Irish Dairying: Innovating for the future

Innovating for the future – Taking stock, where to from here?

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Summary

- The Moorepark Blueprint outlines the targets for a range of KPI's for dairy production systems in Ireland to ensure economically, environmentally and socially sustainable family farms
- Significant progress can be made at farm level from a social, environmental and economic perspective
- The agricultural sector has made significant progress over the past number of years in relation to reducing ammonia, greenhouse gases, nutrient loss and animal welfare
- Increased adoption of innovations will continue to improve the sustainability of pasture-based dairy production in Ireland

Introduction

The Irish dairy industry has undergone a remarkable transformation since the removal of EU milk quotas in 2015. Since preparation for their removal began in the 2007-2009 period, and up to 2022, milk solids output increased by over 96%. While there was a reduction in output between 2022 and 2023, milk solids output increased by 1% in 2024. This increased output has been achieved through increased cow numbers, increased milk yield per cow, increased fat and protein percentages, increased stocking rate, and additional land entering the dairy industry. While it is clear the dairy industry still has great potential to both grow and improve efficiency, it is important farmers remain focused on their system to create a resilient and profitable long-term business. As grass silage and concentrate are three and four times more expensive, respectively, than grazed grass, focusing on maximising the proportion of grazed grass in the diet of the dairy cow has resulted in profitable dairy systems. However, since 2021 production costs have increased due to external factors such as the Covid-19 pandemic and the Ukraine war, compounded by increased levels of purchased concentrate feed use at farm level.

The industry must navigate challenging conditions brought about by changing environmental policies, system creep, variable pasture production, increased reliance on concentrate supplementation, and an economy operating at full employment, all amid ongoing uncertainty in policy and trade conditions.

This paper will present the Moorepark Blueprint for Irish Dairy Systems, the most resilient and profitable system for Irish dairy farmers implement, and it will discuss the opportunities available to the industry despite the many challenges the industry has and will continue to face.

Moorepark Blueprint

The Moorepark Blueprint outlines the targets for a range of KPI's for dairy production systems in Ireland (Table 1) to ensure economically, environmentally and socially sustainable family farms. The Blueprint system operates by matching stocking rate with pasture production, minimising supplementary feeds, combined with a highly fertile herd that has a high six week calving rate. Agtech and other technologies have a role in the system when they can increase farm profitability, reduce costs and increase work life balance.

Table 1. *Key performance indicators for future dairy systems in Ireland*

	Key performance indicator	2023	Future target
Farm system	Stocking rate (LU/ha)	2.13	2.53
	Net margin at 35 c/l base price (€/kg MS)	0.06	1.97
	Net margin at 35 c/l base price (€/ha)	57	2,480
Breeding and animal health	Herd EBI (€)	198	300
	Six-week calving rate (%)	68	90
	Sexed semen usage (% of all dairy AI semen)	34	100
	CBV of non-replacement dairy calves (€)	45	200
	SCC ('000 cells/ml)	172	<120
Forage and concentrates	Pasture utilised (tonnes DM/ha)	8.0	12
	Home grown forage in cows' diet (% DMI)	78	>90
	Concentrate per cow (kg)	1207	<500
	Concentrate crude protein content (%)	16.7	13
Environmental sustainability	GHG emissions (kg CO_2e/kg FPCM)	0.88	0.65
	Biodiversity (habitat area as % farm)	7	>10
	Nitrogen surplus (kg N/ha)	147	100
Social sustainability	Hours per cow per year	40	16
	Farm work hours per week February / June	61	<28

Irish dairy farms must become more resilient and minimise reliance on external inputs to generate output. With this in mind, the cornerstone of Irish dairy farming is the utilisation of grazed pasture in the animals' diet as it remains the cheapest source of feed, the crucial input in the system. Repeatedly, research has shown that the utilisation of grazed pasture is the factor with the most influence on farm profitability. Analysis of the 2024 Teagasc Profit Monitor data showed a strong relationship between pasture utilised (kg DM/ha) and margin (€/ha), once again demonstrating that greater pasture use in the diet is associated with increased farm profitability (Figure 1).

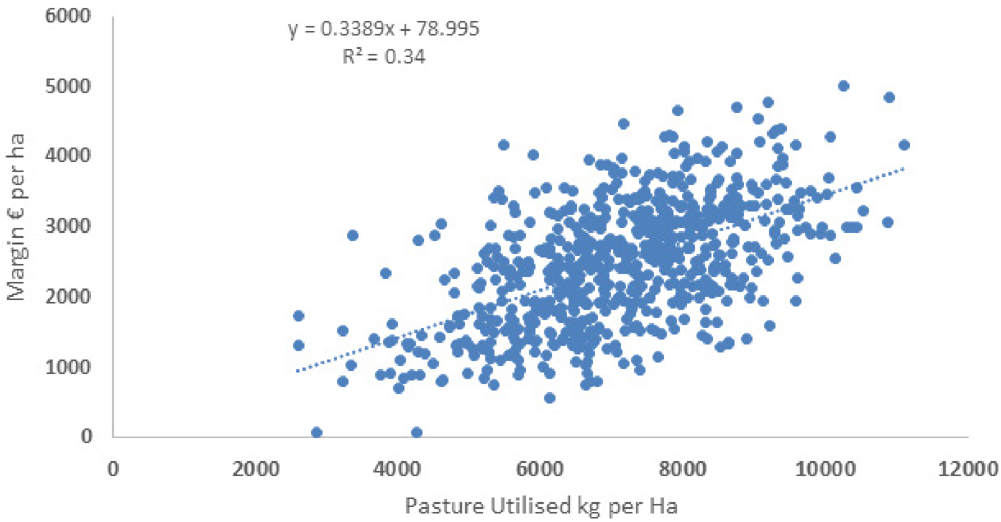

Figure 1. *Analysis of Teagasc Profit Monitor data from 2024 showing the relationship between pasture utilised per hectare and margin per hectare*

In 2023 home-grown forage accounted for just 78% of dairy cow diets in Ireland; to maximise profitability this figure should be over 90% (Table 1). According to National Farm Survey (NFS) data the average Irish dairy farmer grew approximately 10.4 t DM/ha of pasture in 2023. Figures from PastureBase Ireland (PBI) farms, where pasture is actively measured and managed, show an average pasture growth of 11.8 t DM/ha in 2024, a reduction of 0.6 t DM/ha from 2023 (12.4 t DM/ha). Comparing these figures, points to an opportunity for a large cohort of farmers to increase pasture production on farm. Optimising soil fertility, good nutrient management planning, measuring farm cover, and utilising complementary sward species, such as white clover in grazed pastures, will maximise pasture growth. Increased use of data generated through grassland measurement is crucial to farmers maximising pasture utilisation on farm.

Considering the potential for increased pasture growth on farms, the average farmer in Ireland has scope to increase stocking rate. As per Table 1, research has shown that it is possible to increase pasture growth to a level where 12 t DM/ha can be utilised. According to PastureBase Ireland data, many farmers have an opportunity to optimise the alignment of milking platform stocking rate with pasture production potential. To make best use of the pasture produced, farmers need to fully embrace the technologies available to them at farm level. Breeding a cow best suited to a grazing focussed system will be crucial moving forward. The economic breeding index (EBI) is regularly reviewed to provide Irish farmers with up-to-date information from which to select the genetic material best suited to improving profitability of their herds.

Optimising pasture utilisation and breeding cows suited to the system will make the average Irish herd more resilient and allow farmers to achieve a better work life balance, both inside and outside the farm gate. Currently, the average farmer requires approximately 40 hours/cow/year on farm (Table 1); research has shown that the most labour efficient farmers in Ireland require just 16 hours/cow/year. These farmers were described as having compact calving and breeding and excellent calf rearing performance; they used contractors for much of the machinery work; they had a high ratio of units to cows in the milking parlour; and they contract reared their dairy heifers.

The potential profitability, emissions per unit of product and nutrient balance when the farm is operated at the Blueprint targets (Table 1) are €2,480 net profit per ha, 0.63 kg of CO_2e per kg FPCM (with updated enteric methane emission factors), with a nitrogen surplus of 100 kg/ha which compares to the current situation of net profit per hectare of €57, 0.88 kg of CO_2e per kg FPCM (with updated enteric methane emission factors), and a nitrogen surplus of 147 kg/ha.

Environmental sustainability

There has been an increased emphasis on all aspects of the environment over the past number of years. Changes to the Nitrates Directive and uncertainty around future Nitrates Derogation, coupled with the Climate Action Plan and the Nature Restoration Law have put increased pressure on the agricultural sector and required the industry, farmers and policy makers to work on strategies to achieve the defined targets.

Greenhouse gas emissions

Agricultural greenhouse gas (GHG) emissions have declined relative to 2018. The Climate Action and Low Carbon Development (Amendment) Bill 2021 set a 'national climate objective' to achieve climate neutrality no later than 2050 and a total reduction in GHG emissions of 51% by 2030. The agricultural sector is required to reduce emissions by 25% relative to 2018 by 2030. This target poses a significant challenge for Irish agriculture. The most recent EPA report shows that emissions in 2023 from agriculture are now almost 4.1% lower than in 2018. Notably, Ireland's GHG emissions from agriculture in 2023 were 8.2% lower than in 1998 (Figure 2). Agricultural GHG emissions declined between 1998 and 2011, followed by an increase as dairy cow numbers increased following EU milk quota removal. Meeting the sectoral targets will require the widespread and immediate adoption of currently available mitigation solutions, coupled with continued investment in research to develop new solutions in the medium to long-term, in order to provide a means for the industry to meet its overall commitments.

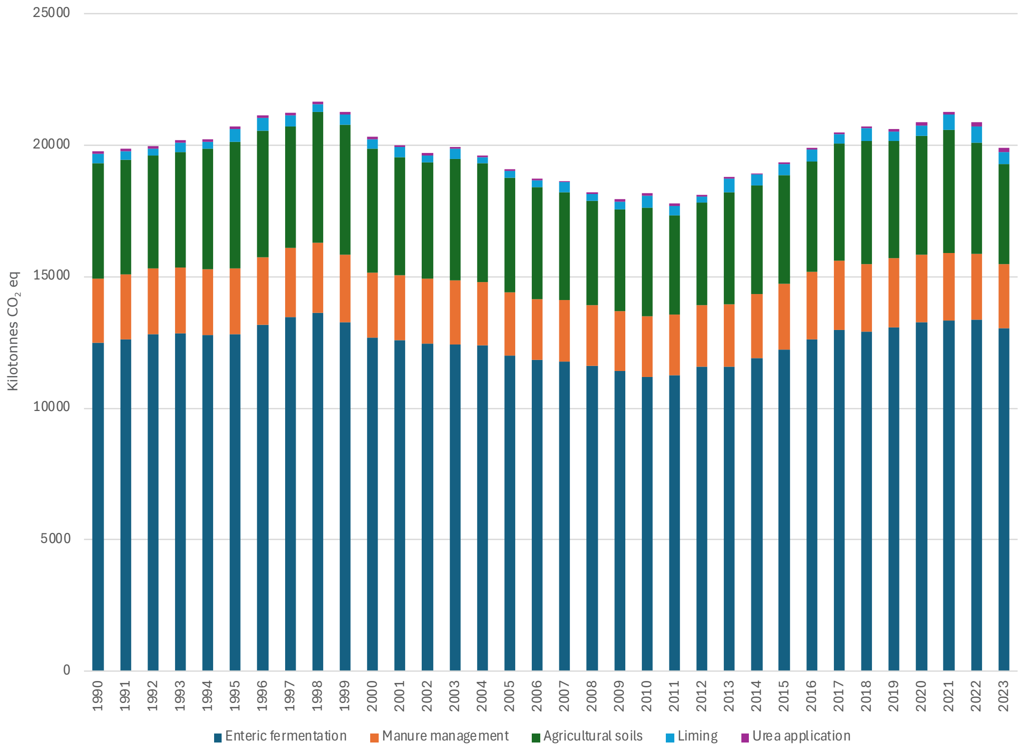

Figure 2. *Agricultural GHG emissions between 1990 and 2023 using GWP100*

Source: *EPA (2025)*

The main challenge post 2030 will centre on achieving climate neutrality (maybe better understood as temperature neutrality); that is ensuring agriculture no longer contributes to increased global warming. Methane is the single greatest GHG emitted from Irish livestock production systems. The reality is that methane is a potent GHG that has a high warming potential. However, it is short lived and will only remain in the atmosphere for 10-12 years. The science around methane is quite clear, if methane concentrations are not increasing in the atmosphere and are slightly reducing, there is no additional warming associated with that methane.

According to one of the more recent reports from the Climate Change Advisory Council, agriculture is expected to play a significant role in achieving Ireland's climate neutrality target, more particularly by contributing to a net cooling (based on historic warming associated with methane) effect through substantial reductions in methane, which would result in agriculture making space for other sectors that do not meet climate/temperature neutrality requirements.

Livestock numbers

The total number of cattle in Ireland peaked in 1998 at 7.3 million (Figure 3). Between 1998 and 2011, dairy cow numbers declined reducing the national herd to 6.2 million. Between 2011 and 2021, total number of cattle increased again to 7.0 million. However, since 2021 cattle numbers have been declining, driven by a slight decline in the number of dairy cows, a significant decline in suckler cow numbers and an increase in intra-community livestock trade from Ireland. In 2024, the average number of cattle had reduced by 550,000 from the peak of 1998.

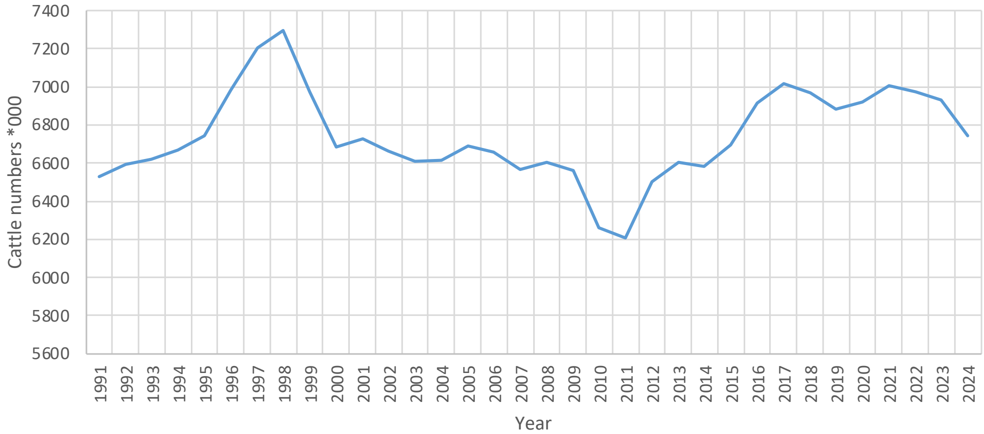

Figure 3. *The average number of cattle between June and December over the period 1991 to 2024*
Source: CSO (2025)

Carbon footprint

Carbon footprints estimate the GHG emissions embedded in product production, typically calculated using life cycle assessment (LCA) models. In agriculture, LCA usually follows a cradle-to-farm gate approach, capturing emissions from input production to on-farm activities. Key on-farm emissions include enteric and manure methane, nitrous oxide from soils and fertiliser, and carbon dioxide from fuel, lime, and fertilisers. Off-farm emissions mainly relate to feed, electricity and fertiliser production. Life cycle assessment results are expressed per unit of output, fat and protein corrected milk (FPCM) for dairy and carcass weight for beef. Since dairy systems produce both milk and meat, LCA methodologies allocate emissions between these outputs, but differing allocation methods can complicate cross-study comparisons.

Comparing agricultural carbon footprints between countries is challenging due to inconsistent methodologies, differences in system boundaries, data quality, and emission factors. Although global standards exist, structural and methodological variations persist. Some studies have attempted to standardise comparisons, showing that pasture-based systems often have lower emissions per hectare and per unit of product than indoor systems. However, comparisons based on differing datasets and inconsistent methods can be misleading due to the wide variability in farm-level emissions. The FAO's GLEAM model offers a consistent global comparison of livestock systems, ranking Ireland's dairy and beef among the lowest in carbon footprint globally. However, GLEAM's generic structure lacks the flexibility to reflect country-specific practices. More detailed national LCA models now provide more accurate insights into local mitigation efforts.

In Ireland, recent research and updated emissions data suggest the average dairy carbon footprint is 0.96 kg CO_2e/kg FPCM, reducing to 0.88 with new country specific enteric methane emission conversion factors that have been generated based on Irish data and are currently being uploaded into the Irish carbon footprint models. Future systems in Ireland aim to reduce this further to 0.63 kg CO_2e/kg FPCM through improved dairy cow fertility, increased grass utilisation, reduced fertiliser use, changing fertiliser type and feed additives. On top of the potential from technology, including C sequestration could lower footprints to around 0.50 kg CO_2e/kg FPCM for the most efficient farms.

Feed/food competition

There is considerable debate on the use of human edible food to feed animals and its impact on food security. Several metrics have been developed to measure the net contribution of livestock to the supply of human digestible protein (HDP), such as the edible protein conversion ratio (EPCR) and the land-use ratio (LUR). The EPCR compares the amount of HDP in animal feed over the amount of HDP in the animal product. The LUR compares the potential HDP from a crop grown on the land used to produce the livestock feed against the HDP in that livestock produce. There is limited research conducted in this area internationally, particularly around pasture-based systems. While food production must increase to meet global demand for animal-based proteins, there is also an increasing need to minimise associated environmental burdens. Thus, there is a need to move the question on from not only what people should eat but also to where and how should that food be produced to ensure there is balance in the overall debate.

Table 2 illustrates clear differences between production systems in terms of EPCR and LUR, with dairy consistently showing the lowest (most efficient) values. This indicates that Irish dairy contributes positively to global HDP production, even when factoring in the opportunity cost of land use based on its suitability for cropping, as measured by LUR. Considering higher LUR values (i.e., >1) alongside some of the environmental drawbacks of ruminant agriculture, it raises important questions about the appropriateness of feeding livestock human-edible crops or using land that could grow food for people. From both a food security and resource efficiency perspective, it may be more sustainable for a larger proportion of global ruminant production to come from regions, such as the majority of Ireland, where livestock farming does not compete with land suitable for growing human-edible crops.

Table 2. *Edible protein conversion and land use ratio values of Ireland's ruminant livestock sector*

	Dairy	Dairy beef	Suckler beef	Sheep meat
EPCR	0.18	0.42	0.29	0.21
LUR	0.47	1.08	1.25	0.95

EPCR = edible protein conversion ratio; LUR = land-use ratio

Source: *Hennessy et al. 2021*

It is evident that foods from different sources vary greatly in their digestibility. While environmental impacts are commonly compared per kilogram of product or per unit of protein, it is important to also consider digestibility and nutrient availability when evaluating different food types. Digestibility scores can differ significantly between protein sources, and when digestibility and amino acid profiles are taken into account, the nutritional value of animal-based proteins is considerably higher compared to plant-based proteins.

Water quality

Nitrates Directive

Ireland is in its fourth year of the 5th Nitrates Derogation. The Nitrates Derogation is how some Irish farmers can surpass a 170 kg per ha limit of organic nitrogen on their grassland area, as set out in the Nitrates Directive. The Nitrates Action Plan outlines specific measures to protect surface and ground waters from nitrates loss. The current Nitrates Action Plan (SI 113 of 2022) has had changes implemented in 2025 based on the mid-term review of the derogation, which occurred in 2024. These changes include changes to the maximum artificial fertiliser N allowances and changes to young stock organic nitrogen, as well as changes to the organic N figures associated with the use of lower crude protein concentrates. Other changes since 2022 include the introduction of banding, reductions in artificial N fertiliser allowances, reduction in the maximum organic N stocking rate limits, and changes to periods when both organic and inorganic nutrients can be spread. All of these changes are designed to reduce the potential for nutrient loss from farms.

In non-pasture-based systems, as operated in many parts of Europe, slurry exports are used as a tool to manage stocking rate. This is not possible in Irish pasture-based systems, where most of the animal manure is applied to the pasture by the grazing animal directly and with no opportunity to distribute the manure elsewhere for the vast majority of the manure (produced during the grazing season). For efficient pasture-based systems to operate, stocking rate management linked to pasture production is a key driver of economic and environmental sustainability. Reducing stocking rates could result in system change at farm level, which could have potentially long-term negative impacts on all aspects of sustainability.

The EPA publish detailed reports describing the changes in biological quality and nutrient concentrations in water on an ongoing basis. The most recent report on water quality was published in 2022 with a new report expected in 2025. The 'Water quality in Ireland 2016-2021' report covers the periods from 1987-1990 through to 2018-2021. The report indicated a consistent and steady reduction in river water bodies described as 'bad' (3.92% in 1987-1990 period and 0.04% in the 2019-2021 period). Just over 60% of rivers were described as having high or good biological status in the 1987-1990 period with the corresponding figures for the 2019-2021 period being 56% (the same as the period 2016-2018). Over the period 2019 to 2021, the number of rivers classified as moderate increased from 26% to 28% while at the same time the number of rivers classified as poor declined from 18% to 17% (Figure 4).

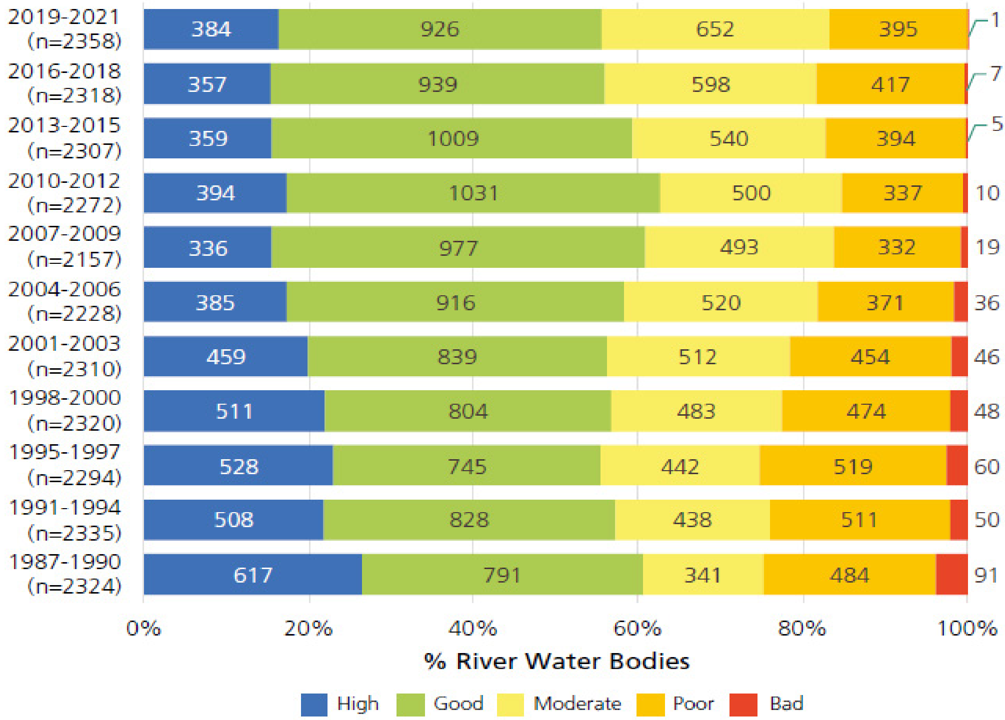

Figure 4. *Biological river water quality in Ireland over the period 1987-1990 to 2019-2021*

Source: *EPA (2022)*

In the same report, when the periods 2013 to 2018 and 2016 to 2021 were compared, the number of 'high' and 'good' status rivers declined by 1%, while more rivers increased in quality than declined in quality over the same periods. It must be noted, however, that 2018 has been identified as a very problematic year in the context of nitrate loss, primarily due to drought conditions across the summer period and a slow growth period in the spring. This was compounded by increased use of chemical N fertiliser at farm level coupled with lengthening of the period when fertiliser could be spread, as well as greater purchased feed use.

Analysis carried out for the 5th Nitrate Action Programme coupled with increased ambition in fertiliser N reductions in the Food Vision strategy, suggests that this will result in a reduction in nitrate-N leaching of just over circa 8 kg per ha. In the most recent water quality report from the EPA, "the early indicators report for 2024" (Figure 5) it can be seen that nitrate concentrations are dropping in rivers. These reductions in nitrate concentrations reflect the positive actions taken by farmers in recent years to reduce nutrient loss. This progress must continue at farm level, and in addition, other nutrient loss sources on farms must be addressed to further improve water quality. A new report on manure production based on monitoring 100 farms over two winters will be published soon, and will suggest that there is a requirement to increase the manure production assumptions per cow per week and this will, therefore, result in the requirement for increased manure storage on farm.

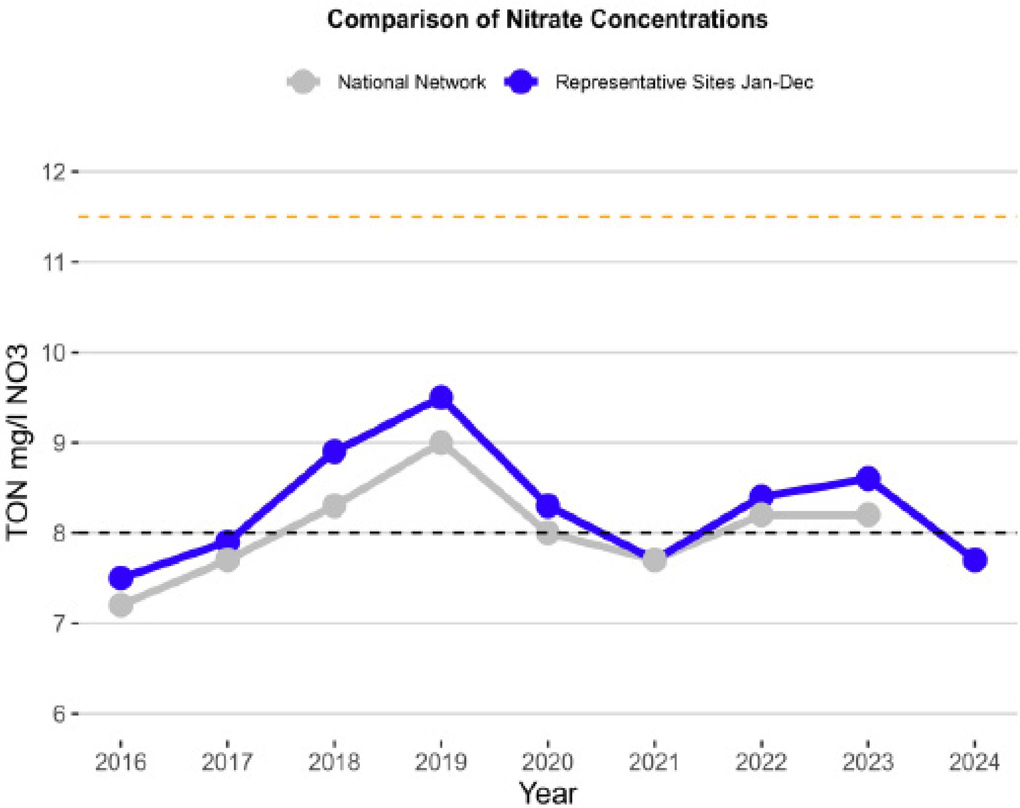

Figure 5. *Early insight nitrogen concentrations for Jan-Dec periods for each year for the period 2016 to 2024 for 20 representative sites located around the country*

Source: *EPA 2025*

In 2024 Teagasc launched its "Better Farming for Water Campaign". This campaign is focused on the actions that can be taken at farm level to reduce nutrient loss. The actions are broadly themed into three key areas: nutrient management, farmyard management and land management. On all farms and across all enterprises in Ireland there are more changes that could be made to positively impact water quality. These changes must continue to be implemented.

Nitrates Derogation

Since 2005, several countries, including the Netherlands (2005-2026), Ireland (2006-2026), Northern Ireland (2007-2022), Belgium (Flanders) (2013-2023), and Denmark (2013-2024), have received derogations permitting higher manure applications under specific conditions. When applying for derogation, Member States (MS) must demonstrate that it will not negatively affect water quality. In these countries, climatic conditions, higher grassland yields, and greater nitrogen losses to the air theoretically ensure that additional manure application does not lead to additional nitrate leaching. This is due to their temperate climates, characterized by ample rainfall and relatively wet soils. The derogation allows for the application of higher amounts of livestock manure under certain conditions. Irelands long grass growing season, mild and wet weather, coupled with a continuous pasture cover in grassland systems reduces the potential for nutrient loss. The reality is that Irelands grazing systems are unique within the European context. In indoor systems, which dominate much of Europe, stocking rate is managed through manure export and therefore a nitrates derogation is not as important as in a grazing system. In an indoor system without a nitrates derogation increased manure export adds cost to the system but it doesn't affect the system operated. In grazing systems, it is impossible to separate the manure from the system when animals are grazing (as they deposit the manure themselves directly) and therefore manure export is not a possible mechanism to manage stocking rate for most of the year and without a nitrates derogation the systems operated are effected greatly for farmers that currently avail of a nitrates derogation.

Biodiversity

The Nature Restoration Law, introduced in 2024, sets legally (and consequently enforceable) binding targets for the EU and its Member States. Agriculture must demonstrate improving trends across many biodiversity metrics including, but not limited to, high diversity landscapes, pollinator index, butterfly index, farmland birds and soil organic carbon from the date of introduction in 2024 to December 2030 and continuing thereafter until satisfactory metrics have been achieved. The percentage of agricultural land area required to achieve satisfactory scores has not been defined but is likely (based on recommendations within the EU Biodiversity Strategy for 2030) to be in the region of 10%.

Further research is required to reverse the decline in biodiversity loss across all land types, and to determine the most appropriate solutions that can be incorporated into the farming systems to enhance the quantity and quality of biodiversity (and associated ecosystems services) on farms.

Technological uptake and change at farm level

Since milk quotas were removed, there has been a movement of land into dairying and it is clear from Figure 6 why this has occurred. Relative to other enterprises, the dairy family farm income (excluding owned land and labour) is consistently higher than that of other enterprises, despite significant year-to-year variation. This volatility creates significant challenges in maintaining a consistent standard of living and meeting ongoing financial commitments.

However, even though there is significant year-to-year variability in dairy family farm income there is a positive net increase over time of the order of €3,776 per year (Figure 7). The increase reflects the returns to owned land and the owner operator. These increases in income are being driven by:

- An increase in herd size from 68 to 94 cows.
- An increase in stocking rate from 1.83 to 2.13 LU per hectare.
- An increase in land area per farm from 58 to 65 hectares.
- Increased grass utilisation from 6.7 tonnes utilised per ha in 2012 to a projected utilisation of 8.2 tonnes utilised per ha in 2024.

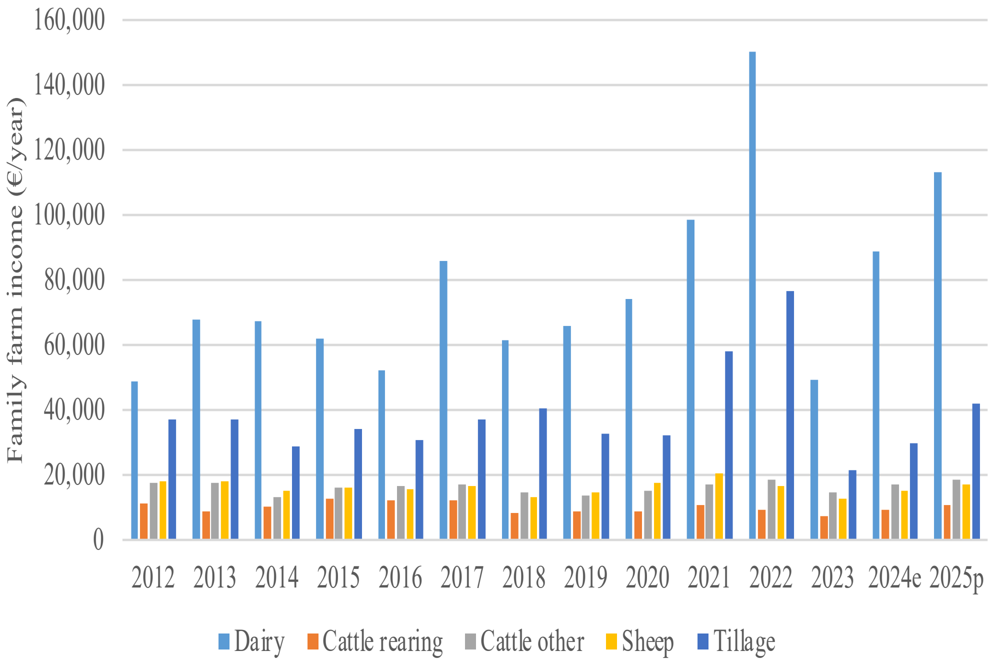

Figure 6. *Family farm income across different farming enterprises between 2012–2025 (2024 expected income and 2025 predicted income)*

Source: *Teagasc National Farm Survey (NFS)*

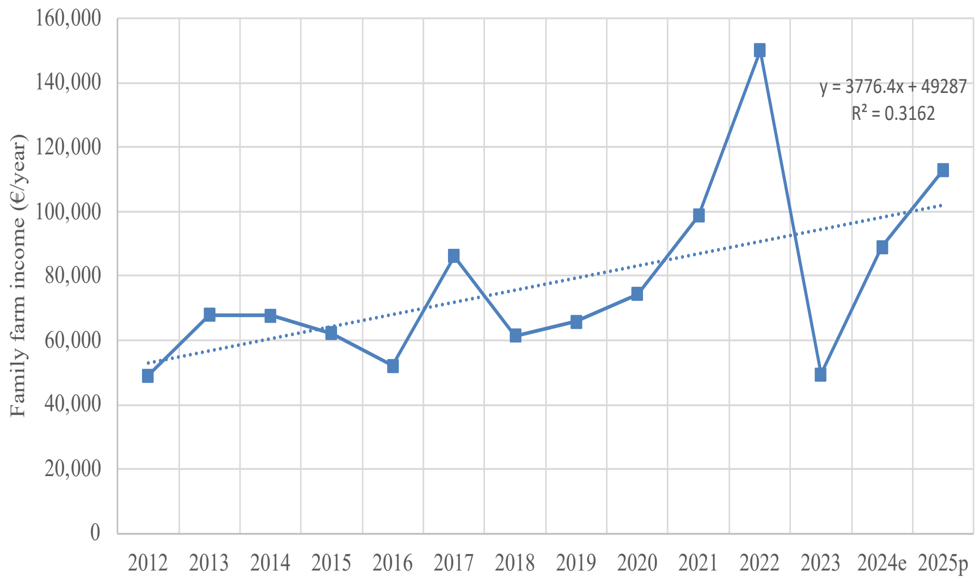

Figure 7. *Change in family farm income for dairy farms between 2012 – 2025 (2024 expected income and 2025 predicted income)*

Source: *Calculations based on Teagasc NFS data*

Pasture utilisation and proportion of bought in feed

Within a pasture-based system the key driver of profitability is grass utilised per hectare, as well as minimising the proportion of bought in feed. As the pasture utilisation per hectare increases the net profit per hectare also increases; conversely, when the proportion of bought in feed increases the profitability per hectare declines. Figure 8 shows the average trends on dairy farms over the past 10 years; pasture utilisation increased from 2012 until 2022 and since 2022 pasture utilisation is declining, due to stagnation in pasture production but also due to an increased focus on milk yield per cow at farm and industry level. At the same time there has been an increase in the proportion of bought in feed. These recent directional changes are extremely concerning for the industry. In certain circumstances stocking rates on the milking platform are too high and higher milk price/feed price ratios are incentivising farmers to feed more to enable more stock to be carried. There is also a more fundamental issue regarding the lack of clarity and differing opinions around the messages being communicated to farmers. The reality is that there is little to no association between milk yield per cow and profitability and if the increase in milk yield is associated with an increase in concentrate feeding levels or purchased forage, there will be a negative association between milk yield and profitability. An analysis of Teagasc Profit Monitor data showed that between 2019 and 2022 concentrate feed per cow increased by 29% (to 1229 kg/cow), however milk solids production per cow in the same period only increased by 14 kg/cow. Ireland's comparative advantage and ability to withstand price volatility lies with being able to grow and utilise pasture, and there is a requirement to refocus on these simple messages and technologies in order that the advantages of the system are not squandered.

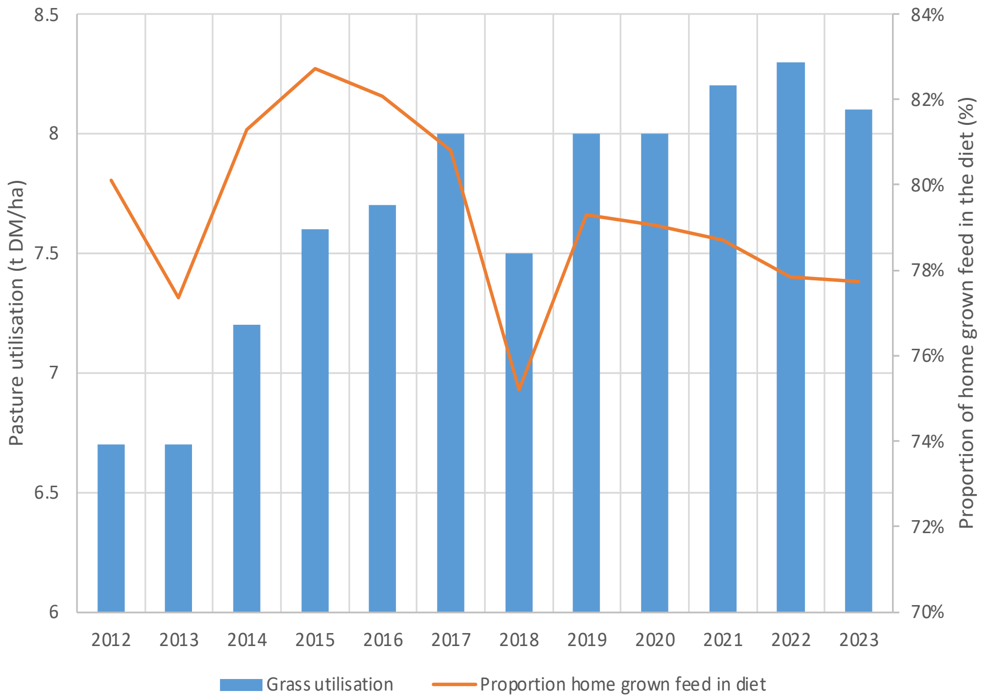

Figure 8. *Pasture utilisation and proportion of bought in feed*

Source: *Authors calculations based on NFS data*

Dairy cow fertility

Within a pasture-based system dairy cow fertility is extremely important. Key to maximising pasture utilisation while minimising costs is matching feed supply and demand while minimising bought in feed. Calving date management is a key strategy to manage feed supply and demand in the spring. As herd fertility increases there is a need for each farmer to assess their calving date. The reality is that as calving date becomes more compact farmers should be pushing the calving start date later to reduce the quantities of grass silage being fed in the spring. Nationally the six-week calving rate has increased as herd fertility has increased (Figure 9). It is important to note that while the six-week calving rate has increased and is now at 68%, the target is 90%, so nationally there is a need to continue the focus on dairy herd fertility, despite some herds coming close to target.

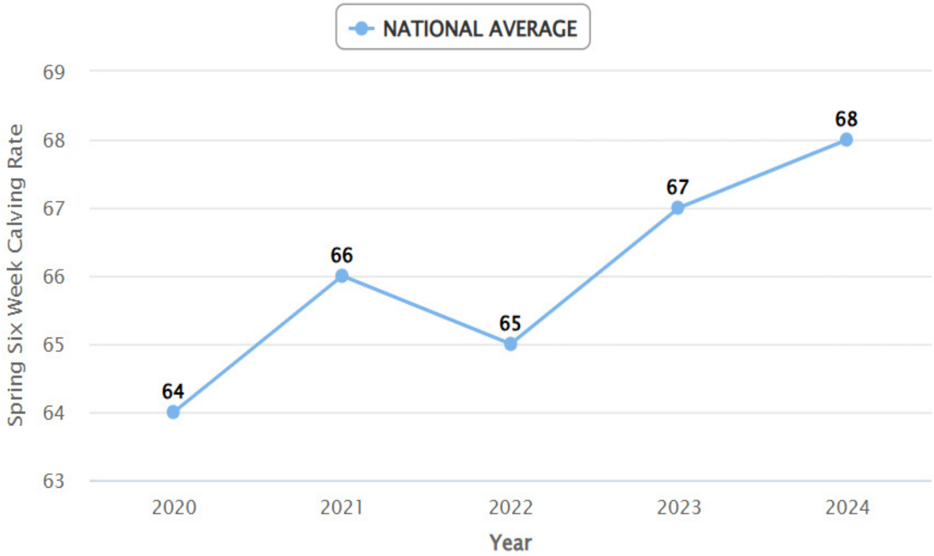

Figure 9. *National average six-week calving rate between 2020 and 2024*

Source: *ICBF*

Productivity

There has been a narrative that nationally milk yield is too low and that there should be increased emphasis on increasing milk yield per cow. The reality is that within a pasture-based system milk yield per cow will and should always be lower than in higher input systems. But the reality is also that focusing on milk yield per cow will not result in increased profitability. The majority of the Irish dairy industry moved to a milk solids-based payment systems over the period 2008 to 2012. When the EBI was developed it was designed for multiple component pricing systems as currently operated in Ireland so before the payment systems were introduced there was a breeding focus on milk solids. Figure 10 shows the rate of increase in milk solids percentages at farm level between 2000 and 2010 and 2010 and 2024. The rate of milk fat percentage increase was 2.6 times faster between 2010 and 2024 compared to 2000 to 2010. Similarly for milk protein percentage the rate of increase was 1.7 times faster in the 2010 to 2024 period compared to the 2000 to 2010 period.

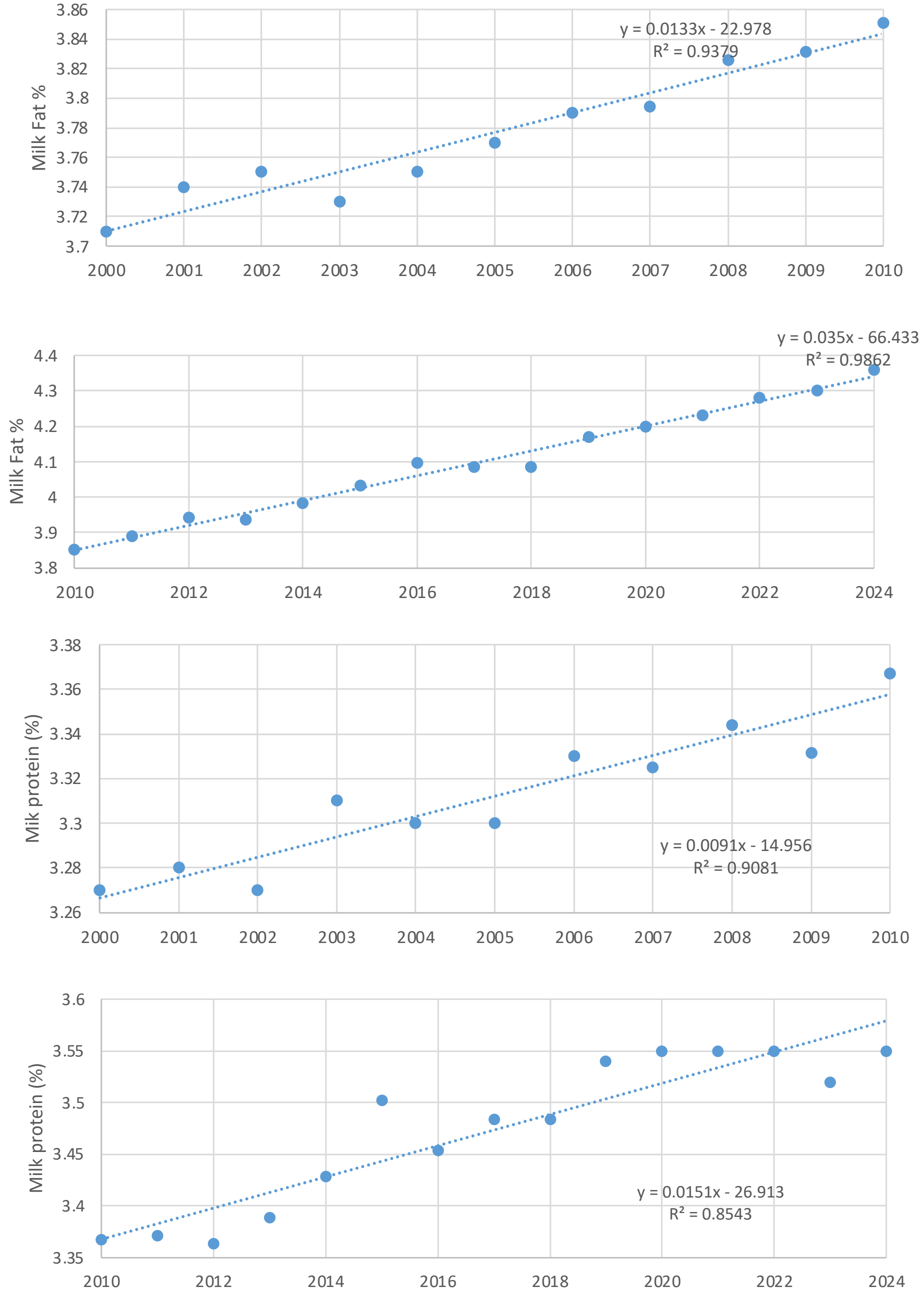

Figure 10. *Milk fat and milk protein percentages from 2010 to 2024*

Calves from the dairy herd

There is a huge opportunity for dairy-beef production systems in Ireland driven by the increased use of sexed semen and the incorporation of high value, early-maturing beef genetics into the dairy herd. These calves can provide a significant opportunity for the beef industry to reduce GHG emissions per unit of product and lower production costs associated with beef production. In the last few years, the dairy industry has embraced the use of sexed semen to generate replacement heifers and selecting bulls from the Dairy

Beef Index (DBI) to generate non-replacement calves. The number of sexed semen straws available in 2025 (driven by demand) was approximately 350,000, which will result in up to 150,000 less male dairy calves than were born at peak.

Superior growth performance and carcass traits are achievable through the appropriate selection of beef bulls for use on dairy females, with only a very modest increase in collateral effects on cow performance. Controlled studies have consistently demonstrated superior carcass characteristics from beef × dairy crossbred animals compared with dairy breed contemporaries. The two key traits of interest to dairy farmers when selecting beef bulls for use on their herds are calving ease and gestation length. Conversely, beef farmers who purchase these calves are interested in terminal traits such as age at finishing, carcass weight, and carcass conformation. The Dairy-Beef Index (DBI) was introduced in 2019 to rank beef bulls for use on dairy females, based on genetic potential to efficiently produce a high-value carcass while having minimal repercussions on milk, health, and reproductive performance of the dairy female. This index helps dairy farmers to select the most appropriate beef bulls and to direct the breeding programme for the next generation of beef bulls to meet the demands of dairy producers. The recent rollout of the National Genotyping Programme and the Commercial Beef Value (CBV) provides information to the beef farmer on the expected economic performance of a cohort of calves from two to three weeks of age. It also provides an incentive to the dairy farmer to select better beef bulls for crossing with dairy dams to produce calves with better CBV through focusing on the beef sub index of the DBI when selecting bulls for use.

Recent analysis suggests that the rate of genetic progress in the beef bulls within the angus breed is limited. Developing a beef breeding programme with a strong focus on meeting carcass specifications, age at finish and that incorporates early life data on phenotypic methane emissions as a criterion for selecting the next generation of elite breeding stock could position Ireland at the forefront of efforts to improve the economic and environmental credentials of the beef and dairy industries. The key objective of such a beef breeding programme should be to generate beef bulls that meet the dairy farm requirements while also delivering higher carcass weights and earlier finish in order for the beef farmer to maximise profitability.

For non-replacement calves born into the dairy herd there are three potential destinations: (1) they can be reared on their farm of origin, (2) sold to a dairy-beef farmer, or (3) intra-community trade. The continuation of the intra-community trade of calves is extremely important to satisfy a market demand while helping Ireland meet its policy targets. Although average calf prices were high this spring, the number of calves traded to continental Europe also increased. Maintaining calf welfare during transport is crucial to the integrity of the intra-community trade process and requires robust monitoring as well as the development of solutions to increase welfare during transport. Over the past number of years Teagasc Moorepark has undertaken extensive research to assess calf welfare during transport, further work is now commencing investigating ways to feed calves throughout their journey from Ireland to continental Europe.

Conclusion

Irish dairy farmers have addressed a wide range of challenges they have faced in the last number of years through innovation and adoption of new research and technologies that came from research. The sector continues to generate the greatest family farm income across agricultural enterprises operated in Ireland. Moving forward, refocussing on pasture production and utilisation, dairy cow fertility and reducing the use of purchased concentrate will ensure a profitable, resilient and sustainable Irish dairy industry.

The business of dairying: future-proofed through innovation

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Summary

- Significant economic value and improved environmental sustainability has been achieved within the Irish dairy sector by focusing on core grazing principles to maintain low production costs and high levels of pasture utilisation
- Our grazing systems can be further improved by reducing reliance on supplementary feed and chemical fertilisers, maintaining appropriate grazing stocking rates and further refining day-to-day operations to reduce workload, simplify systems and improve work-life balance on family-run dairy farms

Introduction

The Irish dairy sector has been transformed over the past 15 years, doubling milk fat and protein output, while total sectoral value has increased by 35% since 2017. With a total estimated value of €6.3 billion in 2024, the record recent performance of the sector has been achieved through a combination of increased average herd size (from 75 to 96 cows per farm between 2017 and 2024) and enhanced productivity via improved animal breeding, grassland management and animal husbandry. Remarkably, the increase in the economic value of the sector has been achieved while chemical nitrogen (N) fertiliser usage has decreased on Irish farms, resulting in lower carbon and nitrogen (N) footprints for Irish dairy products. At the core of this success story are 16,000 family-owned dairy farms, producing over 8.5 billion litres of milk each year and supporting over 60,000 jobs across the rural economy. At the same time, the unique nutritional quality and character of Irish pasture-fed dairy products has been the cornerstone of growing international demand for Irish dairy products, which command price premiums in more than 140 markets worldwide.

Like most dairy industries worldwide, the economics of Irish dairy production have changed substantially during the last decade. While greater volatility in family farm income is a significant feature of the expanded dairy industry since the abolition of the milk quota regime in 2015, the average dairy family farm income has increased substantially since the years before quota abolition (€39,689 per farm in 2008-2010 versus €95,689 per farm in 2022-2024). This growth reflects higher milk prices and strong economic returns from investment in technological development on Irish dairy farms. While the dairy industry faces significant challenges in terms of regulation, increasing international trade uncertainties and generational renewal, the current profitability of the sector has created the opportunity for family farms to continue to innovate and develop more sustainable farming systems, while strengthening the financial position of these farms to invest and develop further for future generations. This paper will focus on key opportunities inside the farm gate to sustain progress over the next decade.

Innovation in uncertain times – the business cycle on Irish dairy farms

Growth in revenues and profits are the yardstick by which we measure the success and health of all businesses. Although different businesses may have various motives for pursuing year-on-year growth, one of the primary reasons is to keep pace with cost inflation, which can strain finances by reducing the purchasing power of earned income. Growth is crucial for long-term business survival, enabling businesses to maintain profitability against inflation, economic downturns and periods of low product prices. While some businesses grow to become larger operations, increased operational scale is not the only avenue to increase business value. Businesses can also grow by reducing costs, simplifying production practices, or gaining unique market advantage. Indeed, all businesses go through the various stages of the business growth life cycle illustrated in Figure 1. Unforeseen challenges are inevitable; disruptions to production can occur due to external shocks, rapidly rising production costs, international trade flow disturbances or restricted access to required primary production resources. Without innovation, businesses typically mature and eventually decline as competitors find better methods and new technologies to gain competitive advantage.

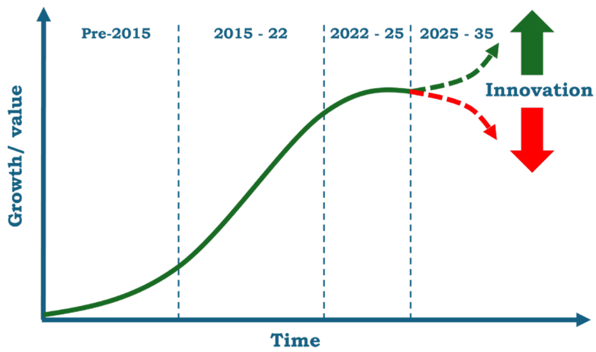

Figure 1. *The importance of innovation in the recent and projected future business cycle of Irish dairy farms during the period from 2015 to 2035*

On pasture-based dairy farms, the impact of turbulence is magnified by the impact of unseasonal weather events on feed supplies and workload. Despite this, the expansion of Irish dairy production during the past decade has followed a typical business growth cycle and represents the most recent chapter in a consistent story of multi-generational innovation. While innovation may seem like an abstract or disruptive concept to dairy farmers, consistent improvements in basic practices such as breeding genetically superior animals, building soil fertility and improving grazing management practices have contributed to increased pasture utilisation and improved business profitability during the last decade. These innovations have improved the financial strength of farm businesses, allowing further investment to improve productivity and reduce workload on these farms for the future.

With the exception of 2021 and 2022, during the last decade family farm income (FFI; National Farm Survey) on Irish dairy farms grew at a similar rate to the average wage rates in other sectors of the national economy (Figure 2).

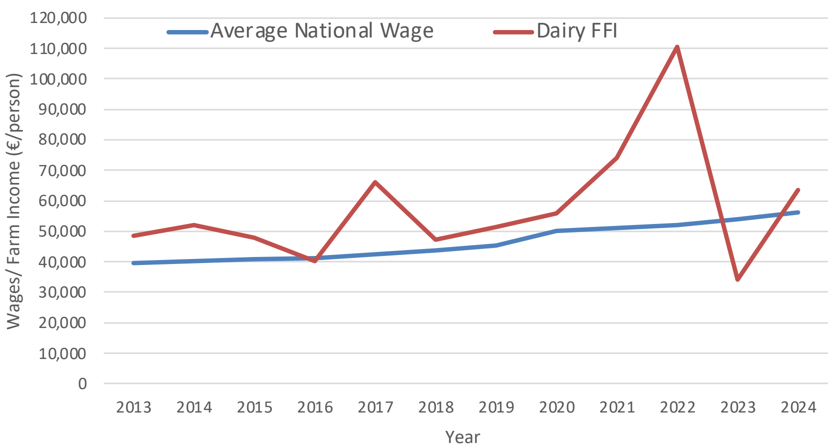

Figure 2. *Trends in average (nominal) national wage rates and dairy family farm income (FFI) per family member employed on Irish dairy farms (2013-2024, inclusive)*

While average wages in the domestic economy have grown by 3% per annum (Compound Annual Growth Rate; CAGR) during that period (from €40,186 to €54,068 per full time employee; Source: Central Statistics Office (CSO),2025), more than half of this increase has been offset by historically high annual inflation during the same period (equivalent to a CAGR of 1.9%). Consequently, while nominal wages increased by approximately €13,900 during the period for the average employee, the increase in real wages was considerably lower at just €4,500. In comparison, average FFI per full time family equivalent (FTE) increased from €49,419 to €69,397 in nominal terms, with a real increase of €8,000 per FTE after accounting for inflation. While FFI and national wage rates aren't directly comparable due to differences in working hours and the use of owned resources on farms (land, labour and capital employed), the growth in FFI has been crucial to maintaining the financial viability of Irish family-run dairy farms. Despite the strong performance of Irish dairy farms during the period, the combination of rising costs and lower milk prices in 2023 is cause for concern, as it led to a significant decline in real FFI, a scenario that could recur in the future.

Irish dairy health check: cost inflation masked by higher milk prices

Dairy enterprise net profit margins are forecast to increase by 35% in 2025 (increasing from €1,578 per ha in 2024 to €2,126 per ha in 2025; Teagasc Outlook, 2025). Despite this positive outlook, dairy farmers should not be complacent. The cost of producing milk on Irish dairy farms has also increased substantially in recent years (increasing from 26.8 c/l in 2021 to 38.2 c/l in 2024; Figure 3) while there is little guarantee that current milk prices will persist into the future.

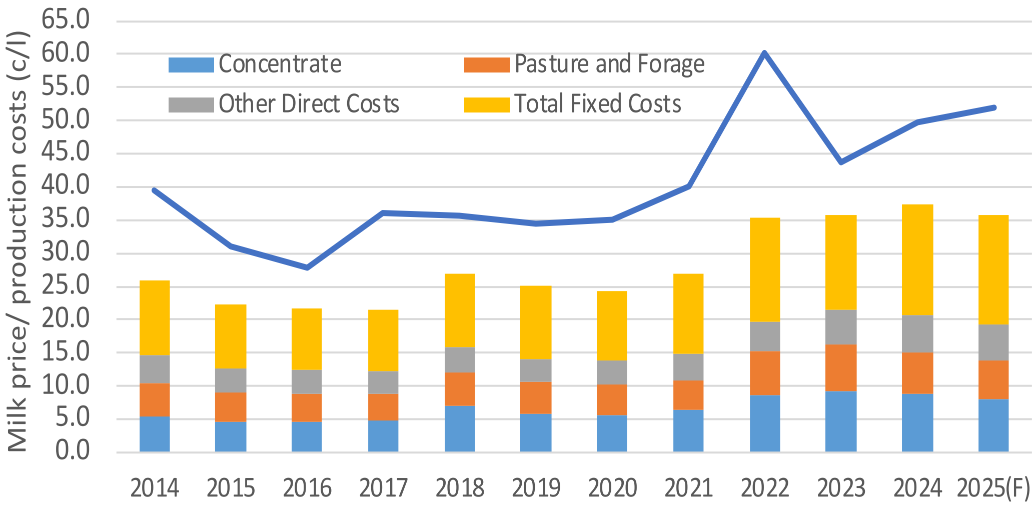

Figure 3. *Milk price (blue line) and production costs (bars) on Irish dairy farms over the last decade and forecast for 2025*

Source: *Teagasc National Farm Survey*

Among the main cost items, feed costs remained high throughout 2024 (+75% compared with 2020), and this will likely contribute to continued inflationary pressures on dairy farms for much of 2025. Purchased feed costs accounted for a quarter of the increase in total production costs since 2020, driven by both increased usage levels and increased costs per tonne. Concentrate usage on Irish dairy farms is largely independent of stocking rate (Figure 4) and has been increasing year-on-year over the last decade (945 kg per cow in 2014 to 1,216 kg per cow in 2023). The rise in production costs can also be partly attributed to increased depreciation charges, stemming from substantial capital investments in machinery and buildings made during the period of higher milk prices in 2022.

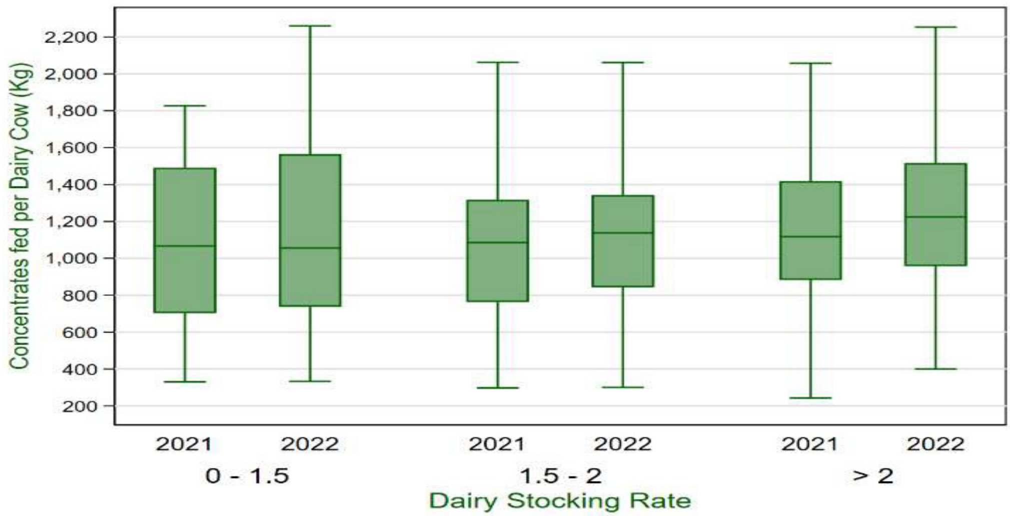

Figure 4. *Distribution of concentrate feed use per cow by whole farm stocking rate in 2021 and 2022*
Source: *Teagasc National Farm Survey*

Focusing primarily on milk production levels (e.g. milk solids/cow) rather than profitability indicators during periods of strong milk prices can tempt farmers to chase marginal milk by feeding more purchased feed. The most profitable farms, however, consistently produce high levels of milk solids without increasing feed costs, and do so instead by maintaining high levels of grazed pasture utilisation.

Looking ahead: next steps to futureproof Irish dairy farm businesses

Individual dairy farms vary considerably in multiple characteristics: family circumstances, enterprise mix, stage of development, soil type and farm system components. Nonetheless, all farm families must plan to further develop and strengthen their farm businesses over the next decade using research innovations and new technologies to maintain economic viability. The remainder of this paper focuses on three key areas where we believe there are opportunities to develop improved practices that will enhance the resilience of Irish family-run dairy farms over the next decade.

Doing the basics well: reducing costs and increasing pasture utilisation

When inflation increases, businesses must operate efficiently to offset rising costs, and wasteful spending can quickly erode profit margins. By cutting unnecessary expenses, businesses can increase efficiency, not only offsetting inflationary pressures but also enhancing long-term profitability. While the outlook for dairy production remains positive, dairy farmers should use the breathing space afforded by high milk prices to benchmark their business performance against key technical indicators and identify areas for improvement. The most profitable dairy farms consistently do the basics of pasture-based milk production to a high standard (Table 1).

To that end, given the overall importance of feed costs to total costs on pasture-based dairy farms, improving pasture productivity remains the cornerstone of efficient grazing systems. The priority should be to enhance profitability by increasing grazed pasture utilisation with high EBI cows, improving sward quality, and aligning stocking rates with the farm's grass growth potential. The key performance indicators for Irish grazing systems are outlined in Table 1 and provide the foundations for profitable pasture-based dairy farming over the next decade.

Table 1. *Key performance indicator targets for Irish dairy farms in comparison with current average and top 10% of dairy farms on profitability per hectare*

Key performance indicator	Current	Top 10%	Target
Economic Breeding Index (€)	198	230	>240
Six week calving rate (%)	68	80	90
Optimum soil fertility (% farm area)	24	75	>90
N fertiliser applied (kg chemical/ha)	147	200	150
Pasture clover content (%)	0-5	5-10	>20
Concentrate fed (t/cow)	1.2	0.9	<0.5
Pasture utilised (t DM/ha)	8.0	11.5	>12.0
Grazed pasture in the diet (%)	55	60	>65
Milk solids sold (kg/ha farmed)	900	1,250	>1,200
Total production costs (€/kg MS)	6.50	5.50	4.75
Net profitability (€/kg MS @ 35 c/l base)	0.06	1.25	2.00
Farmer work hours (h/week; Feb- June)	61	51	< 48

Making dairy farms great places to work

Much of the past decade of Irish dairy farming has been defined by linear growth, with more cows, increased milk output and improved production efficiency. Collectively, these changes have driven significant gains in farm incomes and rural development. The next growth phase on dairy farms will demand greater dynamism, with excellence in business and people management becoming increasingly important. Central to this transition is the need to make dairy farms more attractive workplaces by recognising the growing importance of work-life balance for all farm workers and by creating innovative, appealing working environments for the next generation. Studies have consistently highlighted that long working hours, limited time off, and a range of stressors (such as weather, market prices and disease outbreaks) contribute to negative perceptions of dairy farming as a desirable career path. Worryingly, one in three dairy farmers have stated that they would not encourage young people to pursue a career in dairying. At the same time, increased access to higher education, a buoyant labour market with alternative career opportunities, and evolving expectations around work/ life balance further intensify competition for talent. Data from the CSO shows the aging demographic of Irish dairy farmers and has highlighted generational renewal as an emerging structural challenge for the sector (Figure 5). This alarming change in age demographic raises urgent questions about who will run Ireland's dairy farms in the years to come.

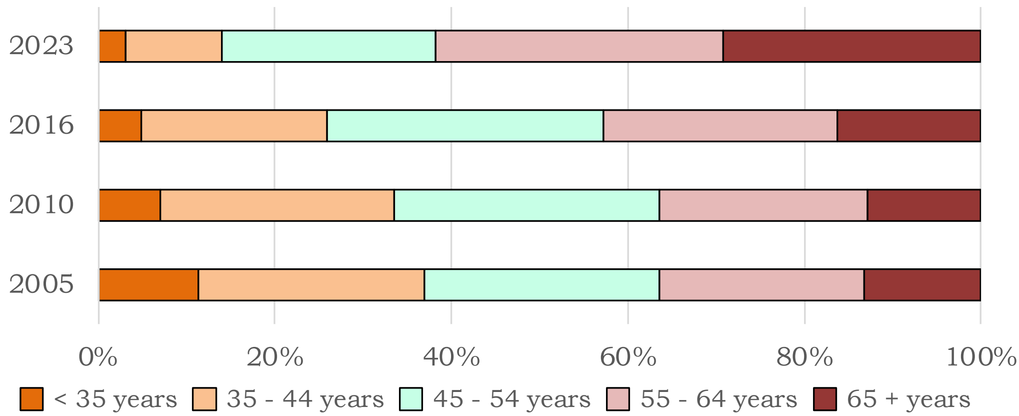

Figure 5. *Age demographic of Irish dairy farm holders (CSO data, multiple years)*

Recent research has identified three key primary considerations that influence young people's career choices: income, job satisfaction, and working conditions (Table 2). Given the evolving expectations of both current and future farmers, it is increasingly apparent that improving working conditions and enhancing the attractiveness of dairy farming as a career are critical for both generational renewal and making farms better workplaces for all involved.

Table 2. *Factors influencing leaving certificate agriculture science students future career choices (n = 976 students surveyed)*

Factor	1st choice %	2nd choice %	3rd choice %	Percentage of all students that indicated factor %
Pay/income	40	28	16	77
Job satisfaction	37	18	19	68
Working hours/time off	13	31	27	64
Location	1	3	8	10
Skills required	3	4	3	8
Career opportunities	1	2	3	5
Others[1]	6	15	24	40

[1]Others include job availability, job security, exam results, and agricultural/ farm related apprentices

Based on these findings, we propose three key benchmarks to guide the development of attractive farm systems. While these benchmarks should not necessarily be regimental, they should offer a mechanism to give all those working on farms greater control, autonomy, and flexibility while creating more time away from the farm and improved work/life balance. The three key benchmarks are as follows:

6pm finish time - Achieving an earlier end to the working day is essential to align dairy farming with the working hours of other employment opportunities that are increasingly competing for labour and prospective successors. Importantly, this target should not be achieved by simply starting earlier, but rather, should shorten milking interval (16: 8 hours) and optimise work organisation to shorten the length of the working day. During peak periods (e.g., calving and breeding) this may be more challenging, however, core essential tasks, such as milking and calf feeding, should be completed within this time frame, with only critical additional tasks (e.g., night checks) taking place as appropriate. Technologies such as batt latches (to support on-off grazing) and nighttime feeding to reduce night calvings can help with this.

Maximising farm profitability - Competitive farm incomes are essential to attract and retain skilled individuals within a buoyant national labour market, and dairy careers must offer competitive financial rewards and greater autonomy. Profitability must underpin any strategy to improve working conditions and sustain viable farm businesses.

The farmer completing 10 milkings per week and taking a two-week annual holiday - To futureproof dairy businesses and retain skilled people, farms must develop systems that enable greater flexibility—allowing time off without compromising farm performance. This transition will require a significant change in mindset. It does not mean that farmers are required to take time off, but rather that they have the option to do so, whether to rest, invest time in other parts of the business (e.g., business planning), or pursue hobbies. Particularly in profitable years, such flexibility can help ensure long-term sustainability by reducing burnout and improving decision-making. This flexibility can be achieved by training relief milkers, additional employees, or adopting flexible milking strategies. We suggest that farmers should be targeting to complete 10 milkings per week, with the additional milkings being completed by workers as appropriate to the farm system (e.g., relief milkers, staff or family). This involves a significant mindset shift in terms of attracting, trusting and developing a capable farm team. Having this team in place will give greater opportunity for the farmer to take time-off and holidays at essential times (e.g., family events, emergencies) as there will be people available that are familiar with the farm system.

Another option is to use flexible milking frequency, particularly from July onwards; where research indicates minimal impact on milk solids yield during the second half of lactation. These approaches are widely used in New Zealand, where 59% of farmers adopted some form of flexible milking (such as 10 milkings in seven days, three milkings in two days, or once-a-day milking) during the 2023/2024 season.

Table 3. *Work organisation effectiveness benchmarks and targets for farms from the 1st February to 30th June*

	Average	Top 25%[1]	Target
Start time	06:48	06:47	07:00
Finish time	19:08	18.25	< 18.00
Farmer workday length (hr)	12.3	11.4	< 11.0
Farmer work (hr/week)	61.1	51.2	< 48
Farmer days off per year (holidays and weekend days)	19	33	>60[2]

[1]Selected based on the farms ranking for work organisation effectiveness; [2]Allowing one day per week off and a two-week holiday on average

To achieve these benchmarks, four foundational practices must be embedded on all farms:

- **16:8 hour milking interval** - A prolonged interval between the morning and evening milkings is the primary driver of long working days. Current data indicates that the average milking interval on Irish farms is 9 h 48 m. Concerns that shortening the interval between the morning and evening milkings to 8 h will result in reduced milk yield are unfounded. Multiple Teagasc studies, corroborated by international research in France and New Zealand, confirm that reducing the interval to 8 h has no negative impact on milk yield or somatic cell count. This presents a clear opportunity to shorten the working day without compromising productivity.
- **Proactive workforce planning** - A recent Teagasc study identified workforce planning as one of the most effective strategies to manage workloads, particularly in spring. Ensuring that skilled labour (family members, students, or employees) is available to support key tasks and provide cover during emergencies is crucial. The key message from farmers involved in that study was that being proactive and flexible around sourcing this labour was essential, and to cast the net wide. Given the positive economic outlook for 2025, investing in additional labour and developing the farm team offers a relatively low-cost, high-impact avenue to improve work-life balance and operational resilience on dairy farms.
- **System specialisation and outsourcing** - Contractors for tasks such as slurry spreading and fertiliser application can reduce labour demands and machinery requirements. Despite the additional economic costs, contracting out key tasks does not significantly reduce farm profitability and will improve labour efficiency.
- **Efficient calf rearing systems** - Calf care accounts for approximately 20% of labour input during spring. Strategies such as contract rearing, early sale of male calves, and investing in calf facilities can substantially reduce labour demands. A recent study demonstrated that automatic calf feeders can improve labour efficiency in calf care by 22%, underscoring their potential as a valuable labour-saving investment.

Strategic investment priorities - further investment in productive areas

On farms that are already achieving the key performance metrics outlined in Table 1, the priority should be to use the financial breathing space afforded by higher milk prices to invest in facilities and technologies that both reduce workload and improve financial efficiency. These investments will directly support the achievement of workplace targets such as improved work-life balance and system flexibility. To maximise returns and impact, it is important that investments are made in a planned sequence, prioritising areas that deliver the greatest benefit first. Based on the available research, we recommend the following investment sequence:

- Grazing infrastructure – improvements in soil fertility, reseeding, and roadway infrastructure are relatively inexpensive and deliver rapid and substantial economic returns.
- Facilities development – as milking accounts for the greatest proportion of work time on farm (circa 33%), milking facilities should be prioritised to reduce milking time. Improved animal handling and slurry storage facilities can also make farms safer and more efficient.
- Automation technologies – innovations such as automatic calf feeders, drafting gates, automatic cluster removers, auto-wash, gap release and automated heat detection technologies can further reduce routine workload. Some automation technologies may not significantly reduce overall labour time but can provide greater flexibility, simplify routine tasks, and make day-to-day farm management easier for the farmer and farm workers.

When considering any investment, a cost-benefit analysis should underpin the decision-making. Different farms will be at different stages of development, and some investments will deliver greater returns or prove more beneficial depending on the needs of the farmer.

Making it happen – developing networks and skills to shape future success

Resilience is the ability to adapt to difficult situations, recover from setbacks, and bounce back from adversity. Resilience is an essential skill for all successful farmers (and teams), and a central component of enjoyable and attractive dairy farm businesses. While some individuals are naturally resilient, it is a trait that can be developed and strengthened over time through intentional practices. Building a resilient dairy farm business is hugely important but can only be achieved by developing technical, business and people skills and having a dedicated support network to reinforce best practice.

Discussion group members that took part in a recent survey stated that building support networks including family members, friends and farmer discussion group peers is important to manage and strengthen resilience. The main challenges to resilience that were identified included poor weather, animal ill-health, long working hours in spring, labour shortages and worries over future policy changes. There was no "one size fits all" set of factors that strengthened the farmers' resilience. Several important insights were developed from the survey:

- Knowing the right system for their farm, building cash and feed reserves and improving facilities were all considered important.
- Picking up the phone and calling a family member, friend or a discussion group member was beneficial during stressful periods. Indeed, 87% of farmers had strengthened their support teams in recent years. Of concern, however, 9% of farmers said they did not contact anybody.
- Taking adequate time off is a consistent challenge; 25% of survey respondents had taken no time off between February and May during the previous spring, and 58% had taken only three days off during the same period.
- 87% of those surveyed had a social network for their off-farm interests, which they felt was very important.

Developing the farm team - The farm team is integral to long-term farm business success and includes a wide diversity of people including family members, full time and relief staff, neighbours, contractors, veterinarians, milking machine technicians, electricians, plumbers, farm and milk quality advisors, accountants and bankers, etc. All of these team members provide essential skills at various stages to the business. The more resilient farm businesses are generally more transparent with the farm team, collecting and sharing benchmarking information regularly, and collectively identifying and solving problems quickly.

Skills development - The next 10 years of development on Irish farms will be underpinned by farmers developing additional skills to manage larger more complex businesses. Table 4 provides a list of key skills required within the farm team to deliver improved business performance in a positive and supportive work environment that will attract and encourage a new generation of talent to the sector in future years.

Table 4. *Developing the farm management skillset for further development.*

Skill area	Key skill descriptions
Personal	
Self-care	• Rest, nutrition, exercise, monitor health
Time management	• Set start and finish time, lead by example • Plan work organisation (prioritising jobs/activities) • White board and "to do" lists • Weekly farm meetings with staff participation • Operational plans (long- and short-term) • Time off to match industry standards, including two week holiday per year
Networks	• Team and family communication • Active participant in a discussion group • Local community engagement
Technical	
Grassland	• Frequent measurement and decision making
Livestock	• Livestock care, biosecurity, herd health
Technology/ innovation	• Building a more attractive farm workplace
Business	
Financial planning	• Record keeping, data analysis, benchmarking • Monthly/quarterly/yearly cost control • Annual farm financial analysis
Problem solving	• Identifying problems early and acting accordingly • Data driven decisions
Risk management	• Long term plans and scenario planning • Developing contingencies for challenging periods (e.g., winter feed reserve and cash reserve)

Discussion group participation - Irish farmer-led discussion groups are unique and provide an essential basis for innovation and technical development for farmers. Data from the Teagasc dairy specialist service indicates that there are currently 256 active Teagasc discussion groups across Ireland with approximately 3,200 members. Results from previous surveys highlighted that established discussion groups were more likely to adopt key technologies (such as artificial insemination and milk recording), resulting in improved farm physical and financial performance. The volume of data collected on farms has increased exponentially in recent years. A key factor in the success of discussion groups is the provision of a structured framework for accurate benchmarking, enabling farmers to compare and track trends in key performance metrics against trusted peers. Through benchmarking, farmers can identify key areas for improvement, while the discussion group visits, and on-farm advice can provide the necessary impetus for further technological development. All farmers should be part of an active data driven discussion group.

Conclusion

The financial landscape for dairy production has been substantially altered during the last five years, with unprecedented fluctuations in dairy product prices and farm cost hyperinflation. In addition to the ongoing requirement to improve efficiency to meet climate action commitments, dairy farmers must also refocus on prudent financial budgeting to reduce costs and maintain financial margins during 2025. Innovation is essential for businesses that want to stay competitive and resilient during inflationary periods. To that end, the core components of pasture-based milk production systems will continue to be high productivity pasture management, appropriate overall stocking rates, and highly efficient dairy cattle managed in a seasonal compact-calving system. Such systems can be further improved by reducing reliance on increasingly uncompetitive supplementary feed imports, the incorporation of clover into diverse grazing swards to reduce dependence on chemical N inputs and the further refinement of day-to-day operations to reduce workload, simplify systems and improve work-life balance for family run dairy farms.

Accelerating genetic gain

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Summary

- Breeding and reproductive programs are intrinsically linked, even more so now with sexed semen and the capacity to accelerate genetic gain through more intense dam selection
- The Economic Breeding index (EBI), which is used to identify genetically elite dairy parents of the next generation, is scheduled to be revised. Both the relative emphasis on individual traits and the genetic base will be updated
- As a direct consequence of increased use of sexed dairy semen, the use of beef semen in dairy herds is now approximately equal to the use of dairy semen. Use the dairy-beef index (DBI) to identify beef bulls for mating to dairy females; a high beef sub-index value for the bull increases the probability of generating a high commercial beef value (CBV) calf
- Use of sexed semen to generate replacements is having the intended consequence of reducing the number of male dairy calf births, but will require new strategies to generate high EBI male calves suitable for breeding the next generation
- Identifying elite genetic merit dams to be oocyte donors and fertilising the oocytes with semen from elite genetic merit sires can facilitate generation of multiple offspring annually per dam-sire combination. Intense selection using this approach increases the likelihood of generating elite genetic merit offspring for both dairy and beef breeds. New technologies can be used to shorten the generation interval, thereby accelerating genetic gain

Introduction

Animal breeding is a well-established and proven strategy that leverages accumulated genetic improvements over generations, ensuring lasting benefits within the population. Advances in reproductive technologies, especially sexed semen, have the capacity to accelerate genetic gain even further. Breeding programs can deliver desirable changes in multiple animal performance traits simultaneously, even if unfavourably associated with each other. A prime example of this is the ability to simultaneously improve fertility and milk production, despite being unfavourably correlated. The capacity to continue to improve dairy traits without compromising beef performance of the resulting progeny is of growing interest today; this can be achieved through integrated dairy and beef breeding programmes.

The Economic Breeding Index (EBI)

The Economic Breeding Index is 25 years old having replaced the Relative Breeding Index (RBI) at the turn of the century. Each trait within the EBI is weighted according to its relative monetary value; these values are based on informed estimates of future market costs and prices. Global and national markets for feed, fertiliser, and energy significantly affect milk revenue and herd management, and thus, the relative importance of these traits in a breeding index. Like all breeding indexes, the EBI must be designed with future resilience in mind. This forward-looking approach justified the inclusion of a carbon sub-index within the EBI in 2022 and underpins ongoing research on genetic variation in methane emissions and nitrogen use efficiency.

The economic values in the EBI are undergoing a review in 2025; they were last updated at the end of 2022. The economic value on each trait in the EBI is defined as the expected change in profit per unit change in that trait, holding all other traits in the EBI constant. The relative emphasis on each trait in the EBI is the product of both the economic value and the quantity of genetic variability in that trait. For example, if all animals are genetically similar for a trait, it contributes little to distinguishing between animals even if it has a large economic value. Hence, a trait receiving little emphasis in the EBI does not necessarily imply the trait is not economically important, but could simply reflect little underlying genetic variability. The relative emphasis on traits in the EBI are indicated in Figure 1.

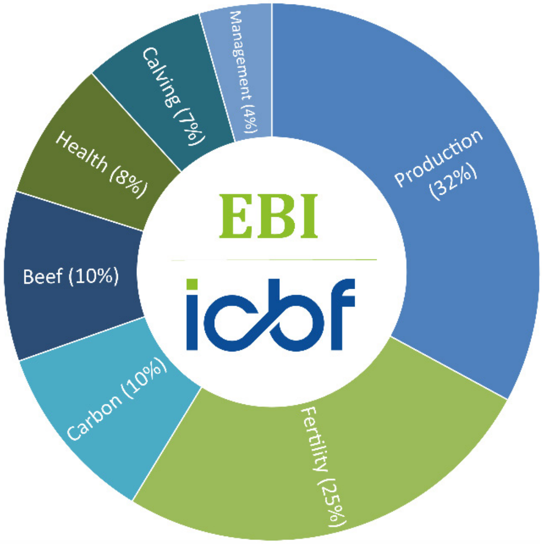


Figure 1. *Relative emphasis of each sub-index within the current EBI (spring 2025)*

The base population in genetic evaluations

In genetic evaluations, a base refers to a defined population of animals, typically from the past with extensive records, used as a reference point. Each animal's estimated genetic merit, or predicted transmitting ability (PTA), is expressed relative to this base. For example, if a sire has a PTA of +10 kg for fat yield and is mated to a base dam (PTA = 0 kg), his progeny are expected to yield, on average, 10 kg more fat than the base population if producing in the average environment. The use of a base is common in all genetic evaluations and provides stability in the genetic evaluations across time. This is because over time, as new data is added to genetic evaluations, the estimated genetic merit of all animals is updated. Countries vary in how often they update their base. Some do it annually, others every 3–5 years, while Ireland and some other countries update the base less routinely. Ireland last updated the base for dairy cows in 2016-2017, and this caused the EBI for all animals to drop by €71. The old base for production and fertility was 2005 born cows, calved and milk recorded in 2007, and milk recorded in at least two of the next five years. This is due to be updated to a more recent base for milk, fertility, health and management traits later in 2025; it is expected the new base will be updated to 2015 born cows, calved and milk recorded in the 2017-2019 period. The most important thing to know about a base change is that it has zero effect on the ranking of animals. Although a base change shifts the genetic evaluation of all animals, the shift is uniform across all animals, and therefore does not impact their ranking.

Updating the base has both advantages and challenges. A more recent base keeps evaluations relevant and makes genetically elite animals easier to identify (i.e., those with favourably signed values). It also reflects real genetic gain and highlights progress by trait. However, changing the base means every animal's PTA shifts, usually downward, creating communication challenges and potential confusion. If the base is old, almost all animals today will have values with a favourable sign, which can be misleading. Ultimately, the choice of base is less about scientific accuracy and more about clarity in interpretation.

Beef-on-dairy breeding strategies

A range of factors is contributing to the growing use of beef bulls for mating with dairy females, primarily reflecting the opportunities that arise from using sexed semen to selectively breed the candidate dams of the next generation. There is a greater opportunity, therefore, to mate the genetically inferior proportion of the herd to beef bulls to generate valuable calves.

The dairy beef index (DBI) is comparable to the EBI, but instead of the EBI being used to select dairy bulls, the DBI is useful to select beef bulls for mating to dairy females. The construction of the dairy-beef index is illustrated in Figure 2; one-third of the emphasis is on traits experienced by dairy producers (i.e., calving difficulty, gestation length, calf mortality) while most of the emphasis relates to traits associated with efficient beef production. Like the EBI, however, positive attributes of the bull (e.g., excelling in carcass traits) can mask or compensate less favourable attributes (e.g., difficult calving or long gestation). It is, therefore, crucial to not blindly select bulls solely on DBI but instead, like with the EBI, identify the individual characteristics of bulls most suited to the herd.

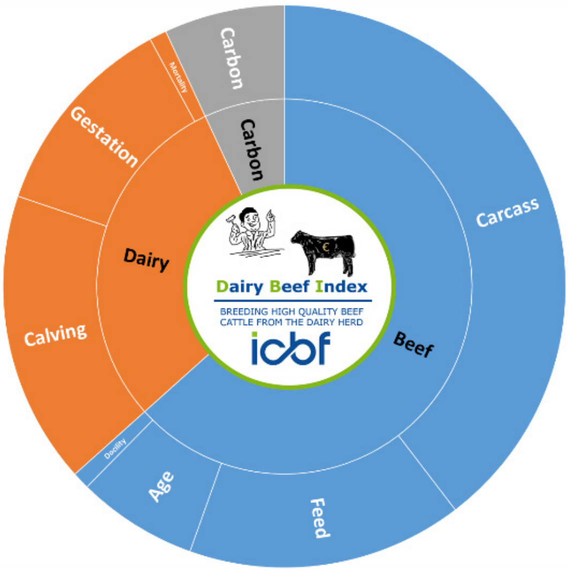


Figure 2. *Relative emphasis of traits in the DBI (Spring 2025)*

The published units of genetic merit for each trait in the DBI (and EBI) is the same as the unit of measure in the field. So, for example, a bull with a genetic merit for carcass weight of +10 kg is expected to produce progeny that have, on average, 10 kg heavier carcasses than the progeny of a bull with a carcass weight PTA of 0 kg assuming mating to the same type of dam. The mean carcass weight PTA of Irish dairy cows is approximately -5 kg; this means that using bulls with a positive carcass weight PTA (anything greater than -5 kg) should, on average, increase the mean carcass weight of the progeny. In fact, based on the average production system, a bull with a genetic merit for carcass weight of +10 kg is expected to generate heifers and steers with a carcass weight of 293 kg and 347 kg, respectively. Similarly, a bull with a genetic merit of +1 day for gestation length is expected to translate to an actual gestation length of 282 days when mated to a dairy cow; the average gestation length PTA of the top 100 EBI dairy bulls on the active bull list is -4.5 days.

The calving difficulty PTA reflects the proportion of calvings that are expected to require considerable assistance or greater. Each beef bull has a separate prediction of his genetic predisposition to cause calving difficulties in heifers and cows. The calving difficulty PTA values of beef bulls are directly comparable to dairy bulls (assuming equal reliability). Although closely related genetically, a bull that is easy calving for cows does not always translate to also being easy calving for heifers. Therefore, when choosing beef bulls (and dairy bulls) for heifers, use the calving difficulty PTA specific for heifers. A bull with a genetic evaluation (i.e., PTA) of 3% is expected to require considerable assistance (i.e., calving jack likely required) in three out of every 100 calving events. However, it is important to take into consideration the trait reliability of the bull. Higher reliabilities indicate less extreme fluctuation in that bull's PTA over time; this is particularly important for stock bulls.

The PTA predictions translate well to reality in the field. Figure 3 indicates the average percentage of difficult calvings for bull calves born to the average Irish dairy cow in 2024 within herds of at least 50 cows that recorded calving difficulty; predictions of genetic merit were from 2023. It also presents the corresponding average calving difficulty for bull calves born to dairy heifers in the same herds. Clearly there is a good concordance between the ICBF-predicted PTA of the bull and the actual percentage of his calvings that required considerable assistance. For example, for a dairy cow mated to a sire with a direct calving difficulty PTA of 3% (i.e., the average of the dataset), 2.9% of his resulting calvings were, on average, recorded as being difficult. In heifers, where the sire PTA for direct calving difficulty was 7% (i.e., the average of the dataset), 7.4% of his calvings were recorded as being difficult. The concordance between genetic merit and actual calving performance was poorer in heifers than in cows, likely due to the greater natural variability that exists in heifers when calving. Nonetheless, this validation exercise clearly demonstrates that there should, on average, be strong confidence in genetic evaluations for calving difficulty. Therefore, only use bulls with published calving difficulty PTAs and stars; these must be specific for dairy cows and heifers and not be confused with calving difficulty PTAs for beef cows or heifers. Although genetic predictions provide an estimate of risk for each bull, individual outcomes may differ; genotyping all stock bulls is important to better manage and monitor this uncertainty.

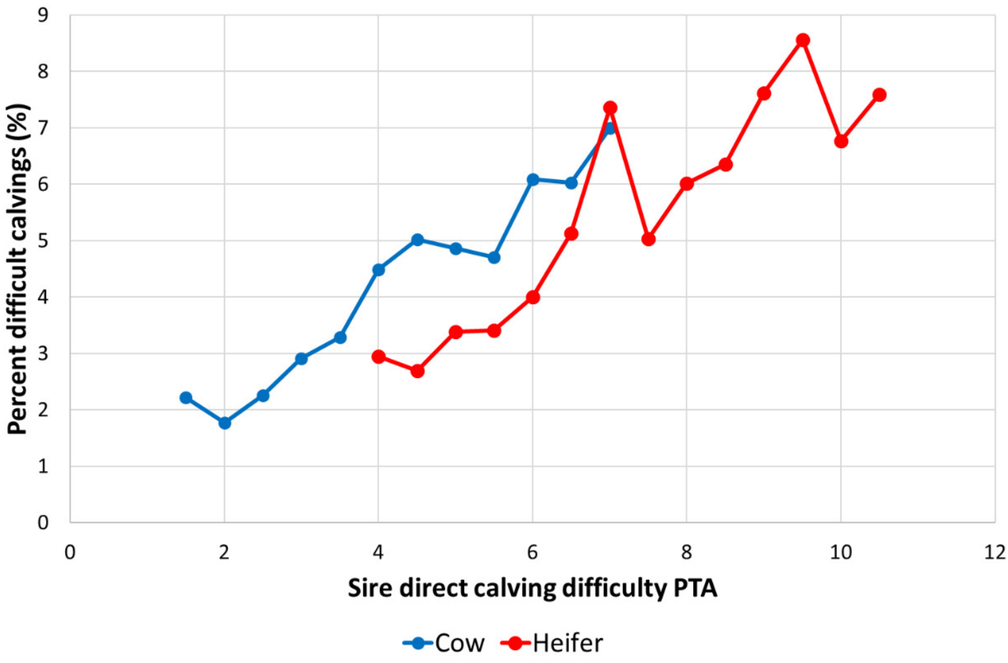


Figure 3. *Mean percentage of difficult calvings in dairy cows (blue) and dairy heifers (red) for sires with different predicted transmitting ability (PTA) for direct calving difficulty in dairy cows and dairy heifers*

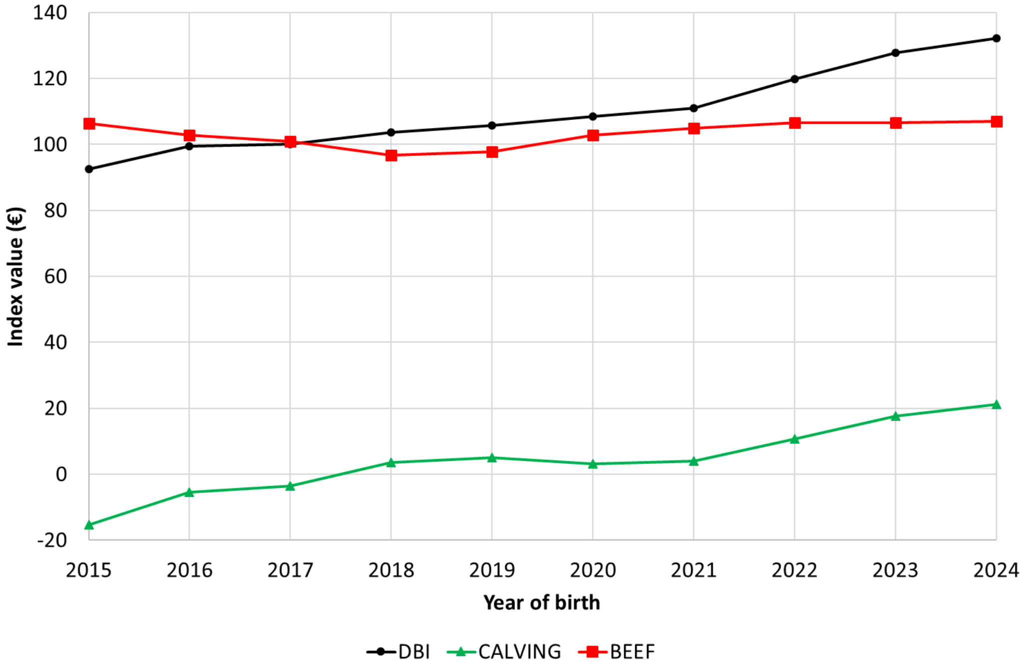


Figure 4. *Mean dairy beef index (black), and the mean beef sub-index (red) and calving subindex (green) of beef AI sires used in dairy herds by year of birth of the calf*

Figure 4 illustrates the average Dairy Beef Index (DBI) of beef AI sires used in dairy herds, by year of calf birth, and includes the mean values of the two primary DBI components, the calving sub-index and the beef sub-index. The mean Dairy Beef Index (DBI) of the beef sires used in dairy herds is improving. In fact, the rate of gain in DBI of €6.43 in AI sires used in the last five years is double that of the preceding five years. By contrast, the annual rate of gain in DBI of stock bulls used is €5.01. Of these gains, 60% to 80% of the improvement was delivered through the calving sub-index. Although the calving and beef sub-indexes are unfavourably correlated, clearly it is still possible to improve both suites of traits concurrently.

Once the team of AI beef bulls has been selected, the ICBF dairy-beef sire advice system can be used to recommend bull-dam matings. The primary objective underpinning the sire advice system is to reduce the likelihood of difficult calvings. Of the bulls selected, the sire advice systems favours the mating of the easiest calving bulls with the females that are more at risk of a difficult calving (i.e., heifers, first parity cows, and cows with a history of calving difficulty), as well as those prone to post-calving disorders (e.g., older cows). The secondary objective of the mating advice system is to recommend matings to maximise the probability of the resulting progeny achieving the minimum carcass specifications for weight and conformation.

Genotyped calves receive a commercial beef value (CBV); the calf must be genotyped to verify the breed composition, sire and genetic merit of the calf. The CBV of the calf reflects the expected profit when slaughtered relative to others of the same animal-type; a €1 difference in CBV is expected to translate to a €1.50 difference in profit at slaughter. The CBV is similar to the beef sub-index of the DBI. On average, high DBI bulls will produce high CBV calves. Greater likelihood of a high CBV calf is possible if bulls with a high beef sub-index within the DBI are used.

Sexed semen

The use of sexed semen in dairy production allows predetermination of calf sex with ~90% confidence. The recent developments regarding the availability and uptake of sexed semen in Ireland have been remarkable, with two commercial sex-sorting labs now operating. The enthusiasm for using sexed semen has arisen for several reasons:

- Large teams of high EBI bulls are now available sexed
- Acceptable pregnancy rates are being achieved across thousands of herds
- Using high EBI sexed semen on the best EBI dams accelerates herd genetic gain
- Using sexed semen to generate replacement heifers at the start of the breeding season ensures that all replacements are born at the start of the calving season the following year
- Sexed-semen facilitates a marked increase in the use of high DBI beef semen to generate all non-replacement calves, which could account for over 70% of the total calf crop. These beef-cross calves are more saleable compared with male dairy calves.

The recent trends and short-term projections for sexed semen use in Ireland, and the implications for the number of male dairy calves born, are indicated in Figure 5.

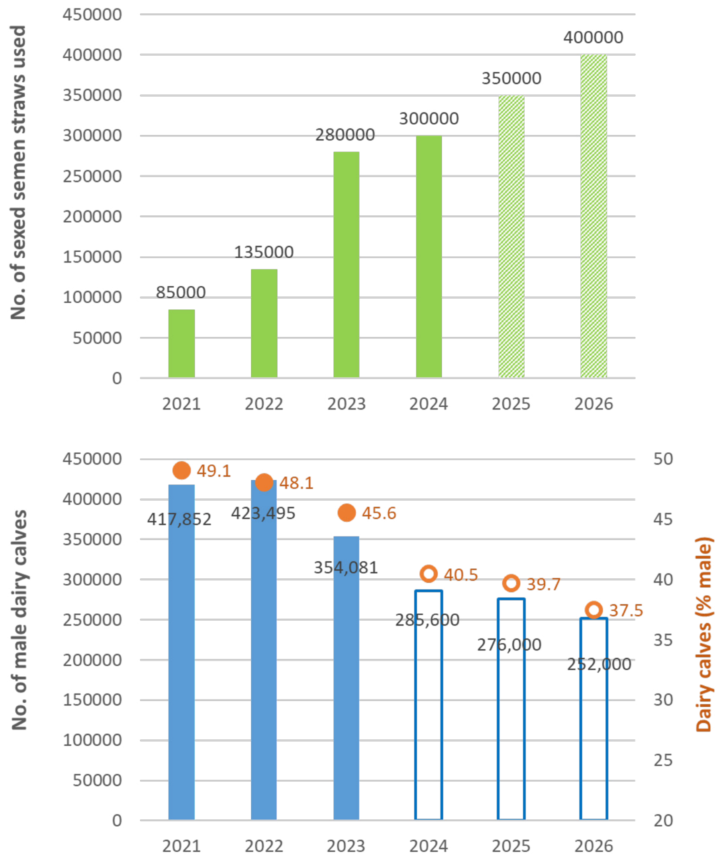


Figure 5. *Top panel: approximate figures for sexed semen usage during 2021 to 2024 (solid bars) and projection for usage in the years 2025 and 2026 (hatched bars). Bottom panel: number of male dairy calves born in 2021 to 2023 (blue bars) and projected number for 2024 to 2026 (open bars), and % (closed orange circle) or projected % (open orange circle) of the dairy-sired calf crop that are male*

Strategies for using sexed semen

The use of sexed semen requires careful consideration: costs per straw are greater, and pregnancy rates per artificial insemination (P/AI) are generally lower compared with conventional semen. Controlled studies in seasonal-calving dairy herds, using both sexed and conventional semen for insemination after detected oestrus or timed AI, have consistently reported P/AI rates approximately 10 percentage points lower for sexed semen.

Several factors contribute to this reduced fertility: sexed semen straws typically contain fewer sperm cells (4 million in sexed straws vs. 15 million in conventional straws); the sorting process may damage sperm; and the fertile lifespan of sexed sperm within the female reproductive tract is shorter. Additionally, the semen's prior exposure to stress during sorting may make it more vulnerable to errors in handling during insemination, such as incorrect thawing temperature or time, cold shock, or delays between thawing and insemination.

Despite these challenges, controlled field studies have also shown that some herds achieve P/AI rates with sexed semen comparable to those with conventional semen, demonstrating that excellent fertility outcomes are possible. Conversely, others experience poor results, highlighting the importance of meticulous technique and attention to detail. Interestingly, field data from New Zealand suggest that when sexed semen is used fresh (i.e., not frozen), non-return rates are similar to those for conventional semen. This indicates that the freeze-thaw process may be a major factor in fertility loss, underscoring the need for strict adherence to thawing protocols. As the technologies used to produce sexed semen continue to improve, the performance gap between sexed and conventional semen is likely to narrow. Successful use of sexed semen requires careful selection of sires and dams, optimal timing of insemination, and precise straw handling on the day of AI (Box 1).

Sire and dam choice

- **Bulls**
  - Pick highest EBI bulls available
  - Use a large team of bulls
- **Dams**
  - **Top 50% of herd based on EBI**
    - Heifers
      - Target live-weight and BCS ≥3.25
      - Cycling regularly
    - Cows
      - Parity 1 to 4
      - >50 days in milk on day of AI
      - BCS ≥3.00
      - Cycling regularly
      - No postpartum disorders or uterine disease

When to use?

- First 3 weeks of the breeding season
- Within first 10 days if possible.

Timing of AI

- 14 to 20 h after heat onset

Fixed time AI

- Costly, but mitigates risk
- Facilitates targeted usage of sexed semen on MSD

Straw handling on day of AI

- Organise sexed straws into one goblet
- Thaw 2 sexed semen straws at a time MAX
- Thaw straws at 35 to 37 °C for 45 seconds
- Load straws into pre-warmed AI guns, keep warm.
- Deposit semen in uterine body
- Complete inseminations within 5 mins

Box 1. *Strategies to maximise success with sexed semen*

Dam selection

The use of sexed semen offers an opportunity to be more selective when choosing the dams of the next generation. These dams should be selected based on both their genetic merit (suitability to generate replacements) and non-genetic factors that influence the likelihood of pregnancy success. Relative to the herd average EBI, the mean EBI of the top 30% of females in a herd (average 30% reliability) is expected to be €51 higher (Figure 6, black dotted line), while the corresponding figure for the top 60% of females is just €28 higher (Figure 6, green dotted line). Hence, there is clearly an advantage of using sexed semen on selected genetically elite dams over and above using conventional semen on all dams. The benefit of dam selection improves if the females are genotyped, thereby increasing the reliability (Figure 6, red line (genotyped, 60% reliability) vs blue line (not genotyped, 30% reliability).

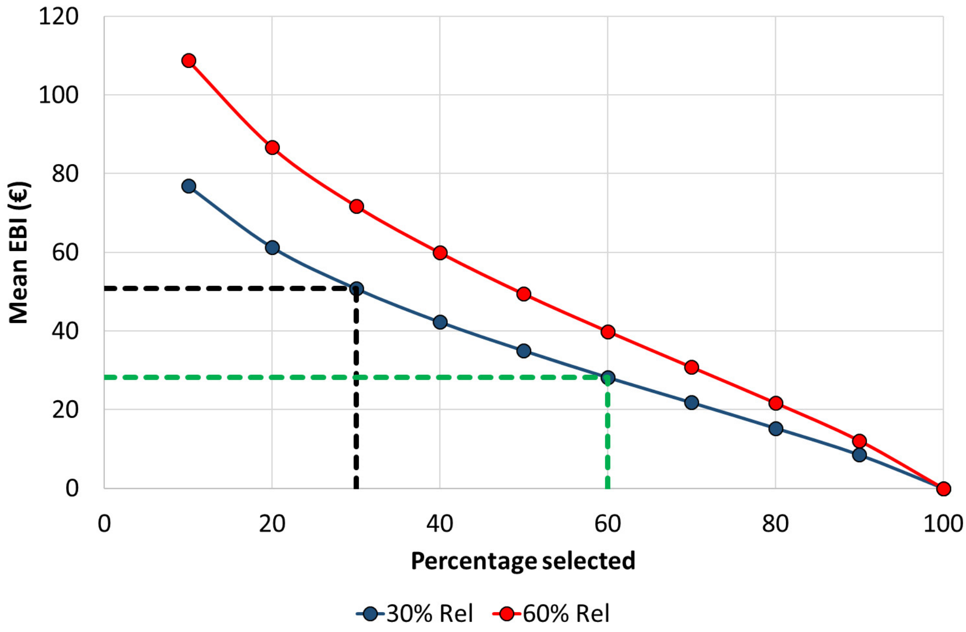


Figure 6. *Expected higher mean EBI above the herd average EBI depending on the proportion of females selected for AI with sexed semen (top 30% = black dashed line vs. top 60% = dashed green line), and how this is impacted by a reliability of 30% (not genotyped, blue line) or 60% (genotyped, red line)*

Considerable natural reshuffling of genetic material occurs during the production of eggs in heifers and cows. The genetic merit of the progeny from a given sire-dam mating is expected to equal the average genetic merit of the two parents. While this holds true on average, considerable variability in genetic merit (e.g., EBI) exists among these progeny. Of course, the higher the EBI of both parents, the higher the expected EBI of the progeny. Nonetheless, a genetically elite female can produce an average calf. However, by genotyping all heifer calf progeny to identify which daughters have inherited the most favourable genes from both parents and then selecting from these, faster genetic progress can be achieved.

Genetic gain through assisted reproductive technologies

The widespread use of sexed semen in dairy herds to generate replacement offspring could hinder the rate of genetic gain nationally as a result of a marked reduction in the births of elite genetic merit male dairy calves. In addition, there will be a greater requirement for semen from beef breed bulls that are suitable for crossing with dairy dams to generate the non-replacement calves. Assisted reproductive technologies, such as multiple ovulation and embryo transfer (MOET) and *in vitro* embryo production (IVP), offer significant potential for accelerating genetic progress in both dairy and beef herds. The MOET method involves stimulating elite cows to ovulate multiple oocytes, which are then fertilised *in vivo* (i.e., in the female reproductive tract) and allowed to develop for one week; the embryos are non-surgically collected seven days later and transferred to recipient dams. The IVP method involves non-surgical harvesting of oocytes, *in vitro* fertilization and embryo culture for seven days, followed by transfer to recipient dams.

For both MOET and IVP, embryos can be frozen for later on-farm thawing and transfer. Both methods enable the production of embryos from elite animals (dairy and beef breeds), offering flexible tools for breeding programs and allowing rapid dissemination of superior genetics. For embryos generated using IVP, sexed semen can be used for fertilization, providing the ability to control the sex ratio of offspring. This allows breeding companies and elite breeders to target specific breeding goals and also control calf sex in both dairy and beef cattle. Use of MOET is typically restricted to pubertal heifers and cyclic postpartum cows. Use of IVP is more flexible, and is conducted on pubertal heifers, postpartum cows and during the first three months of pregnancy (in cows and heifers).

The results of a large, controlled field trial conducted by Teagasc and University College Dublin to compare pregnancy success and pregnancy losses in cows that received timed AI or timed embryo transfer (ET) was recently reported. The study aimed to compare fertility outcomes in seasonal-calving, pasture-based lactating dairy cows following timed AI versus timed ET using fresh or frozen IVP embryos from either dairy or beef breeds. A total of 1,106 cows were enrolled, with 863 receiving ET and 243 receiving AI. Oocytes were collected from live elite dairy and beef donors weekly. The study reported that pregnancy rates on day 32 were similar between AI (48.8%) and ET (48.9%), but significantly less for cows receiving frozen embryos (41.6%) compared with fresh embryos (56.1%). Pregnancy loss between days 32 and 62 was significantly greater for ET (15.1%) than AI (4.7%). Overall, the study concluded that ET can achieve pregnancy rates comparable to AI, especially with fresh embryos. The increased incidence of embryonic loss with ET, particularly with frozen embryos, poses a challenge for maximising reproductive efficiency in dairy herds. The results of a follow-up study that compared the use of conventional and sexed semen for IVF is presented on page 204 of this book.

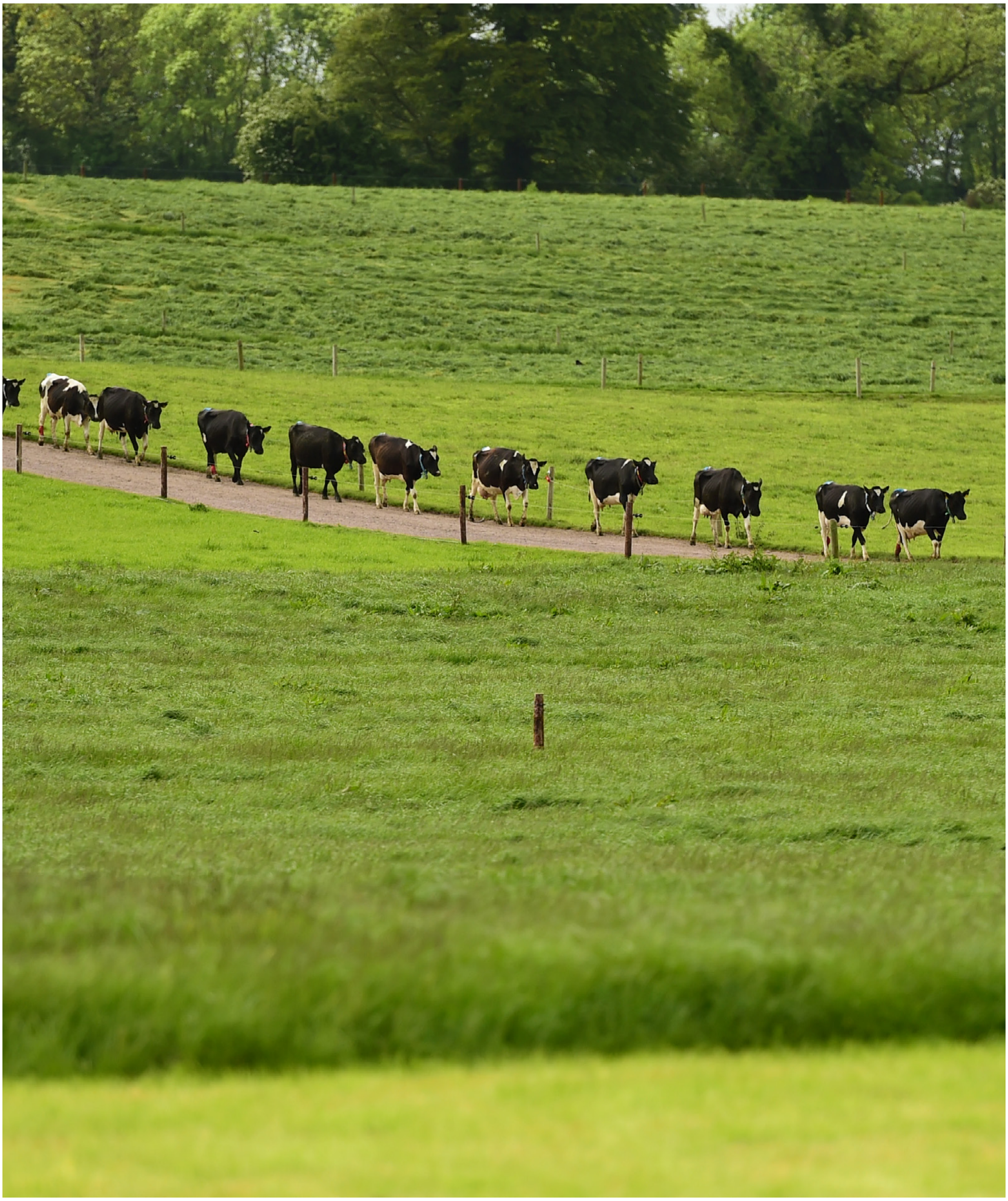
Generation interval is one of the four factors that affects annual genetic gain. Generation interval is the average age of the parents when their progeny were born who, in turn, go on to become parents themselves. While MOET and IVP can be conducted on heifers that have reached puberty, it would be advantageous to be able to generate embryos from elite females at an even younger age. Calves as young as two months of age have an abundant supply of follicles (which contain the oocyte), but before puberty, these follicles do not develop and ovulation cannot occur. Recently, procedures to stimulate follicle growth in calves (2 to 6 months of age) and methods to harvest the oocytes from these follicles have been developed. After the oocytes are harvested, the remaining steps are similar to IVP (i.e., fertilization and culture for seven days, and then embryo transfer to a recipient). The combined sequence of events is called Juvenile In Vitro Embryo Production and Transfer (JIVET), which is the generation of "calves from calves". The genetic dam will be 11 to 12 months old when her first calves are born from surrogate cows, meaning she will already have calves on the ground by the time she reaches puberty.

A trial to evaluate JIVET was conducted at Moorepark in April 2024 in collaboration with University College Dublin and TransOva Genetics, a company based in the US that specialises in providing assisted reproductive technology services. High EBI donor calves were identified, and oocytes were harvested on one occasion per donor. The yield of embryos was highly variable between donor calves (0 to 15), and the pregnancy per embryo transfer was less than what is normally achieved with heifers that are bred using AI (39% vs >60%); the trial did, however, demonstrate the feasibility to generate "calves from calves" within the constraints of a seasonal-calving system. Improvements in calf donor management and embryo production techniques in the coming years could mean that JIVET, complemented by MOET and IVP in older animals, will provide sustained genetic gain in dairy and beef breeds. More details on this study are reported on page 206 of this book.

Despite their promise, ARTs face several practical challenges in seasonal-calving systems. One key issue in seasonal calving systems is the restricted availability of recipient dams, as the timing of embryo transfer must align with the fixed breeding season. Additionally, there is still room for improvement in the success rates of frozen-thawed IVP embryos, as pregnancy loss was greater for embryos that were frozen compared with embryos that were transferred fresh. Further advancements in these technologies are likely to drive greater adoption in the future, particularly as the economic benefits of using them become more apparent.

Conclusion

National breeding indexes like the EBI (for selecting dairy bulls) and DBI (for selecting beef bulls) need to be forward-looking since the peak expression of genes of new AI bulls does not occur for several years. The emphasis on each trait within these breeding indexes is regularly reviewed and, where necessary, updated to reflect future anticipated trends. Sexed dairy semen can be used to generate replacement dairy females from suitable high EBI cows with the remainder of the cows mated to beef semen to increase the value of the resulting calves. Great opportunities exist for the dairy industry that can be readily exploited using innovative breeding and reproductive solutions.



Management strategies to increase grass dry matter performance on Irish dairy farms

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Summary

- Annual pasture dry matter (DM) production averaged 13.2 t DM/ha on PastureBase Ireland farms from 2014-2024, but an additional 2 t DM/ha is achievable on many farms
- Soil pH is improving on dairy farms, but soil fertility is suboptimal on 76% of soil samples tested
- Key farm pasture cover targets are not being achieved
- Precision nitrogen management with grass/clover swards is a critical component of grazing management
- Pasture measurement needs to be used in combination with other decision supports tools. PastureBase Ireland provides several grazing management tools to improve grazing management decisions

Introduction

Irish grassland dairy farms have experienced significant transformation over the past decade. Stocking rates have increased and chemical nitrogen (N) fertiliser use has decreased, but farms face new challenges such as greater weather variability and higher input costs. When long term meteorological data from the period 1991 to 2020 was compared with the period 1961 to 1990, Ireland's climate has become 0.7 ˚C warmer and 7% wetter. Increased frequency of intense rainfall events in the spring and autumn leads to problematic grazing conditions, as well as delayed nutrient applications (organic and chemical fertiliser). Prolonged periods of moisture deficit (June-August) reduce peak grass growth. The main challenge facing dairy farmers today is to increase grass growth and grass utilisation. While grass growth varies daily depending on the prevailing weather conditions, the grassland industry has made major technological improvements in recent years to assist grassland management decision making. Growing grass at a consistent level ensures that the farm is less dependent on imported feed (concentrate and purchased silage) to sustain the farm stocking rate. Additionally, the Climate Action Plan 2023 set a national maximum limit for chemical N use of 300,000 tonnes (t) by 2030; 282,000 t were used in 2023, and 310,000 t were used in 2024. A key target of Irish grassland dairy farms is to be able to grow the required level of herbage on-farm consistently to support their farm stocking rate, with reduced N inputs. Successful grazing management is the 'sum of all the parts'; when one of the key components is not in place, grassland performance declines. The objective of this paper is to explore the options available to improve current grazing management practises and discuss the strategies to increase farm herbage growth capacity.

Cost of Grass – varying grass Dry Matter production

Grazed grass is the cheapest feed source available on Irish grassland farms, with grass/white clover swards being particularly cost effective. The most recent analysis of feed costs indicated that well managed grass swards growing 13 t DM/ha/yr costs €96/t DM, while grass/white clover swards costs €85/t DM, and multispecies swards costs €88/t DM. These costs all compared favourably relative to pit silage (€230/t DM), baled silage (€262/t DM) and concentrate (€326/t DM). When DM yield was reduced to 11t DM/ha, the cost of grazed grass increased to €110 DM/ha, but when DM production increased to 15 t DM/ha the cost of grazed grass reduced to €80 DM/ha. Clearly increasing grass DM production and utilisation can lead to a substantial reduction in feed costs. Consistently achieving high DM/ha production performance is a key strategy to dilute the total farm feeds costs.

PastureBase Ireland

PastureBase Ireland (PBI) was developed and launched nationally in 2013. There have been significant amendments and additions to PBI during the last 12 years, which has resulted in improvements for the end user. There has also been a steady incremental increase in the number of dairy farmers recording grassland measurement, with >7,000 users now using the system. In 2023, the Moorepark St. Gilles (MoSt) grass growth model was incorporated into PBI, providing a 7-to-10-day grass growth forward prediction for a subset of individual farms. In 2026, the MoSt grass growth model will be rolled out to any farms that complete >30 farm walks per year, are linked to a local or private weather station and that record and upload all fertiliser inputs to the system.

Grazing management performance on PastureBase Ireland farms

Grazing management and grass DM production data from 263 farms recording >35 covers on PBI annually over an 11-year period (2014-2024) are summarized in Table 1. Annual pasture growth averaged 13.2 t DM/ha during that period, with 7% variation in DM production (+/- 907 kg DM/ha) between years. Spring pasture DM production had greater variation compared with summer and autumn (Table 1). On average, over the 11 years, spring (Jan-April) pasture DM production was 1.8 (+/- 0.3) t DM/ha, summer (May-July) DM production was 6.2 (+/- 0.5) t DM/ha, and autumn (Aug-Dec) DM production was 5.3 (+/- 0.3) t DM/ha. The average number of days at grass ranged from 274 to 296 days between years, with an overall mean of 285 grazing days. Mean pre-grazing herbage mass declined from 1,611 kg DM/ha in 2014 to 1,474 kg DM/ha in 2023, which is in line with recommendations and was associated with an increase in the number of defoliation events per year (7.1 to 8.1).

Table 1. *Seasonal and annual DM production (tonnes DM/ha) over eleven years (2014-2024) on a sample of PBI farms (n = 263)*

Year	Spring	Summer	Autumn	Annual	No. of grazing and silage events
2014	16	6.4	5.1	13.1	7.1
2015	1.7	6.4	5.5	13.6	7.5
2016	1.4	6.6	5.6	13.6	7.9
2017	2.2	6.5	5.6	14.3	7.9
2018	1.3	5.0	4.9	11.2	6.7
2019	2.1	6.6	5.2	13.9	7.9
2020	2.0	6.4	5.5	13.8	8.0
2021	2.1	6.1	5.7	14.0	8.4
2022	1.9	6.0	4.6	12.5	8.2
2023	1.9	6.0	5.3	13.2	8.1
2024	1.7	5.6	4.9	12.3	8.1

Grazing management improvements

Stocking rates have increased over the 11-year period; the average stocking rate on the milking platform has increased from 2.8 livestock units (LU)/ha in 2014 to 3.0 LU/ha in 2024. The level of pasture allocation to the herd has remained constant, at 3.7 t DM/cow. Supplementation of cows with both conserved forage and concentrate increased over the 11-year period. During the first four years of data collection, supplementation with conserved forage and concentrate averaged 290 kg DM/cow and 520 kg/cow, respectively. During the last four years of data collection, these figures had increased to 550 kg DM/cow and 959 kg/cow, respectively (Table 2). This is a key area of concern. The increase in supplementation during the grazing period is due to reductions in cumulative herbage production (particularly during the last three years), increased stocking rates, and a significant decline in chemical N input, which has resulted in input swapping on many farms in the last number of years (i.e., swapping chemical N fertiliser input for concentrate input).

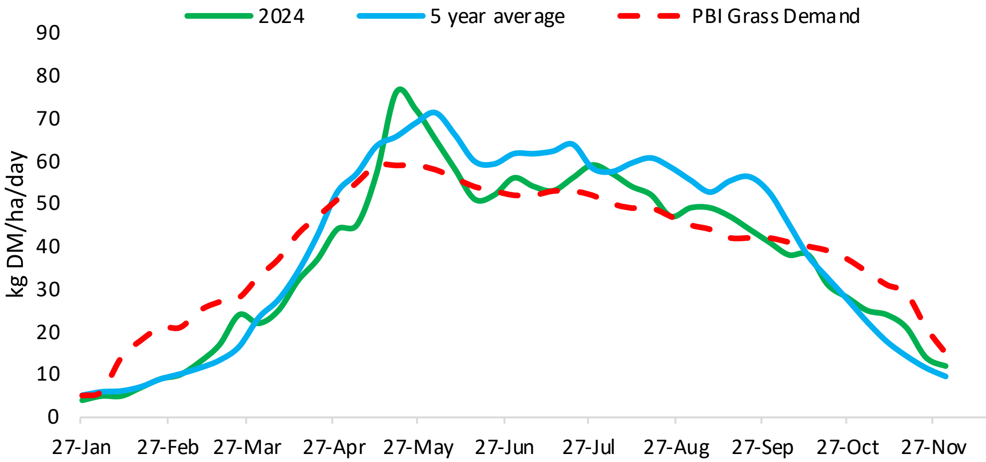

Figure 1. *Weekly grass demand and grass growth on Pasturebase Ireland dairy farms (2013-2024)*

The weekly pasture growth rate in 2024, the 5-year average weekly pasture growth rate (2019-2024) and the average PBI farm grass demand over the same period are illustrated in Figure 1. Daily pasture demand was approximately 40 kg DM/ha per day. The mid-season period (1st May-31st July) had the highest daily pasture demand of approximately 59 kg DM/ha per day, and average pasture growth rate was 60 kg DM/ha over the same period. The year-to-year variation in daily pasture growth rate has increased in recent years, largely caused by prolonged periods of either rainfall surplus or deficit, directly contributing to the significant increase in supplementary feeding levels in Irish dairy systems. In recent years, there has been a strong focus on spring grazing management; the date that the first rotation began advanced from Feb 21st to Feb 5th (2014-2024). The second rotation is also starting earlier (April 8th vs April 2nd). These changes have resulted in an increase in grass demand earlier in the season, but spring grass growths rates have not increased in tandem with this increase in demand. This shortfall in spring grass supply has been replaced with increased concentrate and silage supplementation in early lactation (Table 2).

Table 2. *The overall and seasonal grass demand and concentrate and forage input over the grazing season from 2014 to 2024*

Year	Overall annual pasture demand (kg DM/ha/day)	Spring pasture demand (kg DM/ha/day)	Summer pasture demand (kg DM/ha/day)	Autumn pasture demand (kg DM/ha/day)	Overall annual concentrate offered/cow	Conserved forage offered/cow per year
2014	41	23	60	39	400	261
2015	43	27	63	41	464	262
2016	43	22	65	41	587	325
2017	45	30	64	43	622	315
2018	35	19	51	39	1,122	566
2019	43	27	60	43	750	356
2020	42	27	58	41	799	519
2021	42	27	59	42	857	474
2022	39	26	58	36	1,009	599
2023	42	25	56	42	892	538
2024	41	25	59	40	1066	587

Farm cover grassland targets

There are many factors that influence pasture productivity and production; soil fertility (soil pH > 6.5 and index ≥3 for P and K), sward renewal (8-10% reseeded and 15-20% over-sown each year), grazing infrastructure (paddock size and roadway network) and grazing management (seasonal grazing management and farm cover targets). All these factors are under the farmer's control. Across the grazing season, key farm cover targets should be achieved to maximise overall herbage production to 15 t DM/ha/yr (Table 3). The key targets across the year are outlined in Table 4, briefly:

- >1000 kg DM/ha average farm cover in early February (opening farm cover)
- 600 - 650 kg DM/ha average farm cover in early April (start second rotation)
- 150 - 180 kg DM/LU during mid-season (April to August)
- 1100 kg DM/ha average farm cover in mid September (peak farm cover)
- >750 kg DM/ha average farm cover on December 1st (closing farm cover)

Table 3. *Target blueprint to grow 15 t DM/ha*

Growth period	Target grass production	Current PBI farms performance (2013-2024)	Top 100 farms in PBI (2013-2024)*
	Tonnes DM/ha		
Spring (01/1-30/4)	2.6	1.8	2.1 (2.2)
Summer (10/5-31/7)	6.7	6.2	7.1 (6.8)
Autumn (01/8-31/12)	5.7	5.3	6.1 (5.9)
Total	15.0	13.2	15.3 (14.8)

**Figures in brackets are the average values from 2020-2024*

Spring management

Grazing management in the first two months after calving largely determines spring grass growth and how well-fed cows are before breeding. Spring can be a time of low pasture availability due to low growth rates, especially if closing farm cover was behind target. Ensuring the availability of sufficient herbage for grazing in early spring requires appropriate closing grazing management in autumn, spring N fertiliser application (timing and quantity) and using spring grass budgeting. The objective is to budget the grass allocation until the start of the second grazing rotation in early April and maximise the proportion of grazed grass in the cow's diet. Recent research has indicated that herd average dry matter intake at calving is 13.2 kg DM/day, increasing by 0.8 kg per week for the first four weeks, and 0.3 kg per week until a peak is reached in week 10 of lactation. Ensuring cows are fully fed during this period is crucial.

Opening farm cover (OFC) in February is a key management factor during the first rotation. For farms with a high spring grass demand (influenced by turnout date, stocking rate and calving pattern) a target OFC >1000 kg DM/ha is required to ensure high performance from grazed grass and minimize the requirement for supplementation. Spring demand on most dairy farms has markedly increased in recent years, with an earlier mean calving date, more compact 6-week calving rate and increased stocking rates. However, OFC on PBI farms over the same period (2013-2024) has not been sufficient to satisfy the increased demand on farms. The average OFC for the previous 11 years was 880 kg DM/ha (range 680 – 1004 kg DM/ha). Hence, OFC on most farms was below the target of 1000 kg DM/ha, resulting in a feed supply shortfall on these farms.

The spring rotation planner (SRP) is a tool that tracks the area of the farm that has been grazed at different time points in the spring. While grass supply, growth rates and herd feed demand will vary between farms, farmers should target 30% grazed by March 1st, 66% grazed by March 17th and first the first rotation completed in early April. The SRP must be used in conjunction with a spring feed budget. In the absence of a feed budget, the quantities of supplemental silage and purchased concentrate fed will often increase. Weather conditions in early spring play a vital role in deciding the appropriate first rotation length and impacts grass availability in the second rotation. Routine weekly measuring of herbage production in early spring and strict date-based grazing (relying solely on the SRP) can result in reduced spring grass availability during a year with poor spring grass growth rates. Regrowth rates on the grazed ground and average farm cover must be monitored from early March. This allows implementation of strategic management decisions such as grass allocations and supplementation rates and identify the target end-date for the first rotation. Average farm cover should not be less than 600-650 kg DM/ha at the beginning of the second rotation. If this does happen, the amount of grass available for grazing is reduced, and greater levels of supplementation will be required in the run up to breeding. Feed budgeting, a spring rotation planner and weekly farm cover assessments are vital tools during spring and should be used together.

Mid-season management

The objective during the main grazing season is to maintain high animal performance from an all-grass diet, while at the same time maintaining high pasture quality. In general, from late April onwards, grass supply exceeds demand, and pre-grazing herbage mass should be maintained at 1,300 to 1,600 kg DM/ha, with a grazing residual of 50 kg DM/ha (4 cm post-grazing height). Excellent pasture quality is required to maximize animal performance from pasture in summer. From end of April to 31st July, farm cover should be maintained at between 160 to 200 kg DM/cow with a rotation length of 18-24 days. During this period, aim to achieve five grazing rotations and utilize 6.7 t DM/ha. Paddocks with surplus grass should be removed as they are identified (i.e., baled silage) to maintain grass quality while keeping them within the grazing rotation. In periods of high growth rates, however, paddocks identified as surplus can be held for an additional period to increase silage yield and to better match growth rates and herd feed demand. Maintaining excellent herbage quality throughout mid-season is necessary to maximise animal performance from pasture. During mid-season when grass growth exceeds herd demand, the N fertiliser application strategy needs to be carefully managed, ensuring that N fertiliser is applied in line with clover content. Additionally, there has been a gradual increase in summer stocking rates, increasing the herd demand for grass supply and the requirement for high pasture growth rates. It is vital that mid-season demand is appropriate for an individual farm's capacity to grow grass to ensure adequate high quality grass supply.

Autumn management

Typically, the grazing rotation length is extended from mid-August (+2 days/week) to allow large quantities of herbage to build up before the expected decline in grass growth, allowing the grazing season to be extended into late November. In some years, it may be necessary to supplement with grass silage in late august for a short period to increase overall average farm cover. Peak farm cover should be achieved in mid-September (~1,100 kg DM/ha). Data from PBI farms indicates that peak cover in mid-September is 850 kg DM/ha (range 590 to 956kg DM/ha), which is 250 kg DM/ha less than the target. The large gap between the target peak cover and actual peak cover achieved on farms increases the requirement for supplementation.

Achieving the target peak cover (1,100 kg DM/ha) will reduce supplementation requirement for the remainder of the grazing season and has an important effect on achieving closing farm cover targets. Autumn closing date is the main management factor influencing the supply of grass in early spring. To ensure that adequate quantities of grass are available at the start of the first rotation (early February), an average closing farm cover (1st December) of between 650-750 kg DM/ha is required and is dependent on individual farm demand (stocking rate). PastureBase Ireland data shows that closing farm covers were 150 kg DM/ha behind target (range: 612 to 689 kg DM/ha). This large variation in closing cover has a knock-on effect on spring grass cover.

Farmers need to calculate their own spring grass demand based on planned start of the first rotation, stocking rate, calving pattern and previous 5-year average spring grass growth rates on their farm. An autumn closing strategy should be implemented to facilitate the required spring OFC. The final decisions regarding closing strategy also requires some consideration of the expected grass growth rate over the winter period.

Table 4. *Farm cover targets across the grazing season*

Date	Average farm cover (kg DM/ha)	Cover (kg DM/LU)	Rotation length (days)
01-Feb (opening farm cover)	>1000	330	60
01-Mar	750	250	40
05-Apr	600	200	25
May, June, July	510	170	18-24
Mid-August	750	250	25
01-Sep	990	330	30
15-Sep	1100	370	35
01-Oct	950	380	40
01-Nov	65% closed		
01-Dec (closing farm cover)	>700		

Precision nitrogen management

Reducing chemical N fertiliser input can lead to more variability in pasture production. In spring, improvements have been made using organic N better and using it in combination with chemical N. Spring N application remains critically important to increase spring grass growth rates.

It is important to maintain adequate soil fertility (soil pH > 6.5 and Index 3 and 4 for phosphorous (P) and potassium (K)) to ensure sward productivity. When soil fertility is optimal, N efficiency can be increased by up to 20%, highlighting the significant environmental and economic benefit of improving soil fertility. Although farmers have made significant reductions in the quantity of chemical N applied, the quantities of P and K also declined by 33%, and lime usage declined by 40% in 2023, compared with 2022. The most recent soil fertility report for dairy soils in 2024 highlighted several shortcomings in national soil fertility:

- 24% of soils had optimum pH, P and K
- 60% of soils had soil pH > 6.3
- 47% of soils were index 3 or 4 for P
- 53% of soils were index 3 or 4 for K

White clover can fix atmospheric N into a plant usable form of N by a process called biological N fixation (BNF). This can be used to replace chemical N during the main grazing season. It is important to note that optimal soil fertility is essential for white clover establishment and persistence. Targeted use of chemical N fertiliser is necessary to optimise grass growth and maximise BNF from white clover. Hence, a N application strategy needs to be developed for individual farms and paddocks based on sward white clover content. If Irish grassland farmers are to maintain or increase herbage production, a more strategic approach to chemical N fertiliser application is required. White clover can fix up to 100 kg N/ha through BNF, but the supply of N from BNF is not consistent throughout the grazing season (Table 5) and is influenced by the white clover content in the sward and prevailing weather conditions. A soil temperature of ≥ 10 °C is required for sustained high levels of BNF. Generally, these conditions first occur in late-April to mid-May, and this means that BNF is low in early spring and increases to a peak in July- September. Table 5 summarizes the expected N supply from BNF by month from a grass/white clover sward with an annual average of 23% white clover content. To optimise BNF and chemical N fertiliser while maintaining herbage production, chemical N fertiliser should only be reduced in paddocks with adequate sward white clover content (> 20% average). Starting in May and continuing through September, this strategy allows greater BNF. A strategic N application plan based on paddock sward white clover content in April is outlined in Table 6, reducing chemical N application allows white clover content to increase, maximising BNF.

Table 5. *Nitrogen fixation level in swards with a mean sward clover content of approximately 20%*

Period	Sward clover content	N Fixation per month (kg N/ha)
*Jan-March	8	3
April-May	18	8
June	21	14
July	25	19
August	33	20
September	36	22
October	31	11
November	15	3
Annual	**23%**	**100 kg N/ha**

**Measurement period is in line with grazing rotations*

Table 6. *Chemical N usage based on April sward clover content*

April clover content (%)	Mid-Feb	Mid-Mar	Mid-April	Mid-May (2 rot)	Mid-June (2 rot)	Mid-July (2 rot)	Mid-Aug	Mid-Sept	Total
Chemical Fertiliser (kg N/ha)									
Grass sward	24	36	20	32	28	28	21	23	212*
5%	20	35	20	20	20	20	20	20	175
10%	20	35	20	15	15	10	15	20	150
15%	20	35	20	15	10	SW	10	20	130
20%	20	35	20	15	SW	SW	SW	15	105

**Chemical N fertiliser can be increased to 230 kg N/ha in paddocks with no clover, as long as whole farm N does not exceed 212 kg N/ha. Soiled water (SW) used whenever zero chemical N application indicated; equivalent to 25 kg organic N applied*

Clover150 farm performance

In 2020, 36 farmers from across Ireland were enrolled in the 5-year Clover150 programme. The farms included a range of land types, geographical spread, climate conditions and farming enterprises. White clover was established on the farms through a combination of reseeding and over-sowing. In 2020, the Clover150 farms had clover on < 10% of their milking platform area, chemical N fertiliser application was 232 kg N/ha, herbage production was 14.4 t DM/ha, and farm gate N surplus was 194 kg N/ha. By the end of 2024, 75% of the milking platform area had clover (average sward clover content of 20%), chemical N fertiliser application was 190 kg N/ha, herbage production was 13.1 t DM/ha, and farm gate N surplus was 168 kg N/ha. In 2023, the chemical N fertiliser application recorded was 160 kg N/ha and herbage production was 13.4 t DM/ha (Table 7). A trend on the Clover150 farms is the increase in N/ha derived from purchased feeds, which has increased from 47 kg N/ha in 2021 to 65 kg N/ha in 2024, derived from imported concentrate and forages. When sward clover incorporation and chemical N reduction strategies are implemented, it is vital that herbage production is maintained, highlighting the importance of targeted reductions in the use of chemical N fertiliser on clover paddocks within the farm (Table 5).

Table 7. *Five years on farm performance (2020-2024) for the Clover 150 programme*

Year	Average sward clover %	Average clover area %	DM yield (t DM/ha)	Nitrogen (kg N/ha)	NUE%	N Surplus (kg N/ha)
2020	10%	<10%	14.4	232	31%	194
2021	12%	45%	14.3	215	32%	172
2022	17%	61%	12.6	156	39%	136
2023	23%	65%	13.4	160	36%	136
2024	20%	75%	13.1	190	33%	168

Clover contents 2024

The end of 2023 and the first six months of 2024 were challenging in terms of grass growth and grazing conditions on most farms; 2023 was the wettest year (1510.6 mm) and 2024 had the coldest summer (13.9°C) in the last 10 years. This presented significant challenges to Irish farmers because of the adverse impact on grass and clover growth. Clover favours warm, dry, and bright growing conditions, and when these key meteorological factors do not occur, clover persistency suffers. Data from the Clover150 farms indicates that a significant reduction in sward clover content occurred in spring and early summer 2024 (-8%) compared with the previous three years (Figure 2). When clover content declines, changes to farm management (fertiliser and grazing) are required to ensure clover content can recover, and to ensure that grass growth does not decline as a result of lower clover content and a reduction in BNF. This has occurred in the Clover150 farms; chemical N fertiliser increased from 160 kg N/ha in 2023 to 190 kg N/ha in 2024. Most of this additional 30 kg N/ha was applied up until July when clover content began to recover (Figure 2) and resulted in herbage production being maintained at 13.1 t DM/ha with no adverse effect on autumn clover content relative to 2023 (35% and 37%, respectively). There will be fluctuations in weather and consequent fluctuations in sward clover content from year to year but adapting management practices is vital to maintain herbage production and clover contents.

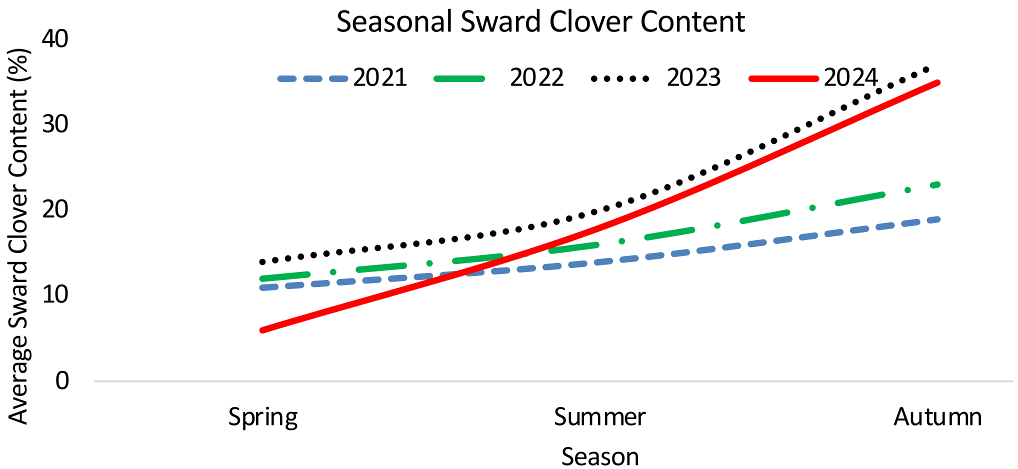

Figure 2. *Seasonal sward clover content on the Clover150 farms from 2021 to 2024*

Perennial ryegrass and clover varieties

Breeding continues to deliver improved grass varieties. New varieties emerging in the 2025 Irish recommended list had an average Pasture Profit Index of €265, an increase of €55 relative the average Pasture Profit Index in 2015. The on-farm evaluation of grass varieties over a 7-year period has indicated large annual differences in DM production between varieties, but also that the DM production profile is consistent for varieties exposed to good grazing management and adequate soil fertility. The primary reasons identified for reseeding swards on many farms are to correct the paddocks with poor graze out, overburden of weed species (dock, dandelions etc) or improve the seasonal performance of a paddock. Reseeding is a substantial investment cost (> €1100/ha when full costs are used). Therefore, it is important that reseeding is carried out to a high standard and the newly established swards are set up for high levels of production. A reseeded sward is capable of achieving 15% greater DM production compared with the mean of the farm during the first two full production years. Similar to the differences observed between perennial ryegrass varieties, recent research has highlighted large differences in agronomic performance between the top and bottom performing white clover varieties. To maximise the agronomic performance of newly sown reseeds, prioritise selection of high performing perennial ryegrass and white clover varieties from the Pasture Profit Index.

Conclusion

To ensure the sustainability and productivity of pasture-based systems, increasing herbage production to support the farm stocking rates must be a key objective in the years ahead. Despite stable total annual levels of herbage production during the past decade (averaging 13.2 t DM/ha), significant variability in grass growth has occurred between years, particularly during spring and summer. Several key aspects of grazing management have improved: more grazing days, a greater number of grazing events and a reduction in pre-grazing herbage mass. At the same time, however, concentrate and conserved forage inputs have increased, highlighting a reliance on external feed sources. Grazing management should be improving on farms each year. There are several KPI's to measure your grazing performance against: optimising soil fertility, meeting seasonal farm cover and growth targets, and implementing a precision fertiliser strategy that incorporates clover. Current farm practices fall short of these key benchmarks. Some of the policy changes related to N management, restrictions on total N usage and delayed spring N applications contribute to stagnant herbage production. The incorporation of white clover into swards is a sustainable strategy for maintaining production while reducing chemical N inputs. A target clover content of >20% on average across the season is required.

The future of grassland systems will depend on the ability to increase herbage production within the constraints of reducing chemical N fertiliser inputs. Using available technologies and achieving grazing management targets will be critical to meeting these challenges.