass characteristics of suckler-bred early- and late-maturing steers on contrasting grass-forage weaning-to-beef production systems was evaluated. Spring-born early-maturing breed (Aberdeen Angus and Hereford sired) and late-maturing breed (Limousin sired) weaned suckler-bred steers were used. Three groups of each maturity type were assigned to grass silage only for the indoor winter, followed by 182 days at pasture and either (i) slaughtered at 21 months of age, (ii) re-housed after 182 days, offered grass only silage for the winter and slaughtered at 24 months of age (iii) or re-housed after 182 days, offered grass only silage for the winter, turned out to pasture followed by 110 days at pasture and slaughtered at 28 months of age). A fourth group of each 'maturity' type was offered grass silage plus 1 kg concentrates per head daily for the winter, then 182 days at pasture, re-housed and offered

grass silage plus 4 kg concentrate daily and slaughtered at 24 months of age. When finishing as *grass-only* fed beef, late-maturing steers had heavier carcasses (+16 kg on average), a higher kill-out proportion (+2 to 3%) and better carcass conformation score (+1.5 to 2.0 units on the 15-point scale) but lower carcass fat scores (1.5 to 2.0 units on the 15-point scale) than early-maturing steers. However, when aiming to slaughter at 20 months of age on *grass-only* diets the late-maturing breed steers were under-finished, whereas the early-maturing breed steers were marginally finished in terms of carcass fatness (average carcass fat score of 2- and 2+, respectively). On the *grass-only* system (no concentrates) when slaughtered at 24 months of age, the late-maturing breed steers were marginally finished, but the early-maturing steers were considered finished (carcass fat score of 2+ and 3=, respectively). When returned to pasture for part of a 'third' grazing season and slaughtered at 28 months of age (*grass-only* system), late-maturing steers achieved an average carcass fatness score of 3=, whereas the early-maturing steers had a fat score of 4-. In contrast, when fed concentrates and slaughtered at 24 months of age, late-maturing steers were adequately finished (~3=) and early-maturing animals were over-fat (~4-). Thus, it is challenging to finish late-maturing steers at a younger age on *grass-only* diets; it is likely that they will need a short (100 days) 'third' season at pasture to achieve adequate carcass fatness. Early-maturing steers could be slaughtered at 20 and 24 months of age on a *grass-only* diet.



Genomic selection for compensatory growth in beef cattle

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Summary

- Feed provision is the single largest variable cost within beef cattle production; therefore, methods of reducing this cost are fundamental to profitability.
- By 'storing' cattle when feed costs are high (i.e. over winter), cattle can undergo compensatory growth when subsequently offered unrestricted access to high quality feed (i.e. at pasture); allowing for a reduction in overall feed costs.
- Recent research at Teagasc Grange has shown that there is variation in the compensatory growth response between individual animals and key genes that are contributing to compensatory growth in beef cattle have also been identified.
- Current research at Teagasc Grange is focussed on evaluating these genes for genetic biomarkers, which could be used to select for cattle with an enhanced ability to display compensatory growth, and thus increase profitability of beef production.
- Genetic biomarkers identified will be added to the International Dairy Beef SNP-chip and implemented in future breeding program strategies, which will be readily exploitable by Irish beef farmers as a method to reduce feed costs.

Introduction

In beef production systems, provision of feed accounts for up to 75% of the total direct costs; therefore, any method by which these costs may be reduced would enhance farm profitability. Through the incorporation of compensatory (or accelerated / 'catch-up') growth into beef production systems, feed costs may be reduced through a reduction in the energy content of feed offered to beef cattle particularly during the winter months. Compensatory growth is a naturally occurring process, whereby following a period of reduced energy intake (i.e. over winter), cattle have the potential to undergo accelerated growth and display enhanced feed efficiency when subsequently offered unrestricted access to high quality feed (i.e. pasture; Figure 1). The naturally occurring compensatory growth process is commonly observed across a number of different species, including cattle, and has likely evolved as a method of coping with alternating feed supply. Studies at Teagasc Grange have shown that a moderate dietary energy restriction followed by compensatory growth can increase net margins by up to €100 per animal in beef production systems. While this practice of 'storing' cattle over winter, prior to turn-out to pasture in spring, has been practiced for generations in Ireland, clear variation in the growth response between individual animals is evident. Through a greater understanding of the biological regulation of compensatory growth, genetic biomarkers may be identified and subsequently used through genomic selection breeding programs for the selection of animals with a greater ability to display compensatory growth. Identification

and subsequent breeding of beef cattle with superior compensatory growth potential will allow for a reduction in feed input costs and consequently an increase in beef production profitability.

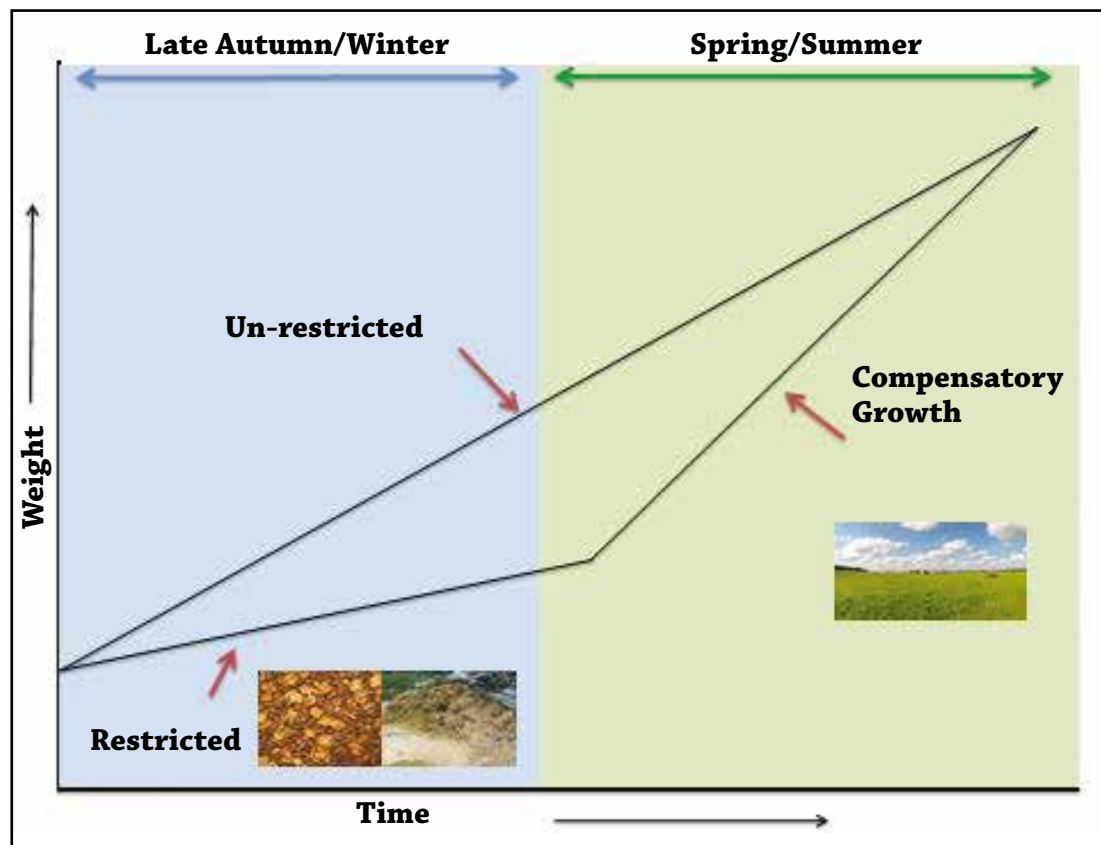


Figure 1. Schematic graph of compensatory growth feeding regime.

Factors affecting the compensatory growth response

The objective of utilising compensatory growth is to keep feed costs as low as possible during winter and exploit compensatory growth at pasture during the following grazing season. Compensatory growth occurs when animals have a plentiful supply of high quality feed (usually grass) available after a period of restricted energy intake or restricted growth. This allows animals that received a limited diet over the winter to gain weight rapidly in spring and early summer. The success of a compensatory growth response may be evaluated through the 'compensatory growth index', which can be calculated as the ratio between growth rate during compensatory growth and that during the restricted growth phase, with larger values indicating a superior compensatory growth response. However, a number of factors can affect successful compensatory growth responses. Some of the most important factors are related to the severity and duration of the period of restricted growth as well as the diet offered to cattle during restricted growth and subsequent re-feeding. A restriction in growth that is moderate results in a better compensatory growth response. For example, data from

Teagasc have shown that a target average daily gain of 0.5 to 0.6 kg for heifers and steers during a period of restricted growth is sufficient to elicit an optimal compensatory growth response. This is in comparison to a more severe restriction on growth rate, where results have shown that stock gaining less than 0.25 kg/day will not be able to compensate sufficiently at pasture, consequently severe growth restrictions are not recommended. It is important that good quality feed is available during both restricted and compensatory growth phases. To achieve the growth targets during the 'restricted' winter period, meal supplementation rate is dependent on silage digestibility, with less concentrates required when high digestibility silage is available. To maximise the level of compensatory growth achieved at pasture, sufficient high digestibility grass must be provided during the grazing period. The length of both winter and grazing periods will also determine the level of compensatory growth achieved. During shorter winter periods and subsequent longer grazing season there is greater potential for compensatory growth, with the opposite outcome apparent during longer winter periods. Additionally the age and stage of development of the animal during the under-nutrition phase is important, as cattle on a restricted growth path at a young age (less than 6 months) may consequently show impaired growth potential, consequently a restricted growth path is not recommended for such young cattle.

Biological processes contributing to compensatory growth

Research conducted at Teagasc Grange has shown that compensatory growth is a multifaceted process, under the control of many biological processes. These include appetite; digestion, absorption and metabolism of feed consumed; nutrient uptake and partitioning; alterations to metabolic rate; cellular functionality and energetics as well as susceptibility to cellular stress. Our research has shown that during the 're-feeding' and compensatory growth phase, following a period of reduced energy intake, cattle have an increased appetite i.e. consume more per unit of body-weight, compared to animals that were never restricted in dietary energy intake. This increase in appetite is more than likely an evolutionary mechanism which allows for greater feed intake than what is actually required, thus permitting the build-up of body energy (fat) reserves, should another period of under-nutrition occur. The gastrointestinal tract has been shown to be very responsive to both dietary restriction and subsequent re-feeding. Increased digestibility of feed apparent during compensatory growth, may be due to alterations in the size and physical structure of the gastrointestinal tract and may contribute to compensatory growth through enhanced nutrient absorption from the feed consumed. Our data have also demonstrated that cattle undergoing compensatory growth have a greater diversity of microbial populations residing within the rumen which are responsible for the digestion of feed. Such an increase in diversity leads to greater digestion and more efficient utilisation of feed, resulting in less waste of nutrients from the diet. This is also highlighted through the increase in cellular metabolism in cattle undergoing compensatory growth. The increase in cellular metabolism during re-feeding and compensatory growth may be necessary for the animal to cope with the greater dietary intake observed and required for complete metabolism of ingested feed. A period of reduced energy intake may also provoke changes to an animal's maintenance energy requirements. Such alterations include reductions in the size of tissues or organs that require a large proportion of energy, meaning that during the compensatory growth phase, more energy from feed can be used for growth as opposed to body maintenance requirements. We have also observed greater cellular activity in animals undergoing compensatory growth, which allow for the enhanced growth. Results also show that there is an enhanced response towards cellular survival and preventing cellular stress in

cattle undergoing compensatory growth, which again allows for energy from the diet to be used for growth purposes as opposed to maintaining a stress response within the cell. Multiple studies conducted by our group have shown increased skeletal muscle tissue deposition during compensatory growth, particularly during the early part of re-feeding. Collectively, alterations to appetite, digestibility and metabolism, rumen microbial populations, maintenance energy requirements, cellular activity and survival during re-feeding contribute to an improvement in feed efficiency in cattle undergoing compensatory growth.

Current research on compensatory growth in beef cattle

From research conducted at Teagasc Grange, we have observed a clear biological control for the phenomenon of compensatory growth. Additionally, a number of genes have been identified as being central to this naturally occurring phenomenon. However, there are currently no breeding values associated with compensatory growth potential in cattle. On-going research by our group, funded by Science Foundation Ireland, is aimed at identifying DNA-based biomarkers associated with greater compensatory growth potential. Following validation, genetic biomarkers could be applied through genomic selection breeding programs to identify cattle with a greater ability to undergo compensatory growth. Biomarkers which are associated with compensatory growth would provide information on a young calf's ability to undergo compensatory growth in later life using their DNA profile alone. Potential genetic biomarkers within the genes identified as important to compensatory growth are now being validated through a large on-farm study. As part of that study, compensatory growth responses from Irish (1013 Holstein-Friesian bulls) and Canadian (1510 Angus bulls, heifers and steers) cattle have been recorded through consecutive weighing and measuring of average daily gain during a dietary restriction or 'storing' period and then also during a re-feeding compensatory growth period. The compensatory growth index, defined above, was determined for all animals used. When evaluating the compensatory growth response (through the compensatory growth index), as expected, there was large variability in compensatory growth response between animals used within each herd as well as across individual herds. This result suggests genetic control over the compensatory growth phenomenon. Blood samples for DNA isolation were also collected from all animals used. Using the compensatory growth index as a measure, individual animal DNA profiles will be evaluated for genetic biomarkers associated with enhanced compensatory growth potential. This will facilitate the identification of a panel of genetic biomarkers associated with enhanced compensatory growth response. The panel of genetic biomarkers will be retained on the International Dairy Beef Genotyping SNP-chip and implemented in future breeding programs allowing for the selection and propagation of genetically superior animals for their ability to display compensatory growth and thus reduce feed costs.

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On-farm influences on the eating quality of beef

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Summary

- Eating quality (tenderness, juiciness, 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 breeds in tenderness or overall consumer acceptability of meat.
- Based on current evidence, increasing age at slaughter (up to 22 months at least) does not negatively influence the tenderness of suckler or dairy bull beef but the type of production system may have a small effect.
- In general, producers can choose the most cost-effective feed ingredients for beef cattle rations without having a commercially-important effect on beef eating quality.

Introduction

As more than 85% of beef produced in Ireland is exported there are a myriad of markets and consumers for Irish beef. Each consumer group may therefore have a different characterisation of beef meat quality. Within the broad definition of beef meat quality, which includes appearance, shelf-life and nutritional composition, the satisfaction which consumers derive from eating beef is particularly important in ensuring its continued purchase. 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 meat 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 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 on 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 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 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 tenderness 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, and they had similar intramuscular fatness.

Age: The age at which an animal, particularly a bull, is slaughtered is of current interest specifically with regard to beef tenderness and overall acceptability. 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 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.

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 (Gender) 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 v. 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	*	*

¹NS= not significant, * = $P < 0.05$, *** = $P < 0.001$; ³Scale: 1=least, 8 = most

Ration composition effects on the eating quality of beef

It is important to note that 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. Indeed, 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.

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 was examined in Grange. In general, subcutaneous fat from grass-fed cattle was more yellow than from similar cattle fed concentrates but there was little difference in the effect of concentrate-based rations or grazed grass *per se* on muscle colour. In the most recent study, 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 (260 kg). 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 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.

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

¹NS= not significant, * = $P < 0.05$; ²Scale: 1 = least, 100 = most.

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 diet 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	Ingredient						Sig ¹
	Barley	Corn Gluten	Citrus Pulp	Maize Distillers	Wheat Distillers	Oats	
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	*

¹Sig = significance, NS= not significant, * = $P < 0.05$, ** = $P < 0.01$

²Scale: 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

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Breeding for superior beef meat eating quality

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Summary

- In Ireland 9 to 16% of the variation in tenderness, flavour and juiciness of beef meat is due to animal genetics.
- Large variability in genetic merit exists among beef sires for tenderness meaning that the progeny of some sires will, on average, have more tender meat than progeny from other sires.
- Following a blind consumer test at BEEF2016, 75 out of 101 consumers preferred the meat from a higher genetic merit animal for meat eating quality compared with meat from a lower genetic merit animal.

Introduction

Research has shown a consumers decision to select beef over other types of meat is strongly linked to its sensory properties of flavour and tenderness. For instance, a bad eating experience has been shown to have an adverse effect on consumer purchasing decisions for up to 3 months. With pork, chicken and lamb being the major competitors to beef meat consumption, it is paramount that beef is consistently of the highest eating quality. This is particularly true for Irish beef which is strongly branded internationally. Major advancements in meat eating quality have been made in recent years through processes within the farm gate as well as within the abattoir, including animal handling, slow chilling, hip hanging and the dry aging process. Despite improved control of these aspects of beef production, large variability in meat eating quality persists; genetics undoubtedly contributes to this variation.

The potential of breeding to increase meat quality

Individual animal performance differences are due to both management (e.g. nutrition) and underlying genetic effects. Genetic improvement is both cumulative and permanent implying that the performance of the animal for a particular trait is a function of the past decades of breeding, and improvements made in one generation can be further added to by successive generations. The proportion of the difference between individuals for a certain trait that is attributable to genetics is known as the *heritability* of that trait.

Data are routinely collected in Ireland on a range of performance traits including the carcass traits of weight, conformation and fat score. The collection of these data has facilitated the inclusion of these traits in the Euro-Star Terminal and Replacement Indexes, which in turn empowers farmers to select sires to produce progeny with more favourable carcass characteristics. Meat sensory data such as eating quality, however, are both more difficult and expensive to measure. As part of the Meat Technology Ireland initiative, sensory data are being collected on several thousand Irish cattle representing the genetics that have been

used in Ireland in recent years. Meat sensory-based assessments for tenderness, flavour and juiciness are now available on 2,456 young bulls, steers and heifers slaughtered from the years 2010 to 2018, inclusive. Two steaks were obtained from each animal at slaughter, aged for 14 days and then frozen prior to sensory analysis. Sensory analysis was undertaken by trained panellists. Samples were rated by panellists for tenderness, juiciness and beef flavour on 10 point scale. The scale was as follows: tenderness, 1 = very tough and 10 = very tender; juiciness, 1 = not juicy and 10 = very juicy; beef flavour, 1 = no beef flavour and 10 = very strong beef flavour.

Genetic variability exists in meat tenderness

The heritability of meat tenderness, flavour and juiciness is presented in Table 1. Meat tenderness has a heritability of 0.16, which means that 16% of the variability between animals in meat tenderness is due to genetics; thus implying the potential for breeding to improve the meat tenderness of the entire Irish cattle population.

Table 1. Heritability estimates for the three meat quality traits

	Heritability
Tenderness	0.16
Beef Flavour	0.10
Juiciness	0.09

Table 2. Correlations between the meat quality traits

	Tenderness	Beef Flavour
Beef Flavour	0.84	
Juiciness	0.88	0.87

The correlations between all the meat quality traits are strong (Table 2); this means that the traits are strongly related to each other and a change in one trait will result in a similar change in the other traits. Genetic merit for beef tenderness was estimated for all animals, and their ancestors, as is routinely done by the ICBF for national genetic evaluations. The mathematical methodology applied produces estimates of genetic merit for all animals and their pedigree irrespective of whether or not a meat sensory observation exists for that animal. The aim of the Meat Technology Ireland initiative is to collect meat sensory information on 20 progeny per sire; this would allow the genetic merit for meat quality of each sire to be estimated with a reliability of 67%. The distribution of genetic merit for meat tenderness for sires with $\geq 30\%$ reliability is shown in Figure 1. Large variation clearly exists in the genetic merit for meat tenderness among Irish sires, which means that the meat from the progeny of some sires is expected, on average, to be more tender (= higher positive breeding value) than the meat from the progeny of other sires (= lower negative breeding value), regardless of breed.

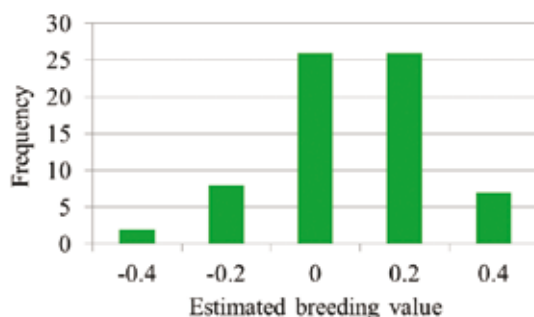


Figure 1. The distribution of genetic merit for tenderness for sires $\geq 30\%$ reliability

Validation of results

Two approaches exist to validate this research and ensure that the estimates of genetic merit can actually differentiate carcasses on meat quality.

Consumer validation of meat sensory analysis

Using a subset of the available sensory data at the time, a random 101 consumers at the Grange BEEF 2016 Open Day were invited to taste two steak samples from animals of the same breed; one steak from an animal that had an estimated genetic merit towards tender meat and one from an animal that had an estimated genetic merit towards tougher meat. Seventy-five of the 101 attendees of BEEF 2016 favoured the sample that was from the superior genetic merit animal (Table 3).

Table 3. Results from the ICBF consumer-tasting session at BEEF2016 Open Day

Pair	High genetic merit for tenderness		Low genetic merit for tenderness		Number of consumers selected "high"	
	Breed	EBV ¹	Breed	EBV	High EBV	Low EBV
1	BB	3.3	BB	-0.3	5	2
2	CH	3.6	CH	-3.2	6	1
3	CH	2.8	CH	-3.6	5	2
4	LM	2.9	LM	-4.0	7	0
5	LM	2.5	LM	-2.9	4	3
6	LM	2.2	LM	-5.6	6	1
7	SA	1.7	SA	-1.6	7	0
8	AA	2.3	AA	-2.4	7	0
9	BB	2.6	BB	0.0	3	4
10	CH	3.0	CH	-3.0	5	3
11	CH	2.2	CH	-0.1	3	4
12	LM	2.4	LM	-1.0	5	3
13	LM	2.2	LM	-0.1	6	2
14	SI	-0.2	SI	-6.7	6	1
Mean EBV		2.4	-2.5			
Total					75	26

¹EBV- genetic merit for tenderness

Prediction of progeny sensory performance

A second way to validate genetic evaluations for any trait, including sensory traits, is by predicting the genetic merit of an animal before slaughter (using pedigree and potentially the meat phenotypes of relatives), and then comparing the predicted genetic merit of these animals with the actual meat eating quality measured by a trained panel. The genetic merit for meat tenderness, flavour and juiciness of 107 animals was predicted from their ancestral information prior to the animals being slaughtered. Animals were subsequently divided into 4 genetic merit groups based on predicted meat tenderness, juiciness and flavour (very low, low, medium, and high); meat from animals in the very low genetic merit group was expected to be of the poorest quality and meat from the highest genetic merit group was expected to be the highest quality. After slaughter, two steaks taken from the striploin (*longissimus dorsi* muscle) were obtained from each animal and sensory analysis undertaken; the predicted sensory results from genetic analysis and measured sensory results were then compared.

The mean scores for each of the 3 sensory traits for the validation animals is presented in Table 4; the scores have been adjusted to account for environmental impacts that could influence the results, such as slaughter date and gender of the animal. Although the mean differences between the different genetic groups may seem small, the 10 point scale used in the sensory analysis ranges from 1 i.e., not tender (inedible) to 10 i.e., very tender (melt-in-the-mouth). However, the range of values for tenderness for the majority of animals ranged from approximately 5 to 8; therefore, a score difference of 0.36 between the very low and high genetic merit group for tenderness is a large (statistically significant) difference.

Table 4. Mean tenderness, beef flavour and juiciness scores of the validation animals divided into genetic merit groups based on the estimated quality of their meat. Meat quality is expected to improve as genetic merit increases.

	Genetic Merit	Mean tenderness score
Tenderness	Very low	6.69
	Low	6.88
	Medium	7.01
	High	7.05
Beef Flavour	Very low	6.39
	Low	6.39
	Medium	6.41
	High	6.44
Juiciness	Very low	6.40
	Low	6.38
	Medium	6.51
	High	6.49

Future work

The accuracy of genetic evaluations is a function of the number of animals included in the analysis. With a heritability of 0.16, achieving highly-reliable estimates of genetic merit for meat tenderness requires information on approximately 20 progeny per sire. As well as this, information on a large number of animals that are representative of the genetic diversity present is required to facilitate more intense selection. This means it will be possible to identify sires that excel not only in meat quality but also other attributes affecting profit. Furthermore, DNA samples (also known as *genomic* information) are being collected on all animals for which beef eating quality is being analysed. The potential addition of this genomic information into genetic evaluations in the future will allow for genetically superior animals to be more accurately identified, and as the DNA of an animal does not change throughout its lifetime these animals can be identified at a younger age. Using these technologies to aid breeding programmes and potentially breed for animals with higher meat quality will give Ireland's beef meat a distinct advantage in international markets.

Conclusion

Considerable genetic variation in meat eating quality traits exists among sires across breeds, which results in the meat from the progeny of some sires being, on average, of superior quality compared to the meat from the progeny of other sires. With more data, it will be possible to investigate the usefulness of including meat quality traits such as tenderness, flavour and juiciness into the genetic indexes to produce higher-quality meat from more profitable animals.



Technology Village

**Environment:
Being both
Competitive
and Sustainable**

SQUARE - the Soil Quality Assessment Research Project for Ireland

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Summary

- The SQUARE project is mainly concerned with understanding threats to soil structure, such as compaction but it is also driven by an even greater focus on the positive benefits and opportunities for sustainable soil management.
- Together with farmers, the aim is to develop field level tools to support sustainable soil management.
- Soil 'quality' is defined as "the capacity of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal production, maintain or enhance water and air quality and support human health and habitation".
- This multi-functional approach evaluates soil in terms of its ability to fulfil a bundle of functions, rather than traditional definitions that value soils solely for agricultural production.
- The three components of soil quality are biological, physical and chemical.

Introduction

Within Ireland, objectives to intensify agriculture are coupled with a demand to meet greening objectives of the Common Agricultural Policy. Thus, any intensification of agriculture must be achieved in a sustainable manner. SQUARE (Figure 1) is the Soil Quality Assessment Research Project for Ireland. Soil is a vital non-renewable resource that delivers multiple functions simultaneously including food and fibre production, nutrient retention and cycling, and filtration of water. The ability of the soil to deliver soil functions simultaneously is referred to as functional soil capacity.



Any impairment of soil quality affects the delivery of soil functions. Thus, SQUARE seeks to support the delivery of co-benefits achievable from the same soil resource. However, knowledge gaps exist in relation to both the threats and benefits of soil quality. In particular, soil structural quality is one major threat within Ireland. These knowledge gaps form the basis of the SQUARE research agenda.



Figure 1. SQUARE project site locations and multi stakeholder interaction through Ireland.

Why is soil structure so important?

Soil structure refers to the shape, size and development of soil structural units or ‘peds’. Soil structure is critical in determining the provision of nutrients, water and air in soil. There are numerous benefits of good soil structure from an agronomic and an environmental perspective. These include:

- Root support, water and air for the growth of food and fibre.
- Cycling of nutrients into plant-usable forms.
- Purification of water through the percolation process.
- Storage and cycling of carbon.

Project objectives

The specific objectives of the project are as follows:

- Evaluate the status of soil structural quality at a select number of sites across different land drainage types and agro-climatic regions.
- Assess impact of soil structural degradation on functional capacity of soil.
- Develop a toolbox appropriate at different scales to assess structural quality.

Development of a tool to examine soil structure

Visual Soil Examination and Evaluation (VSEE) techniques are procedures for visually and tactilely evaluating soil structure. Techniques have been designed to examine both the topsoil and subsoil, focusing on the impact of management on soil structural quality. Some procedures are semi-quantitative and include scoring frameworks, allowing visual assessments to be quantified. Despite their apparent simplicity, techniques have been found to closely correlate with a number of quantitative soil measurements. VSEE techniques are quick to conduct, have the ability to holistically examine soil structure while generating immediate results by

means of inexpensive and simple equipment - making them accessible to a range of users. VSEE techniques are therefore useful tools for both research and practical soil management.

A tool to assess soil structure (see photographs below of examples of good - Figure 2 A - and poor - Figure 2 B - soil structural quality) of a grassland field has been developed called *GrassVess*. This has now been published (Emmet-Booth et al. 2018) in the scientific journal *Soil Use and Management*, and the paper is available online at: <https://onlinelibrary.wiley.com/doi/full/10.1111/sum.12396>



Figure 2 A. A sample exhibiting good structural quality



Figure 2 B. A sample exhibiting poor structural quality

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Biodiversity on intensive grassland farms

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Summary

- Many of our best-known wildlife plants and animals are dependent on agricultural management.
- Wildlife measures designed and targeted for beef systems can play an important role in halting the decline of biodiversity and achieving the goals of sustainable expansion.
- The quality of existing farmland habitats should be maintained or enhanced before new biodiversity measures are established.
- New biodiversity measures could be targeted to less-productive areas of the farm.

Introduction

Agriculture is the dominant land use in Ireland and many of our best-known plants and animals are dependent on agricultural management. Changes in agricultural practices can therefore affect farmland wildlife. Intensification of agriculture over recent decades has resulted in a decline of biodiversity within agricultural systems throughout the world. Whilst there is a need to increase agricultural production to cope with increasing food demands, the environment and ecosystem services that agriculture provides need not be compromised. Emerging research and policy agendas are now based on sustainable management of agricultural land.

Grass-based farming systems in Ireland are well-positioned in terms of the wildlife they support within the landscape. It is estimated that natural and semi-natural habitats make up on average approximately 12 to 14% of the area of grassland farms. The amount of wildlife habitats is highest on more extensively-managed farmland, resulting in most focus to date being centred on sustaining and enhancing biodiversity within these extensive systems. Less is known about the habitats on more intensively-managed grassland systems. Although they have received less attention to date, intensively-managed systems can also play an important role in halting the decline of farmland biodiversity and providing associated ecosystem services such as clean water and clean air.

Objectives of the *Food Harvest 2020* and *Food Wise 2025* reports include the need for the development of effective methods for biodiversity conservation, as part of the development of sustainable production in both intensive and extensive systems. Incorporation of such measures could provide a very important and much overlooked branding and marketing opportunity to Irish farmers and retailers in terms of capitalising on Ireland's 'clean, green' image.

Biodiversity on intensively-managed beef farms

Teagasc undertook a study to assess the biodiversity on intensively-managed grassland and tillage farms across Ireland. In relation to intensively-managed beef farms (i.e. stocking rate >1.4 livestock units/ha), the habitats on thirty-eight farms were assessed as part of this study. Preliminary results suggest that approximately 9% of the land area on the surveyed beef farms was made up of natural and semi-natural habitats.

Table 1. Dominant habitats on intensively-managed beef farms in Ireland.

	Occurrence (%)	Average per ha per farm
Hedgerow	100	117 m
Buffer strips	92	19.5 m
Open drains	92	19.4 m
Field margins (>1m wide)	82	22.3 m
Field copse (plot <0.3 ha)	76	0.01 ha
Semi-natural woodland (plot >0.3 ha)	50	0.03 ha

Figures in Table 1 show that there are a number of dominant habitats which occur frequently on beef farms, many of which are important landscape features. Table 1 highlights the widespread occurrence of hedgerows on intensively-managed beef farms. There was an average of over 6 km of hedgerow per farm, ranging from 60 m/ha on the farm with the lowest cover, to over 229 m/ha on the farm with the highest cover. Additional landscape features such as buffer strips and open drains were also a regular feature, with an average of over 19.4 m/ha on intensive beef farms. The results also highlight the importance of habitats such as field margins, which occur frequently on intensively-managed farms, but are often overlooked by agri-environment policy in terms of their biodiversity value.

Measures to enhance biodiversity on beef farms

Teagasc results highlight that intensively-managed beef systems can also support a broad diversity and abundance of habitats and wildlife. However, although there was often a high abundance of habitats, occasionally the quality of some of these habitats, from a biodiversity point of view, was moderate-to-poor. There is a need for appropriately-designed wildlife measures, targeted for extensive and intensive systems, to improve the quality and increase the quantity of habitats on grassland farms. These measures can play an important role in halting the decline of biodiversity and achieving the goals of sustainable expansion. Such measures can also play an important role in delivering on other environmental goals such as improving water quality and reducing greenhouse gas emissions.

1. Maintain and manage existing habitats

There is a wide diversity of existing habitats in intensively-managed grassland farms. It is important to optimise the biodiversity value of existing farmland habitats before new biodiversity measures are established on grassland farms. It is typically more effective to retain existing habitats than establish new ones. Where possible, existing habitats, such as woodland plots, ponds and wetlands, should be protected from more intensive agricultural management; however, many of these semi-natural habitats are dependent on agricultural management, and thus benefit from farm practices that prevent the area from “scrubbing over”. For example, light grazing of woodland plots in spring and autumn can help improve the ‘quality’ of the area thus benefitting a variety of species. These areas should be appropriately managed and avoided when sites are being selected for ‘new’ biodiversity initiatives.

2. Hedgerow management

Hedgerows are the dominant habitat on intensive farms through-out Ireland (Table 1). Appropriately managed hedgerows can have multiple benefits, including providing shelter for stock and improving biosecurity; intercepting overland flow and improving water quality; sequestering carbon; and acting as a refuge for biodiversity. Hedgerows are also important in acting as wildlife corridors connecting various habitats with one another.

Ensure that appropriate management is undertaken outside the 'closed period' for hedgerow maintenance from March 1 to August 31.

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

3. Watercourses and buffer strips

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

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



Image 1. Mature hedgerow with a fenced field margin.

4. Field margins

Although a lot is known about field margins in arable systems, relatively little is known about the importance of field margins within grassland systems. As with some of the recommendations for buffer strips:

- Avoid nutrient (fertiliser or slurry) or herbicide application in the field margin.
- Allow vegetation in the strip to develop, but avoid the strips becoming dominated

by scrub. Periodic cutting or grazing can improve the buffering capacity and habitat quality of the strip.

- Fencing field margins (Image 1) improves the potential to create a valuable habitat for a range of different species.

5. Establish new habitats

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

- The banks of a cattle underpass could be sown with grass and wildflower mixes (see Image 2). This measure helps stabilise the banks, prevents undesirable plant species from encroaching into the field, and also provides a habitat for plants and animals.
- 'Awkward' field corners could be left uncut following silage removal. This temporary measure provides food and cover for a variety of species such as farmland birds and small mammals. Corners could be grazed-off when animals are re-introduced to the field.



Image 2. Planted bank with grass and wildflowers

6. Green Low Carbon Agri-environment Scheme (GLAS) measures

Agri-environment measures can also play an important role in halting the decline of biodiversity on more intensively-managed grassland systems.

a. Bird and bat boxes

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

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

b. Wild bird cover

Wild bird cover, a spring-grown mixture of cereals that is not harvested, could be sown on grassland farms, thus providing winter food and cover for farmland birds whose numbers are in decline. Mixtures include a cereal (oats or triticale) and oilseed rape, linseed or mustard. The measure is part of the GLAS scheme

Conclusions

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

Additional information <https://www.teagasc.ie/environment/biodiversity--countryside/>

Water quality and sustainability

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Summary

- Achieving sustainable production can deliver significant gains on Irish beef farms.
- Protecting and maintaining water quality is a key component of sustainability.
- Good sustainability credentials enhance the value of food products.
- Ireland's water quality is among the best in Europe.
- Protecting water quality can deliver a win : win for farmers.

Introduction

By developing truly sustainable systems of production the Irish beef sector has an opportunity to capitalise on our clean environment and increase the value of our products. Protecting and improving water quality is at the core of this challenge.

What is sustainable beef farming?

There are many definitions of sustainability but sustainable beef farming may be described as the efficient production of safe, high-quality beef in a way that protects and improves the natural environment, safeguards the health and welfare of the cattle, and provides for the social and economic needs of the farming community.

To be truly sustainable a beef farm must be capable of being handed on to the next generation in as good or better physical, financial and environmental shape as it is in now. In the current difficult financial climate beef farmers may be forgiven for not prioritising the importance of some aspects of sustainability, but it's now more important than ever that beef is produced in a way that protects the environment and ensures high animal welfare. The negative effects of environmentally unsustainable farming more than outweigh any short-term saving that might be gained.

Sustainability has a market value

Sustainability is one of the biggest worldwide trends in food marketing, and therefore, it has a substantial value in the marketplace. While beef processors and retailers around the world all like to attach sustainability claims to their products, not all of them can do it in a transparent and verifiable way. Ireland has a major marketing advantage in this regard, which is recognised by Bord Bia and incorporated into their marketing strategy in the *Origin Green* initiative. This is the first sustainability programme in the world that operates on a national scale, bringing together government agencies, the private sector and farmers. To date, over 50,000 Irish beef farms have been audited, accounting for over 90% of our total beef production. Importantly, *Origin Green* includes an inspection and verification requirement, with sustainability targets for farmers and processors. By moving towards achieving these targets the beef sector can reduce environmental impacts and protect Ireland's extraordinarily rich natural resources. Our grass-based beef production systems give Ireland a strong foundation in sustainable production.

Water quality in Ireland

The quality of Irish groundwater and surface waters are among the best in Europe. However, the Environmental Protection Agency (EPA) water status assessment for 2010-2015 shows that 43% of rivers, 54% of lakes, 69% of estuaries and 14% of coastal waters (by area) assessed were classified at less than good ecological status. Only 1% of groundwater bodies are at poor chemical status due to high phosphorus levels or due to historical contamination from mining activities and industrial development. Elevated nitrogen and phosphorus levels continue to be the most widespread surface water quality problem in Ireland. The EPA associates these elevated nitrogen and phosphorus levels primarily with human activities, such as agriculture and wastewater discharges to water from towns and villages, and septic tanks in rural areas (Table 1).

Table 1. Summary of Water Framework Directive (WFD) water status for groundwater (chemical status) and surface waters (ecological status) during 2010-2015. (EPA, 2017)

Water body	Status of Irish waters (2010- 2015)				
	High	Good	Moderate	Poor	Bad
Groundwater (% area)	n/a	99	n/a	1	n/a
Rivers (% water bodies)	10.4	46.3	25.5	17.5	0.3
Lakes (% water bodies)	11	35	33	13	8
Transitional (% area)	8	16	63	12	1
Coastal (% area)	41	44	12	2.5	0.0

Trends in river water quality since the last reporting period (2007-2009) show little overall change in status. However, the number of river water bodies classified as “High” (the best category) has declined from 13.4% in the 1987-to-1990 monitoring period to 0.7% in the 2013-to-2015 monitoring period. Also of concern is the number and area of transitional waters (i.e. the tidal part of estuaries) that are not reaching High or Good status. Nitrate levels are considered a significant factor influencing the ecology in this type of water.

Rules and regulations

The Nitrates Directive is one of the key EU laws for the protection of waters against agricultural pressures. In 2006 Ireland’s National Action Programme under the Nitrates Directive was introduced. It brought into force the Good Agricultural Practice (GAP) measures which are generally known as the “Nitrates Regulations”. Since then farmers have been operating under these regulations and are subject to inspections and potential penalties if there are any breaches of the GAP measures.

The Nitrates Directive is one of a group of directives that have been brought together in the Water Framework Directive (WFD). This Directive is unique in that, for the first time, it establishes a framework for the protection of all waters including rivers, lakes, estuaries, coastal waters and groundwater, and their dependent wildlife/habitats under one piece of environmental legislation. While the Nitrates Directive focusses mainly on achieving good chemical status for water, the WFD is primarily concerned with bringing waters to at least good ecological status.

Specifically the WFD aims to:

- protect/enhance all waters (surface, ground and coastal waters);
- maintain existing “high status” waters;
- achieve “good status” for all waters;
- manage water bodies based on river basins or catchments; and,
- involve the public in this process.

Protecting water quality on beef farms

Farmers have two strong incentives to work towards better water quality; market demand for sustainably produced food and regulations. However, there is a third and probably more important incentive; improved production efficiency. Many actions that a farmer can take to reduce the risk to water quality will also have the effect of improving economic performance i.e. a win : win for the farmer. The most important of these are listed below:

1. *Improved nutrient management planning* — this is the single area with the greatest potential to improve outcomes for water quality on Irish farms. Better management of nutrients, including liming to correct soil pH, will optimise nutrient use efficiency and deliver better profits for farmers, while reducing the risk of nutrient loss to water. An enhanced approach to supporting farmer nutrient management decisions is one of the elements needed to achieve this improvement. The new Teagasc *NMP Online* nutrient management planning software aims to address this need by making it easier for advisers and planners to produce high quality NMP with maps that make it easier for the farmer to understand and implement the plan. Of course, specialist advisory support to interpret the plans is also important and more information on this can be got from your local Teagasc office.
2. *Better slurry-spreading decisions* — generally farmers are reasonably good at deciding where, when and how much slurry or dung to spread. This is backed up by recent research from the Agricultural Catchments Programme (ACP), which found that there was little evidence of slurry in streams following the end of the ‘closed period’ for slurry spreading. This means that farmers either weren’t spreading slurry or farmyard manure at this time, or were spreading it on the parts of their farms where it was less likely to be washed off. There were, however, some signals of slurry runoff at the start of the closed period. This happened when heavy rainfall associated with early-autumn storms occurred shortly after the ‘open period’. These signals were also found during the particularly wet summer of 2012 when soils were wet and storms coincided with normal summer slurry spreading. Farmers can reduce the risk of slurry run-off by targeting slurry spreading in the growing season, while keeping an eye on the weather forecast to avoid adverse climatic conditions. The use of low-emission slurry spreading methods allows slurry to be spread on grass covers not suited to splash plate applications. This enables spreading well before the start of the closed period. In future it may be possible to have real-time updates on expected ground conditions for farmers based on weather forecasts to support their decision making.
3. *Eliminating point sources* — point sources is the term used to describe sources of nutrients other than those lost off the land through run-off. These are divided into agricultural sources (what escapes from farmyards, milking parlours, silage pits, effluent tanks etc.) and non-agricultural sources (mainly septic tanks). The impact of farm and non-farm point sources can be significant and where there is evidence of this impact, targeting and eliminating these sources will reduce pressure on the receiving waters and leave more ‘head-room’ for losses from farming. The ACP has found that point sources can have a

disproportionately large negative impact on stream-water quality during the summer. In some catchments, summer phosphorus concentrations in streams increase as the water level reduces, indicating that it's mainly a point source influence since in summer losses by run-off from land don't generally happen. This may have a disproportionately large impact on year-round stream ecology as streams generally don't recover from the damage suffered during the summer and the cycle is repeated from year to year.

4. *Reducing sediment losses* — Irish sediment losses are low by international standards. Stream bank and bed erosion and road losses make up most (75% in a poorly-drained catchment) on the more common land uses, i.e. grassland in catchments with modified channels. This sediment can cause significant damage to the stream ecology either directly, by clogging up gravel beds, or indirectly, by carrying phosphorus which binds to the particles of sediment into the stream. Farmers can reduce the risk of sediment loss by some simple measures like: taking care to avoid siting field gaps, troughs and feeders near streams; directing run-off from roads away from streams or drains; and, reducing cattle access, especially where stream banks are likely to collapse.
5. *Improving production efficiency* — most improvements in farm management, such as better animal breeding or better grassland management, will lead to better nutrient use efficiency as relatively more product is produced from less input. This means that the farmer gains, either through lower input costs and/or having more live weight to sell. Thus, better farm management practices, while not directly targeting environmental gains, will likely have positive environmental and economic effects — a classic win : win.

Ongoing Teagasc Research

Teagasc has a substantial research programme focused on farming and water quality. The largest single part of this is the *Agricultural Catchments Programme* which is funded by the Department of Agriculture Food and the Marine. We are currently in Phase 3 of this programme (2016-2019), which is building on the data collected and the work done in the previous two phases, as well as developing a greater capability to model the future impact of farming on water quality.



Reducing emissions and nitrogen losses from beef cattle systems

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Summary

- Irish beef production is one of the most nitrogen and carbon-efficient in Europe.
- However, the sector faces challenges to limit greenhouse gas and ammonia emissions, as well as nitrate leaching in order to meet climate, air quality and water quality targets.
- Increasing nitrogen-use efficiency can reduce losses to air and water, and reduce farm input costs.
- Optimising the timing/method of slurry application, incorporation of clover into pastures, optimizing soil pH and changing mineral fertiliser type will reduce on-farm losses of nitrogen to the environment.

Nitrogen emissions from the beef sector

Global meat demand is expected to rise by 35% up to 2050, and the value of Irish beef production is set to increase under *Food Wise 2025*. As a consequence, the requirement for nitrogen (N) inputs is set to increase to meet the increased demand for food. This has implications for environmental quality through water, air and soil pollution, and contributes to biodiversity decline. European and national legislation has set strict limits in terms of greenhouse gases (GHG) and air/water quality, and N-based emissions are a key component of these losses. Nitrous oxide (N_2O) is a potent GHG that traps almost 300 times more heat than carbon dioxide (CO_2). Ammonia (NH_3) acidifies waterways and is a cause of air pollution, and nitrate in water causes a decline in water quality and is a threat to aquatic species through eutrophication.

Nitrogen-use efficiency in livestock systems is generally low, with only 15 to 20% utilised. In 2016, over 190,000 tonnes of N, in the form of manures and fertiliser, was applied to Irish farmland for beef production, and almost one-third (62,000 tonnes) of this was lost as NH_3 (65%), nitrate (31%) and N_2O (4%). Reducing N losses and increasing N-use efficiency on farms will also reduce the need for fertiliser inputs and can increase farm profitability. Data from the Teagasc National Farm Survey (NFS) shows that these efficiency gains present a win: win in terms of environmental and economic sustainability, with the most profitable beef farms having the highest N-use efficiency. The *Origin Green* initiative, in terms of the Beef Quality Assurance Scheme, has also provided a growing impetus to further improve production efficiency, which will increase N efficiency of beef. Despite the large contribution of the sector to national emissions, the efficiency of Irish beef production compares favourably to other countries. The UN Food and Agriculture Organisation (FAO) estimated that Irish beef production has the fifth best carbon footprint and the best N footprint in Europe.

Mitigating nitrogen loss

Reducing N loss in beef systems can be achieved through increasing N-use efficiency and thus reducing N inputs or by replacing the form of N from one that is easily lost from the soil with another form that is stored for a longer period (see Table 1).

Improving soil nutrient status: pH and lime

Soils in Ireland are naturally acidic and require applications of lime (usually ground limestone) in order to restore a more favourable soil pH for crop and grass growth, and nutrient release. Currently two-thirds of soils have suboptimal pH levels. Optimal liming (restores soil to pH 6.3) reduces the requirement for mineral fertiliser by up to 70 kg N/hectare per year. This, in turn reduces annual losses of NH_3 (1.3 kg N/ha), nitrate (7 kg N/ha) and N_2O (0.9 kg N/ha). Lime has also been shown to make stored soil phosphorus (P) more available, therefore reducing the need for high levels of additional P fertiliser inputs by up to 20%.



Clover: Legumes, such as clover, take up N at a rate of 80 to 100 kg/hectare per year from the atmosphere and slowly release it over time as the clover roots decompose. This greatly reduces, and at lower stocking rates negates, the need for artificial N fertiliser application. Due to the way clover N is released, there are very little N_2O emissions associated with this form of N. While winter cover may be lower in grass/clover swards, there is better late summer/autumn growth. The incorporation of other species in the pasture mix can also build in resilience to drought.

Fertiliser formulation. Calcium ammonium nitrate (CAN) is a highly N-efficient fertiliser but produces a greater amount of the GHG, N_2O in Irish grassland conditions compared to straight urea. Urea, on the other hand, is cheaper per unit N, but up to 20% can be lost as NH_3 . New N fertiliser, Protected Urea (urea + a urease inhibitor, NBPT), has reduced losses of both NH_3 and N_2O compared to conventional N fertilisers, while consistently yielding as well as CAN and at similar cost.



Slurry amendments: Reducing pH of manures and slurries using compounds such as alum or ferric chloride can reduce NH_3 emissions during storage and on landspreading. The inclusion of these chemicals in slurry pits has been shown to reduce NH_3 emissions (and improve N efficiency) by almost 90% during storage and by 50% on landspreading. There was also a co-benefit in that methane, the main agricultural GHG, was reduced by 90% in storage.

Slurry landspreading - Timing and application technique: Shifting the timing of splashplate-applied slurry from dry, warm conditions to cooler periods has been shown to reduce NH_3 losses and improve N fertiliser replacement value by 20 to 30% at no extra cost. Alternatively, slurry can be spread using low-emission techniques, such as trailing hose or trailing shoe. The trailing hose reduces the surface area of slurry exposed to the air by placing it in bands rather than a thin film on the grass. The trailing shoe (see Figure 1) is more effective at reducing NH_3 loss, as the slurry is placed in bands, but also directly on the soil beneath the sward. The trailing hose will deliver up to a 30% reduction and the trailing shoe a 50% reduction in NH_3 loss. There is also a co-benefit of reduced sward contamination from slurry, thus decreasing grazing return times and improving grazing rotation compared with splash-plate application.



Figure 1. Trailing shoe slurry spreader

Draining heavy soils: Approximately one-third of mineral soils are classified as poorly-drained, resulting in retarded grass growth and poor trafficability. The installation of shallow or deep drains, as appropriate (see Teagasc Drainage Manual), will improve drainage and result in increased grass growth (up to 20%), increased grazing periods and better trafficability. The resulting increased soil aeration will also reduce N_2O emissions and increase plant N uptake. However, an increase in nitrate leaching may also occur.

Table 1. Impact of measures on ammonia, nitrate, nitrous oxide (N_2O) and cost.

Stars indicates effectiveness in terms of losses or cost. ★★★★★ = very effective, ★★★★ = effective, ★★★ = marginal effect or neutral, ★★ = somewhat detrimental, ★ = detrimental

Measure	Ammonia	Nitrate	N_2O	Cost
Liming	★★	★★★★★	★★★★★	★★★★★
Clover	★★★★★	★★★★★	★★★★★	★★★★★
Fertiliser type	★★★★★	★★★★	★★★★★	★★★★
Slurry amendments	★★★★★	★★	★★	★
Timing of spreading	★★★	★★	★★	★★★★★
Trailing hose	★★★★★	★★	★★	★★
Trailing shoe	★★★★★	★★	★★	★
Drainage	★★★	★	★★★★★	★★★★

Reaching out: Helping farmers make decisions

Improving farm efficiency and enhancing farm sustainability, both from a financial and environmental viewpoint, will require the combined efforts of farmers and industry in concert with advisory, education and research services. Teagasc provide a number of initiatives to improve on-farm N status.

Nutrient Management Planning (NMP online) and 'Green Book': Teagasc have developed an online system for creating nutrient management plans for improved productivity, environment and regulatory purposes; *NMP online*. This tool allows farmers to optimise nutrient requirements on a paddock by paddock basis. It requires farmers to soil test their fields and the tool then provides maps of the N, P, potassium (K) and lime requirements in order to optimise output. The data underlying the tool has been obtained from Teagasc research and is synthesised in the Major and Micro-Nutrient Advice for Productive Agricultural Crops 'Green Book'.

Carbon Navigator: Teagasc and Bord Bia jointly developed the Farm Carbon Navigator application to aid farmers and advisors in selecting cost-effective / cost-beneficial mitigation options customised for their individual farming system and environment. The Carbon Navigator assesses potential for on-farm improvements and presents savings in standardised carbon equivalent units and in monetary terms. Current measures include better slurry management and improved N-use efficiency and the Navigator report compares a farmer's performance relative to similar farms and highlights the economic and GHG benefit of adoption of the above measures. All beef farms and dairy farms in the Bord Bia Quality Assurance Scheme have been carbon-audited and also received a Carbon Navigator report.

BETTER Farms and the Heavy Soils Programme: The BETTER beef farms programme, has at its heart, increases in farm efficiency. Now in Phase 3, previous phases have led to increased gross margins by 52% for farmers who joined the programme in 2012, with technical efficiencies delivering 83% of this improvement. The Heavy Soils programme aims to improve the profitability of grassland farms on heavy soils through the adoption of key technologies including, appropriate drainage solutions, which will also help decrease N₂O emissions.

National Farm Survey: Measuring impact of measures on the ground will be a key requirement into the future and it will allow the sector to take credit for environmental improvements. The Teagasc NFS has been incorporating features into the survey that will allow for the monitoring of N efficiency measures such as timing and application technique of slurry spreading, grazing season length, fertiliser type and use, and feed efficiency at farm level.

LIFE Beef Carbon: A European initiative to reduce greenhouse gas emissions from beef production

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Summary

- Europe and Ireland are committed to reducing greenhouse gas (GHG) emissions.
- The Irish target for 2020 is a 20% reduction on 2005 emission levels.
- Beef farms are an important source of GHG emissions and this 'carbon footprint' (i.e. GHG emissions/unit of beef) needs to be reduced.
- 'Beef carbon' is a voluntary initiative that involves 2,000 European farmers.
- It is a multi-stakeholder partnership that includes Ireland, France, Italy and Spain.
- The program aims to reduce the carbon footprint of 2,000 beef farms by 15% over a ten-year period, equivalent to 120,000 tonnes of carbon dioxide equivalents.
- Early results indicate that progress is being made.

Introduction

'Beef carbon' involves 4 partner countries - Ireland, France, Italy and Spain - or 13 livestock areas (Figure 1), representative of the diversity of beef production systems across the EU, and encompasses both dairy-beef and suckler-beef systems. The nations involved typically account for 32% of the EU cattle herds' population. The program aims to demonstrate beef systems and management practices that enhance farm profit and sustainability and reduce the beef carbon footprint i.e. greenhouse gas (GHG) emissions per unit of beef. Beef carbon is targeting reducing GHG emissions by 120,000 tonnes of carbon dioxide equivalents (CO₂e) in 10 years. The program's ambition and scientific rigour is recognised by the United Nations and received the COP21 label in Paris.



Figure 1. Beef Carbon partners and target farms

Beef carbon program

The main phases of the program for 2016-2020 are:

1. Share a common framework across nations for beef farm GHG and environmental assessment.
2. Build a network of 170 'innovative' farms that will test, apply and promote innovative techniques to reduce GHG emissions and increase carbon storage (Figure 1). This will include 20 innovative Irish beef farms.
3. Create a demonstrative observatory or survey composed of a further 2000 beef farms (including 100 Irish farms) that will take part in the first carbon assessment actions operated at such a scale covering several European beef farming systems.
4. Develop Irish, French, Italian and Spanish national carbon action plans and a relevant partnership strategy for other nations. These action plans will demonstrate to the beef value chains the interest and feasibility of this approach, which aims to reduce the beef carbon footprint of these farms by 15% within 10 years.

The first stage, sharing a common framework, is nearly complete. This stage involved the development of evaluation tools and decision support systems to carry out an assessment of GHG emissions on many farms, to inform farmers and advisors and to develop initial action plans to produce a low beef carbon footprint. The Irish tools, 'carbon audit' and 'carbon navigator', were updated during this stage. Additionally, carbon audit was expanded to evaluate other farm sustainability metrics e.g., water quality. Currently, the revised carbon audit tool is being used to compute the carbon footprints of commercial beef farms as part of Teagasc and industry extension programs.

Innovative beef farms carbon footprints

Methane belched from the digestive system of cattle was the main source of GHG emissions on the innovative farms (Figure 2). Nitrous oxide and CO₂ losses from artificial nitrogen fertiliser and manure excreted by grazing cattle were the next most important contributors. The remaining GHG emissions were mostly from manure storage and spreading.

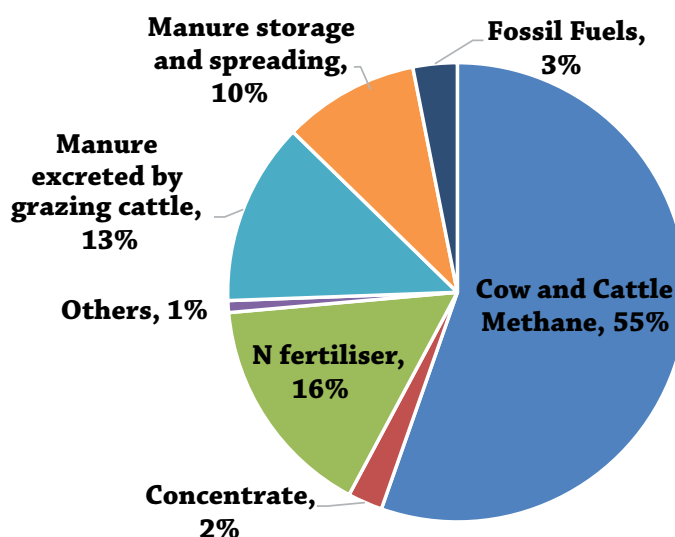


Figure 2. Sources of greenhouse gas emissions from innovative Irish beef farms

Early results for 10 suckler beef and 2 dairy beef innovative farms indicate that their average live weight gain (LWG) output per hectare was above the national average (Table 1). The difference in beef production output per hectare was largely explained by a higher stocking rate rather than superior individual animal performance. The higher stocking rate or more 'intensive' production of the Irish beef carbon farms was primarily supported by greater forage utilization, although concentrate feeding was also higher than the national average. Of the innovative farms that reared cattle to slaughter, they generally finished their animals before or at 24 months of age, which is 3 to 4 months earlier than the industry average.

Table 1. Technical and carbon footprint summary of innovative Irish beef farms

Item	Beef Carbon 2015	National Average 2015-16
¹ Gross carbon footprint, kg CO ₂ e/kg LWG	13.1	14.6
² Net carbon footprint, kg CO ₂ e/kg LWG	11.3	11.6
Stocking rate, livestock units/ha	2.1	1.5
Live weight output, kg/ha	774	422
Concentrate feeding, kg/livestock unit	474	393
Forage utilization, t/ha	8.3	5.6
Nitrogen surplus, kg/ha	150	91

¹ Carbon dioxide equivalent and live weight gain

² Includes carbon removed from the atmosphere by grassland soil

Better animal and grassland performance contributed to the innovative farms having a 10% lower gross carbon footprint than the national average. However, their net carbon footprint was only slightly lower than the national average, because intensive farms were assumed to remove the same amount of carbon per hectare as extensive systems, even though they produced more beef per hectare. The rate of carbon removal by grassland soils may be higher on more productive intensive farms, but this is currently unknown, and thus requires field research.

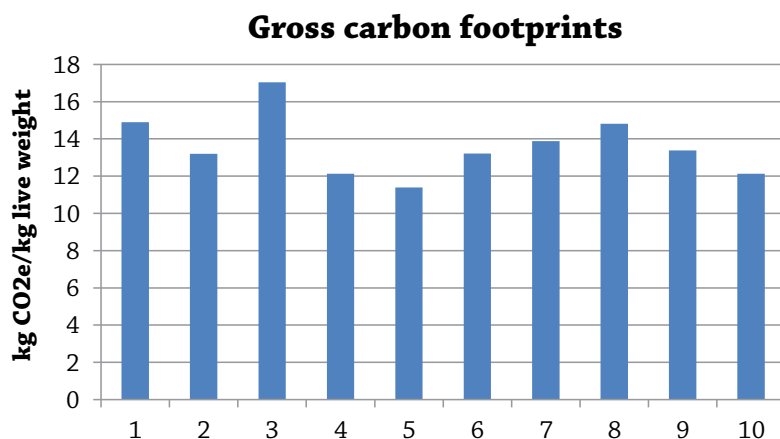


Figure 3. Illustration of variation in a selection of innovative beef farms gross carbon footprints in kilograms of CO₂-equivalent/kg of live weight (kg CO₂e/kg LW)

Across the innovative farms assessed there were notable differences in gross and net carbon footprints. Figure 3 highlights the variation across farms in gross carbon footprint. Differences between farm footprints were due to 'natural' factors, such as soil type, the type of finishing system operated (e.g. bull vs. steer) and management practices (e.g. sire selection). In some cases, such as farms 4, 6 and 7, management practices and finishing systems rather than location or climate explained most of the difference between farm footprints. This early finding suggests that there is potential for farms within the group to deploy strategies to reduce their current footprint. Further work will assess the effect that these, and new reduction strategies, have on the overall sustainability of beef systems.

Demonstrative farm observatory

Irish farms that participate in the Bord Bia Beef Quality Assurance Scheme, are included in the programs demonstrative farm observatory. These additional farms represent the main production systems practiced nationally and are summarized in Table 2. Technical data are collected from these farms to estimate their carbon footprint using the calculation tools developed by Teagasc. The carbon navigator decision support tool is used by advisors and farmers to set management practice targets to reduce emissions. The carbon footprint of demonstrative farms will be evaluated again in 2020 to determine the quantity of GHG emissions avoided.

Table 2. Irish farms included in the Beef Carbon demonstrative farm observatory

Beef system	Number of farms
Suckler-to-weaning or store	30
Suckler-to-beef	20
Dairy calf-to-store	25
Dairy calf-to-beef	10
Store-to-beef	15

Beef carbon action plan

The beef carbon reduction plan will summarize the individual action plans that Ireland, Spain, France and Italy provide to reduce GHG emissions. Currently, specific action plans are being created for 5 types of Irish beef production systems. Similar plans will be developed in France, Spain and Italy. The Irish action plans are building upon the carbon navigator work carried out by Teagasc and Bord Bia. They gather together a range of practices and technologies (e.g., low-emission slurry spreaders) and estimate the reduction in a production systems footprint. Most practices and technologies reduce carbon footprint by increasing farm efficiency. The primary goals of the measures included in current Irish action plans are:

- Improve animal health and forage quality
- Optimize calving rate and age at first calving
- Increase genetic merit and optimize finishing age
- Enhance soil fertility and soil carbon
- Increase grass yield and utilization

The feasibility of applying carbon footprint reduction measures will be tested on the innovative beef farms. Practicable measures will be prioritized based on their effectiveness and overall sustainability. The final action plan will demonstrate the scope to reduce the carbon footprint of Irish beef production and will be provided as a roadmap to reduce GHG emissions from the sector.

Geospatial research and its application to beef production

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Summary

- Satellite mapping of farmlands allows for the development of improved decision support tools for farmers, advisors and other stakeholders.
- Teagasc is upgrading its web-enabled geographic information system (WebGIS) infrastructure to better utilise historical and current data, including satellite and aircraft data, weather, soils, etc., and develop new farmer support tools.
- We showcase here the following areas of active research:
 - Current plans for integrating Teagasc geospatial resources into an effective WebGIS;
 - How the WebGIS can benefit farmers with High Nature Value (HNV) farmlands;
 - Research in remote sensing of drainage;
 - Remote sensing grass growth;
 - Remote sensing the influence of weather on fodder stocks.

Introduction

Satellite data are used for global rangeland and pasture productivity mapping by projects such as GEOGLAM-RAPP (<https://map.geo-rapp.org/>). While these data are particularly useful in drier, warmer climates, they are not properly calibrated for the colder, more humid Irish climate. Thus, these tools are of limited utility in assessing local fodder conditions. The development of improved remotely sensed grass growth estimation models could provide more accurate estimates of fodder conditions and stocks, and enable farmers, advisors, and the Irish government to better predict and respond to future weather conditions. An integral part of mapping is the infrastructure required to bring disparate data sources together into models that predict and estimate the outputs that are required, and then disseminate these results in a clear, concise, and easily accessible manner so that stakeholders can make the proper decisions. To that end, Teagasc is upgrading its WebGIS infrastructure to bring together data from varying sources, including the Teagasc remote sensing imagery archive, the Soil Information System (SIS), the IdealHNV data set, agrometeorological data, and other data sources. The upgraded WebGIS will enable access to geospatial data, models and outputs from a variety of interfaces, including custom-designed precision farming apps.

WebGIS overview

A WebGIS is an infrastructure that provides geospatial data (map layers) from one or more servers with other computers via a web-based interface such as a browser, a smartphone or tablet-based app, or via REST. Teagasc has individual WebGIS services, including the SIS, <http://gis.teagasc.ie/soils/>, farmer support tools such as PastureBase Ireland (<https://pasturebase.teagasc.ie/>) and NMP Online (<https://nmp.teagasc.ie/>), and geospatial layer data on ArcGIS Online (www.arcgis.com), and has a large volume of geospatial data sets that are accessible to individual Teagasc users, such as the Landsat imagery archive. However,

at present there is no single interface that enables these systems to properly interact with one another. The WebGIS infrastructure upgrade project will address those concerns in an effective and secure manner that is General Data Protection Regulation (GDPR) compliant.

1. Description of Teagasc geospatial data sets

Within Teagasc, a wide array of differing data sets exist which can be utilised in a geospatial setting. These include vector (point, line, and polygon) data sets which are used in traditional mapping, raster (image) data sets such as satellite or aircraft-acquired imagery, and laboratory sample data.

- *The Soil Information System:* The SIS consists of a 1:250,000 soil association map of the Republic of Ireland in polygon layers, plus derivative soil data (Figure 1).
- *IdealHNV:* The IdealHNV data set describes the probability of High Nature Value (HNV) farmland occurring in an electoral district (Figure 1).
- *Land cover/ land use data sets:* These data sets comprise the internally-produced Teagasc Land Cover 1995 and externally-produced land use data sets like CORINE 1990, 2000, 2006, and 2012.
- *Data from external agencies:* Map data produced by Ordnance Survey Ireland, the Environmental Protection Agency, the National Parks and Wildlife Service, etc.
- *The satellite imagery archive:* Teagasc has ingested thousands of Landsat images acquired from 1984 – 2018 over all of Ireland, and also has data from other satellite sensors, e.g., MODIS, Sentinel 1 – 3, etc. (Figure 2).
- *Unmanned aerial vehicle (UAV/drone) data:* Teagasc is now acquiring increasing volumes of high-resolution drone imagery for a variety of research projects.
- *Laboratory data:* Soil and plant samples are utilised in a secure manner to provide farmers with decision support tools to maximise farm profitability.

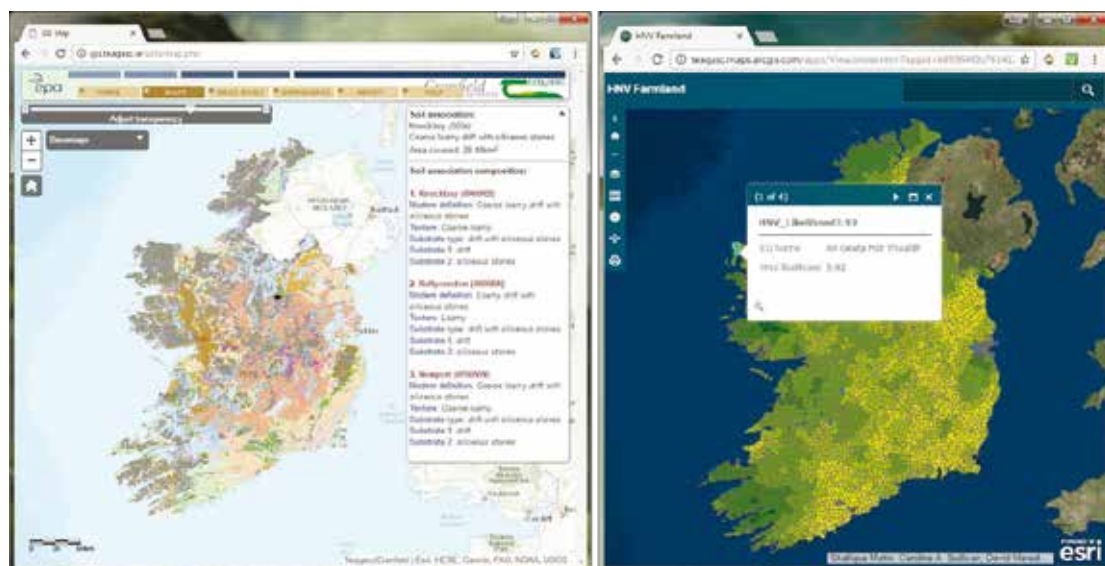


Figure 1. The Soil Information System (left) and IdealHNV (right) WebGIS resources.

2. Remote sensing of Irish grasslands

As much of Ireland's farming is geared toward beef and dairy production, grasslands are of particular importance. Within Teagasc, the following research projects assess the effectiveness of remote sensing for addressing issues like land drainage, HNV farmlands and biodiversity, and grass production.

Drainage and grass growth: Grassland production is relatively unaffected by saturated soils in the winter months, as growth is minimal. However, where saturated soil conditions persist during periods when soil temperature becomes conducive to grass growth, production can suffer. For example, soils at full saturation in early April (Figure 3) may not be back to "normal" growth until June/July, which puts additional stress on farmers to grow sufficient fodder for the following winter.

HNV farmlands: High Nature Value farmlands (Figure 1) are combinations of low-intensity land use, presence of semi-natural vegetation, or landscape mosaics. They are associated with high levels of farmland biodiversity, and provide a range of ecosystem services. The Common Agricultural Policy (CAP) contains a number of initiatives to promote ecologically and environmentally favourable agricultural practices with the objective of conserving natural resources and providing better ecosystem services. These initiatives respond to objectives set out in the EU Habitats Directive, 92/43/EEC and EU 2020 Biodiversity strategy. The 2017 European Union Commission Communication on the Future of Food and Farming highlights the intention to continue these supports into the future. HNV farming and forestry was included as one of seven headline environmental indicators of the Rural Development Programme of the CAP. The European Environment Agency (EEA) estimates that the share of

HNV in farmed areas in Ireland is 20.2% compared to the EU total cover of 31.9%. Teagasc research suggests that 33.6% of the total farmland in Ireland possesses high HNV farmland potential, of which almost half lies in the uplands. Reports suggest that for many EU regions,

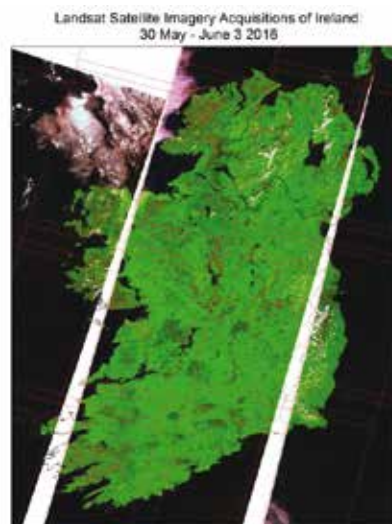


Figure 2. Example of data available in Landsat satellite imagery archive.

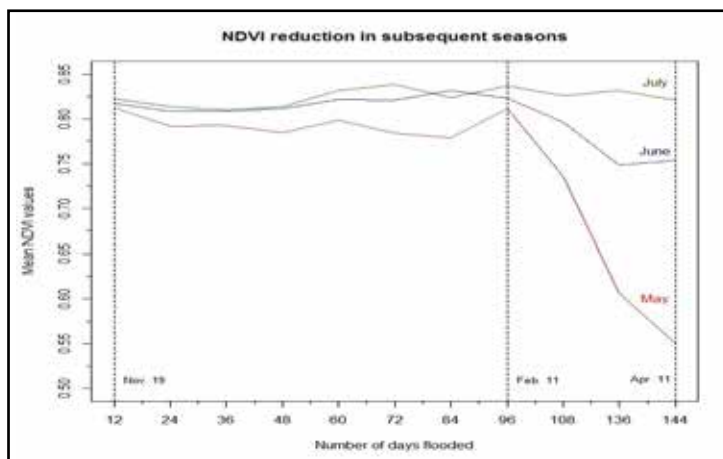


Figure 3. Grassland Normalised Difference Vegetation Index (NDVI) response following prolonged saturation from flooding in the winter 2015/16.

such as England and Scotland, HNV farming is mainly associated with beef production, especially in upland and marginal areas, where it has a high reliance on semi-natural vegetation for grazing. However, there are likewise cases from the lowlands which incorporate some low input arable and mixed cultivating frameworks and waterfront territories.

Urine patch detection:

Urine and faeces from cattle and sheep contribute nitrogen (N) to the soil and grasses growing upon them. These can act both as fertilisers and as pollutants.

By utilising UAV imaging technology, Teagasc researchers are better understanding the spatial distribution of these urine patches and the associated greenhouse gas emissions. The UAV research, which included data from Figure 4, showed that for a total of 1,125 m² of grassland, 12.2% of the area consisted of what was classified as urine patch. A simple up-scaling method was applied to these data to calculate N₂O emissions for the entire field providing an estimate of 1.3–2.0 kg N₂O-N per ha emissions from urine and fertilizer inputs.



Figure 4. UAV (drone) imagery acquisition at Teagasc showing cattle and sheep urine patches in a field.

Conclusion

The upgraded WebGIS interface will enable Teagasc researchers, advisors, farmers, and other stakeholders to better utilise existing and future geospatial data sets. This will enable the development of improved web- and smartphone/ tablet-based tools that harness data sources from satellites, UAVs, agrometeorology, and other data sources, and improved grass growth models that are optimised for Ireland. These will help farmers and advisors better manage farming operations.



Technology Village

Education

Teagasc education and training for the land-based sector

Brian Morrissey, Carmel Finlay and Pdraig Gray

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Summary

- Farm families should set aside adequate time to investigate the wide range of agricultural training programmes that are currently available for the land-based sector.
- Teagasc provides accredited further (vocational) education for the land-based sector and its courses include progression routes to other educational programmes in higher education and post-graduate education. This enables progression from Level 5 through to Level 10 on the National Framework of Qualifications.
- Quality and Qualifications Ireland (QQI) Level 5 and 6 agricultural award standards were reviewed and updated in 2016. Teagasc is developing and rolling out new programmes to meet the revised QQI awards.
- The QQI Level 6 Specific Purpose Certificate in Farming (Green Cert) is a part-time or distance education training programme which covers Animal and Crop Production, Farm Mechanisation, and Farm Business Management and Planning.
- QQI Level 6 Advanced Certificate in Agriculture is a two-year programme including options on Dairy Herd Management, Drystock Production, Crops & Machinery and Agricultural Mechanisation.
- The Teagasc Professional Diploma in Dairy Farm Management is a two-year professional work experience programme aimed at those intending to manage a commercial dairy farm.
- The Knowledge Transfer Walsh Fellowships 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 while pursuing a higher degree.

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. Farm families should set aside adequate time to investigate the wide range of agricultural training programmes that are currently available for the land-based sector.

Quality and Qualifications Ireland and the Irish National Framework of Qualifications

Quality and Qualifications Ireland (QQI) has responsibility for validation, quality assurance and certification of all further and higher education and training programmes in Ireland. The Irish National Framework of Qualifications (NFQ), which was established in 2003, is a framework of 10 levels, based on standards of knowledge, skill and competence.

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 Courses

- Certificate in Agriculture
- vCertificate 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

Revised Teagasc Agriculture Education Programme

The QQI Level 5 and 6 agricultural award standards were reviewed and updated in 2016, and Teagasc is developing and rolling out new programmes to meet the revised QQI awards. From September 2018, all students entering fulltime agricultural education will complete a newly revised two-year programme. This will allow 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: 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 that are classified as “Green Cert” awards. Among these awards, 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 Animal & Grassland Research and Innovation Centre. Applicants must be holders of a Level 6 Advanced Certificate in Agriculture or equivalent. The programme is validated by UCD.

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: accredited short courses such as Best Practice in Milking Routine, Managing Ruminant Animal and Managing Crop Nutrition and Health and Safety.
- Informal Training: non-accredited by attending discussion group meetings, open days, conferences.

Walsh Fellowship programme

The Knowledge Transfer Walsh Fellowships 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 Fellowship 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	principal@gurteencollege.ie
Ballyhaise Agricultural College	john.kelly@teagasc.ie
Kildalton Agricultural & Horticultural College	paul.hennessy@teagasc.ie or grainne.mcmahon@teagasc.ie
Mountbellew Agricultural College	tvburke@iol.ie
Clonakilty Agricultural College	keith.kennedy@teagasc.ie
Pallaskenry Agricultural College	derek.odonoghue@pallaskenry.com





Technology Village

**Keeping yourself
safe on
beef farms**

Best practice for health and safety on beef farms

John G McNamara¹ and Francis Collier²

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Summary

- Farm accidents and ill-health cause tragedy, suffering and long-term disability. They also have the potential to 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 2017, 24 fatal farm accidents occurred. In 2018, 7 deaths have occurred to the end of April. An estimated 2,800 serious farm accidents take place each year.
- Farmers have been identified as an occupational group who have a high level of ill-health. The data available suggest that farmers need to give more attention to maintaining their health, including having a regular medical check-up with their GP.
- Considerable grant aid support for farm safety improvement is available through the Targeted Agricultural Modernisation Scheme (TAMS II) up until 2020. Beef farmers need to consider how to make optimum use of this scheme.
- Farmers need to comply with the legal requirements of recently revised standards 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 a third of all workplace deaths occur in the agriculture sector. In 2017, 24 farm deaths occurred, accounting for just over 50% of all workplace deaths. This year, 7 farm deaths have occurred to the end of April, and involved tractors, machinery and livestock. 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. Farm accident victim Mr Peter Gohery will be present at BEEF 2018 to outline the consequences of an accident he had with a power take-off (PTO).

Farmers as an occupational group have been identified as having high levels of preventable ill-health. Ill-health affects quality of life and a person's capacity to farm effectively. More awareness of health promotion is needed among the farming community. At BEEF 2018, there will be a Farm Safety and Health Village exhibit to demonstrate how farm health and safety can be improved.

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.

An updated 'green covered' Risk Assessment Document has been prepared to accompany a revised Farm Safety Code of Practice. It is a legal requirement to complete this updated document before 31 December 2018. The requirement to conduct a risk assessment has replaced the requirement to prepare a safety statement for farms with 3 or less employees, which are estimated to make up about 95% of farms nationally.

Health and Safety Authority staff will be on hand at BEEF 2018 to explain the requirements to manage safety and health, and provide information to assist farmers.

Targeted Agricultural Modernisation Scheme (TAMS11).

Grant aid of €675 million is available through the various TAMS Schemes up to 2020. Full details of each scheme are available on the Department of Agriculture Food and Marine (DAFM) website at <http://www.agriculture.gov.ie/farmerschemespayments/tams/>. The principal health and safety 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 recommended that you discuss your application with your advisor to optimise the benefit for your farm. 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.). Your claim for payment will not be processed until evidence of completion of the course is provided.

The FBD Insurance booklet 'Build in Safety – An Advisory Booklet for Farmers', outlining how to comply with SHWW Construction Regulations will be available at BEEF 2018 and from Teagasc and FBD offices and web sites.

Agricultural Vehicle Standards for public roads

Revised standards for use of agricultural vehicles on public roads are in place. In addition to the agricultural vehicle, the standards include both trailers and attached machines. The purpose of the standards is to enhance the safety of all 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 will be demonstrated at BEEF 2018. These will include:

Braking – More powerful braking systems will be required for agricultural vehicles operating at speeds in excess of 40km/h. Where correctly maintained, most of the 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 will benefit from being able to operate at higher weight limits of up to 24 and 34 tonnes for tandem and triaxle agricultural trailers, respectively, provided that they meet certain additional requirements. At BEEF 2018 a comprehensive exhibit of vehicles and trailers to illustrate the requirements of the new legislation will be on display.

Gardai will be on-hand at BEEF 2018 to demonstrate weight limits for livestock and horse boxes and trailers.

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. Farmers, as they are classified as professional pesticide users (PU), must be registered with the DAFM and have a PU number. In order to register, a farmer must have completed a training course provided by an approved training agency. A list of training agencies is provided on the DAFM website at <http://www.pcs.agriculture.gov.ie/sud/>. In the event of a DAFM inspection, a farmer may be required to produce evidence of having completed appropriate training.

All boom sprayers greater than 3 metre boom width must have been tested by 26 November 2016 and subsequently at intervals of 5 years or less. A list of approved sprayer testers is available on the DAFM website.

At BEEF 2018 a practical demonstration of the key issues associated with effective sprayer operation and use of protective equipment will be provided.

Safety of children on farms

Safety of children and young persons must be paramount on farms. Members of the IFA Farm Family Committee will be on hand to discuss safety of children 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 be provided with a seat and wear a seat belt.*

The renowned safety booklet for children 'Stay Safe with Jesse' by the late Lily Nolan will be available at BEEF 2018.

Preventing machinery accidents

Vehicle and machinery-related deaths account for 50% of all farm deaths. With vehicles, being crushed (67%) is the most frequent cause of death followed by being struck by a vehicle (25%), falling from a vehicle (6%), and being pierced by a vehicle part (2%). With machinery, being crushed (41%) or struck (38%) are the most frequent causes of death followed by entanglement (14%), and falls from machines (5%). Data show that most fatal accidents occur due to being crushed or struck, so safety vigilance is especially needed when in proximity to moving vehicles/machines. A demonstration of blind spot areas around farm vehicles will take place at BEEF 2018.

Entanglement deaths and serious injuries are particularly gruesome and occur most frequently with PTO driven machines used in a stationary position, such as a vacuum tanker or slurry agitator where contact can occur between the operator and the PTO. A range of modern and effective PTO covers will be on display at BEEF 2018.

Quads (ATV's) are useful machines on farms for travel but they have a high risk of death and serious injury if misused. A demonstration of safe driving of a quad will take place at BEEF 2018.

Preventing accidents with cattle

On Irish farms, livestock deaths make up 13% of all deaths and 42% of farm accidents. Cows

or heifer accidents account for 54% of livestock-related deaths, with bulls (14%), horses (14%), bullocks and other cattle (18%) accounting for the remainder. A major 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.

Both cow calving pens and bull pens, designed particularly with safety in mind, will be on display at BEEF 2018. Breeding for docility will also be considered at the event.

Preventing deaths from slurry

Farm deaths associated with slurry and water account for 10% of farm deaths. 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 concentrations. Key preventative measures are to pick a windy day for agitating, evacuate all persons and stock from livestock houses and open all doors and outlets. A range of other gases including methane, ammonia and carbon dioxide can be produced during slurry handling or in semi agitated or emptied tanks. Never enter a slurry tank as lack of oxygen or the presence of poison gasses could be fatal. Also, never have an ignition source near a slurry tank due to the risk of methane explosion.

At BEEF 2018, practical means of checking for sufficient air movement will be demonstrated.

Farmer health

A major Irish study has indicated that farmers have a 5 times higher 'all cause' death rate than occupational groups with the lowest rate. The major causes of elevated death rates include cardiovascular disease, cancers and injuries. A further Irish study indicated that only 59% of farmers had a health check with their GP in the last year compared to 74% for the general population. Among farmers, despite 60% being classified as overweight or obese, only 27% believed that they were too heavy.

Irish Heart Foundation nurses will be on hand at BEEF 2018 to conduct blood pressure checks and provide health-related advice to farmers.

Looking after wellness

We can all go through low points from time-to-time 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*, *Samaritans Ireland* and *Shine and Grow*, will be present at BEEF 2018. *Embrace Farm*, who support Farm Families after a farm accident will also be in attendance.

Further information

A key to improving farm health and safety is the genuine interest of farmers. New and current information can be downloaded at the following web sites:

Teagasc: http://www.teagasc.ie/health_safety/

H.S.A.: <http://www.hsa.ie/>

Notes

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Notes

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