AGRI-FOOD & BIOSCIENCES INSTITUTE

Proceedings for an Open Day for Industry on 21st June 2023

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Acknowledgements

AFBI are grateful to the Department of Agriculture Environment and Rural Affairs for their underpinning financial support to the Grass Breeding Programme in Loughgall.

The organising committee also want to acknowledge the contribution of the wide range of funders and stakeholders who have contributed to the delivery of this event.

Introduction

Professor Elizabeth Magowan

Director of Sustainable Agri-Food Sciences Division, AFBI

Over 70% of the land in Northern Ireland produces grass-based forages which are used to feed almost 1.7 m cattle and over 2 m sheep per year. This output of meat and milk provides an important source of macro (energy and protein) and micro (vitamins and minerals) nutrients to multiple millions of people across the UK. Grass remains a crop well suited to NI where the growing of crops directly for human consumption is challenging, mainly due to our current climate. As such, the use of this land to grow forage to support the production of meat and milk optimises the use of land in NI to support food security across the UK. However, this land must also support our environment going forward as well.

Optimising the quality, growth and resilience of grass-based swards can significantly benefit the three key pillars of sustainability:

Benefiting the environment:

Grassland swards have the potential to sequester carbon from the air when managed appropriately, and indeed the farming of grassland swards through the application of organic manure represents a highly effective way to maximise carbon sequestration in grassland. Furthermore, the inclusion of additional species in the sward, such as clover, can significantly reduce the need for artificial fertiliser and in turn reduces the emission of nitrous oxide, a very potent greenhouse gas.

The inclusion of additional species in the sward can contribute significantly to promoting biodiversity both within the soil and the grass sward itself. In combination with other strategies such as agro-forestry, the extended grazing of grassland can reduce the level of ammonia emissions generated from cattle production systems. Optimising the amount of meat and milk produced from forage, within environmental boundaries, will also reduce the need for imported feeds and in doing so has the potential to reduce the amount of phosphorus in slurry. It will also reduce the carbon footprint of the farm since feed often carries a notable carbon footprint, especially on dairy farms.

Benefiting society:

As noted above, grassland-based swards have the potential to promote some important ecosystem services such as promotion of biodiversity and reducing the environmental impact of meat and milk production. These factors in turn play an important role in human health and wellbeing through the promotion of a healthier environment. However, fundamentally, meat and milk produced from forage can play an important role in a balanced, nutritious diet with many nutrients that are provided being essential to support a healthy lifestyle. NI's food and green image also supports a thriving tourism industry and is one of the attributes which underpins NI's culture, especially in rural areas.

Benefiting the economy:

While the above will all contribute to a more prosperous economy, the direct impact of maximising the quality and growth of grassland swards will support the profitability of farm enterprises since maximising the proportion of meat and milk produced from forage remains a key driver of on farm profit.

In the future, maximizing the ecosystem services that grassland can offer such as carbon sequestration and biodiversity has the potential to support farm incomes if such markets are developed appropriately.

The AFBI grass breeding programme works in collaboration with AFBI soil, agronomy and livestock scientists to ensure that the programme can produce varieties which work in harmony with our soil, environment and livestock. In order to enhance the benefits noted above, the Grass breeding programme continues to produce high quality varieties for the local NI market and in doing so continues to provide farmers with a tool which has a permanent and long-lasting positive impact on their farm.

Due to the important and pivotal role that grass plays in the fabric of NI farming systems, this 'GRASS' event, with a theme of 'Grass-roots for resilient, adaptive and successful swards' will highlight how the production and management of grass swards can be used to underpin the sustainability of cattle and sheep farming in NI into the future.

In closing, I would like to congratulate Dr Gillian Young (AFBI's Grass breeder) and Dr Suzanne Johnson (Grass trials manager) and their wider team for all the hard work invested in bringing you an excellent event which I trust you enjoy and can take home some useful messages from to help your business thrive.

Key Messages

Optimising the quality, growth and resilience of grass-based swards can underpin the sustainability of cattle and sheep farming in Northern Ireland into the future. The following lists the key messages from todays' event to support the industry achieve this goal:

- The correct balance of nutrients in the soil and its overall health is foundational to sustainable farming. Knowing this, DAERA are significantly investing in The Soil Nutrient Health Scheme (SNHS). The scheme is being delivered by AFBI and CAFRE and is designed to help farmers optimise crop nutrient applications to their land, save money and protect water and air quality.
- The SNHS is a comprehensive soil sampling and analysis programme, which aims to sample every field in Northern Ireland. It will also assess on-farm carbon (C) stocks to support the industry in the future. Zone 2 of the scheme opens for registration on 26th June 2023 with sampling planned during November to March 2024.

All eligible farmers will be contacted in advance by AFBI. More information is available on pages 23-25.

- High quality grass requires the right genetics. The AFBI grass breeding programme is currently breeding varieties for use in 2040 and beyond and these have a strong focus on supporting the environmental sustainability of grasslands. Over the next few years, the varieties that enter the market will have further improvements in traits such as yield, digestibility and disease resistance.
- AFBI grass varieties are tailored for the Northern Ireland environment and are amongst the best available on the market. They also offer different varieties for different circumstances. To create a strong foundation in grassland management, it is essential that leading grass varieties are used. For example, the annual yield improvements of the AFBI varieties are estimated as 0.52% under silage management and 0.35% under grazing. A list of AFBI varieties with their key attributes can be found on pages 16-18.
- The industry recommendation for reseeding is between 10-15% of the grass platform per year, making a 7 to 10 year complete rotation of reseeding on farm. This ensures that all fields have swards containing the latest plant genetics, and the farm is receiving the best possible benefit in performance and profit from highly productive swards in good condition. See pages 19-21 for more advice.
- High quality grass grown on farm is the cheapest source of feed available to farmers in the UK. Maximizing its growth and utilisation is key to optimising profitability on farms. However, a greater level of volatility in grass growth and quality has been observed over recent years making grassland management very challenging.

- AFBI's GrassCheck initiative provides farmers with weekly grass growth and quality information during the main grazing season through weekly bulletins published in the press and on-line, along with 7 and 14-day grass growth predictions to support good grassland management on Northern Ireland farms, which are particularly important during spells of unseasonal and unpredictable weather such as experienced just recently. This information is commonly used by farmers to help them plan ahead and overall achieve optimum growth and utilisation.
- It is very likely that grassland swards will look very different in the future. At the very least, the incorporation of clover will be more common. However, the inclusion of additional species of grasses, legumes and herbs to create 'multi-species swards' (MSS) is highly possible.
- Research to date shows that MSS have the potential to increase sward diversity (promoting biodiversity both above and below ground) and produce similar yields to grass-only swards but at lower nitrogen application rates, mainly due to biological nitrogen fixation. The quality of the sward for livestock nutrition is also not affected. These swards also appear to be more resilient during dry spells of weather.

- However, MSS are more challenging to establish and maintain than grass-only swards and there are issues with persistency of some species in the sward. They also demand a higher level of management. Many farmers are trialling various mixtures of species in swards with mixed success. If MSS are something you wish to try, don't give up if it doesn't work the first time, try again. More information on the research underway on MSS can be found on pages 31-34.
- To achieve the reductions in methane emissions needed, we will need a wide range of mitigations. Improving grass quality is one of those since research has demonstrated that increasing the quality of grazed grass can also reduce the methane output from grazing animals. For example, for every 1 unit increase in grass digestibility, methane emissions from a grazing dairy cow (producing 8000 kg of milk per year) reduced by ~1.8% (see pages 35-37 for more information).
- Other interventions to optimise sustainability on farms include silvopasture (pages 47-49), the use of virtual fencing to help manage swards (pages 51-55), the identification and management of leatherjackets in pastures (pages 61-64), and on pages 57-59, the outcomes of paddock-based grassland management research to optimise lamb production is summarised.
- Overall, the production and management of grass-based swards underpins the overall sustainability of cattle and sheep farms. However, attention to detail on all aspects (i.e. soil, varieties, species mix, management etc) is essential.

Ryegrass Breeding at AFBI Loughgall: breeding grasses for today and tomorrow

Gillian Young, Grass Breeding Programme, AFBI Loughgall

David Linton, Barenbrug UK Ltd.

The AFBI forage grass breeding programme based at Loughgall has been breeding grasses for more than 70 years, and the huge success of the programme is clear.

Since 1998, 39 improved forage grass varieties have entered forage grass variety recommended lists around the UK and Ireland, at a rate of 1.5 per year. Each of these varieties have been tested against its peers by national testing authorities across the UK and Ireland, only gaining a place on a recommended list once proven to be equal or better to other varieties on the list.

(L-R) David Linton (Barenbrug Agriculture Commercial Manager) and Gillian Young (AFBI Forage Grass Breeder) at the forage grass breeding plots at AFBI, Loughgall.

Twenty-one AFBI-bred varieties are currently included on the Recommended Grass and Clover Lists for England and Wales (RGCL) and nine are recommended for use in ROI, highlighting the longevity and robustness of AFBI varieties to perform year on year consistently across different regions.

The main objective of the programme is: to develop and adopt innovative scientific approaches to grass breeding and in doing so bring forward perennial ryegrass varieties with traits which promote positive environmental outcomes whilst maintaining productivity to drive prosperity in ruminant systems.

New varieties at a late stage of development show consistent improvements in traits such as yield, digestibility and disease resistance to improve productivity and raise outputs, with annual yield improvements shown of 0.52% under silage management and 0.35% under grazing, demonstrating the continual improvement of new forage grass varieties. But, as both environmental and consumer needs change, improvements for new traits, including nutrient efficiency, to offset fertiliser reduction, and resistance to stress, including drought resistance, are being targeted.

Key objectives for ryegrasses of the future

Nutrient efficiency/resistance to stress: improve root-based traits to increase efficiency in use of soil nutrients and water to improve yield under silage and grazing under reduced fertiliser application rates and increase resistance to stresses, such as drought.

Quality: continue to improve digestibility to increase metabolizable energy for the ruminant animal and therefore improve productivity, as well as reduce methane emissions.

Persistency: produce ryegrasses with improved sward longevity to improve productivity, reduce carbon loss, and reduce timescales for required re-seeding.

One of the strengths of the AFBI site at Loughgall is its environment, which is perfect for the production of high yields of grass, allowing AFBI to push its grass varieties to their maximum. This detects differences between varieties more easily.

The site itself lies at a low altitude and is sheltered from the elements with few extremes in temperature and a low risk of frost, but has a rich, fertile soil that is high in calcium and essential nutrients. This, coupled with the high rainfall experienced throughout the year that Northern Ireland is so well known for, leads to typically mild, damp conditions that are perfect for grass production in most growing seasons.

Yields at AFBI Loughgall (under very high fertilization rates) regularly exceed 20 T DM/ha under first year silage production, highlighting the high yielding potential of the varieties on the site.

The AFBI Grass Breeding programme is extensive, with over 10 hectares of grass trials in around 2,000 plots and 20,000 spaced plants in the ground at any one time.

Only through breeding can sustained improvements in grassland be made. As the AFBI grass breeding programme continues to thrive, the team continues to use advances in grass breeding science to develop a steady supply of new varieties that can meet the ever-changing demands of the future grassland industry in Northern Ireland.

Table 1: Key AFBI-bred varieties commercially available in seed mixtures in Northern Ireland

Variety	Ploidy	Maturity	Heading date	Key characteristics
Glasker	Diploid	Early	18-May	Excellent first cut yield and spring yields
Bannfoot	Tetraploid	Hybrid	20-May	Perennial-type; excellent persistence with yield advantage of hybrid
Fintona	Tetraploid	Inter-mediate	20-May	Unrivalled spring grazing yields; excellent ground cover
Strang-ford	Diploid	Inter-mediate	21st May	Early and late season growth provides excellent forage at either end of the growing season
Seagoe	Tetraploid	Inter-mediate	22-May	High silage yield; excellent crown rust resistance

Variety	Ploidy	Maturity	Heading date	Key characteristics
Galgorm	Diploid	Inter-mediate	22-May	Highest yielding intermediate diploid under grazing
Moira	Diploid	Inter-mediate	24-May	Early spring grazing yield; Excellent disease resistance
Gosford	Diploid	Inter-mediate	29-May	Multi-purpose high quality variety; high crown rust resistance
Caledon	Tetraploid	Inter-mediate	29-May	High early grazing yield; high quality silage yield; excellent crown rust resistance
Ballintoy	Tetraploid	Late	31-May	Excellent early grazing yield; consistent growth pattern throughout growing season
Gracehill	Tetraploid	Late	01-Jun	Excellent all-round performer right across the growing season

Variety	Ploidy	Maturity	Heading date	Key characteristics
Callan	Diploid	Late	02-Jun	High spring growth, comparable with earlier varieties; best suited to grazing
Glenarm	Diploid	Late	02-Jun	Excellent first cut yield; good all-arounder but best suited to silage
Ballyvoy	Diploid	Late	02-Jun	High spring growth, comparable with earlier heading varieties; excellent silage variety

THE AFBI GRASS BREEDING PROGRAMME IS CO-FUNDED BY DAERA AND COMMERCIAL PARTNER BARENBRUG.

Aligning your grass to your goals

Janet Montgomery, Product Manager, Barenbrug UK

The contribution of productive grass swards to a farm's productivity and profitability cannot be understated. Increasingly, farmers are keen to manage their grasslands as a perennial crop, and are monitoring the performance of the plants, alongside the performance of the animals that the grass is supporting.

There are multiple factors to consider in making reseeding and grass management decisions, but at Barenbrug UK, our passion is grassland agronomy, and we are here to help.

In making grass management decisions, production goals should be front of mind, helping to guide through the clutter of choices. How much grass is required, to support the optimal performance for the class of livestock on the ground? Will that grass be required in a grazed or a conserved format, or both? Is the highest quality required? What is the overall fodder flow on the farm throughout the year, and are there any periods of shortfall that must be addressed? These questions and many more should be addressed to each field, and the overall farming operation.

The industry recommendation for reseeding is between 10-15% of the grass platform per year, making a 7 to 10 year complete rotation of reseeding on the farm. This ensures that all fields are being kept in the latest plant genetics, and the farm is receiving the best possible benefit in performance and profit from high yielding fields in good condition.

In addition, this allows an opportunity at least once every 10 years to address any large-scale problems that may develop in a field, such as soil structure damage, or changes to fence or water infrastructure.

Our Grassland Management Guide is a valuable source of information when considering reseeding, particularly the guide on how to index score fields to determine the order of priority for overseeding or complete reseeding. Each field is scored 1 through 5, with fields on the low end of the scale requiring immediate attention, while fields at the high end of the scale are productive and profitable. There is no substitute for walking through each field and laying eyes on the condition of the sward to be able to make strategic decisions.

Once a reseeding plan has been made, then there are two key factors of grassland management: establish a new sward properly, and then don't ruin it.

To establish grass seed properly, it pays to take time and do each step properly, as this is a period of investment to ensure performance and profit for the next 7 to 10 years. The most resilient swards that can go up against weeds, poaching, and adverse weather conditions, are the swards that are a dense and healthy population of sown species.

Consider any problems that need to be resolved before sowing, such as soil structure, pH, nutrient balance, and weed burden. Of particular importance is sowing into a fine, firm, and clean seed bed, and to seed at a consistent and low speed to ensure uniform seeding depth.

After sowing, defoliation decisions determine the success of a sward. An initial nip-off graze to promote tillering and root strength, followed by consistent grazing or cutting between the 2.5-3 leaf stage, and sufficient rest times between defoliations, will ensure a large yield of high-quality grass, and a persistent stand.

When reseeding, select a mixture that will perform according to the goals for the field and the farm. The backbone of pastoral agriculture in Northern Ireland is perennial ryegrass, but within this species, consider the ploidy (diploid or tetraploid), heading date (early, intermediate, or late), and how these factors will work together in a mixture. In addition, there are legumes and herbs that may be used in combination with perennial ryegrass to achieve other objectives, such as improving soil quality or augmenting feed quality, without sacrificing biomass production or animal performance.

High quality grass grown on farm is the cheapest source of feed available to farmers in the UK, and can work in a myriad of systems to drive production and profitability. By making strategic choices about the grass platform, utilise all the advantages of ryegrass to accomplish your goals.

Soil Health — Optimising nutrient management on farm through the Soil Nutrient Health Scheme

Rachel Cassidy, Agri-Environment Branch, AFBI

Aveen McMullan, Senior Technologist (Agriculture), CAFRE

The Soil Nutrient Health Scheme (SNHS) is a comprehensive regional soil sampling and analysis programme, that will enable Northern Ireland's farmers to optimise crop nutrient applications, assess on-farm carbon (C) stocks and build farm resilience. Simultaneously it is expected that the scheme will provide a baseline to develop strategies for improving the sustainability of the region-wide soil resource, agriculture, and the natural rural environment.

The Department of Agriculture, Environment and Rural Affairs (DAERA) is funding the £45m scheme, which runs from 2022-2026 and is managed by the Agri-Food and Biosciences Institute (AFBI).

Zone 2 of the scheme opens for registration on 26th June 2023 with sampling planned during November to March 2024.

All eligible farmers will be contacted in advance by AFBI.

Figure 1: Four zones for soil sampling 2022-26.

Benefits to Farmers

Comprehensive testing of all fields on each participating farm in SNHS will enable farmers to optimise the application of crop nutrients to their soils and help increase farm profitability.

Farmers participating in the scheme will receive:

- Detailed information on the nutrient and pH status for each field, and crop-specific recommendations for the year of application
- LiDAR-derived runoff risk maps highlighting sub-field scale hot-spots with potential for nutrient loss to waterbodies
- Estimates of C stored in soils and as above ground biomass on each farm
- Training on the interpretation of soil nutrient reports and generation of farm nutrient plans (provided by the College of Agriculture, Food and Rural Enterprise - CAFRE).

All work on the scheme is supported by a comprehensive programme of research led by AFBI and with partners at both Ulster and Leeds Universities.

Left- Figure 2:For each field 25 cores are taken in a "W" track across each field.

Right- Figure 3: Participating farms receive mapped results of soil status, runoff risk and carbon stocks.

Training

Training for farmers participating in the Soil Nutrient Health Scheme (SNHS) is provided by CAFRE and is available at www.cafre.ac.uk/snhs-training.

This training programme consists of a series of short videos designed to assist farmers with the interpretation of their SNHS soil analysis reports and guide them through the steps required to create a Nutrient Management Plan. Participants will learn about the importance of soil analysis and soil fertility, how to read their soil analysis report & access the online SNHS map viewer and consider the various sources of nutrients and their value. Helping them to take a planned approach to nutrient application, by targeting organic manures at areas where they will provide the most benefit, this will potentially lead to increased grass quality and yield, reduce overall spend on inorganic (chemical) fertilisers, while protecting the environment and improving water quality.

The role and importance of carbon in soil and how to protect and enhance carbon on farm will also be covered in the training.

Figure 1 – GrassCheck simulated grazing plots at AFBI Hillsborough

GrassCheck: Latest discoveries and future outlook

Dr Kathryn Huson & Dr Taro Tarahashi,
Livestock Production Sciences, AFBI

Grass monitoring and growth forecasts. Having launched in 1999, GrassCheck is now in its 25th season. This is a unique and highly valuable long-term monitoring programme which tracks the impacts of weather and ground conditions on grass growth and grass quality. Our core data are generated from four sets of experimental plots located at AFBI, Hillsborough and CAFRE, Greenmount, both under simulated grazing management (Figure 1, Left).

Through weekly bulletins published in the press and online, GrassCheck provides Northern Ireland farmers with current grass growth rates and grass quality information, along with 7-day and 14-day grass growth forecasts to support on-farm planning (Figure 2).

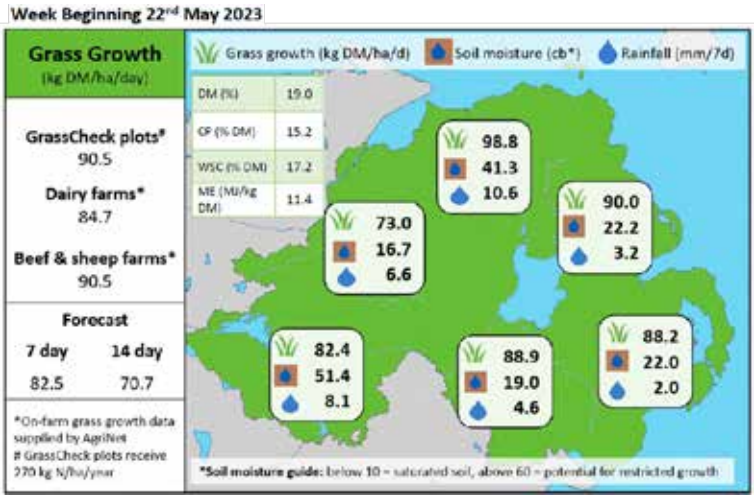


Figure 2 – Recent example of the GrassCheck weekly bulletin, published online and also as part of Farm Week, Farming Life and Irish Farmers Journnal

The data are also used to inform AFBI's wider effort to improve the profitability and sustainability of grassland agriculture. As an example, we are currently investigating the exact mechanism under which last year's prolonged heatwave affected the grass and how we can best prepare for similar shocks in the future (Figure 3).

Figure 3 – GrassCheck soil data during the 2022 heatwave (average across NI)

GrassCheck Farm Network. Since 2017, with the support of AgriSearch, grass growth and grass quality records have also been collected from the GrassCheck Farm Network.

The network is composed of ~50 dairy, beef and sheep enterprises spread across NI, carefully selected to represent a diverse range of geographical conditions as well as grazing management strategies adopted on the farm.

We have also partnered with Centre for Innovation Excellence in Livestock (CIEL) and Rothamsted Research in England to run a sister programme called GrassCheckGB, so that we can accumulate data under warmer conditions to prepare ourselves for the future climate.

The average dry matter production in 2022 was 12.4 t/ha for dairy farms and 10.3 t/ha for beef & sheep farms, with a farm-level maximum of 14.7 t/ha.

There was, however, a weak tendency that the grass utilisation rate was lower amongst high yield farms, possibly suggesting that the demand and supply did not match after the soil moisture came back to normal in the late summer (Figure 4).

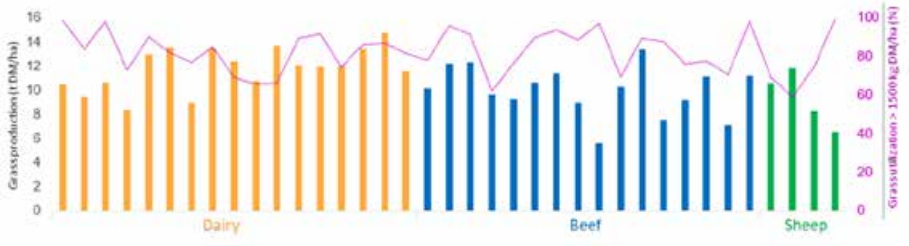


Figure 4 – Grass production and grass utilisation rate on selected GrassCheck Network farms during the 2022 grazing season (anonymised data)

In addition, a number of farms observed a very large degree of between-field difference in yield, meaning that they could potentially have benefited from varying rate applications of fertilisers (Figure 5).

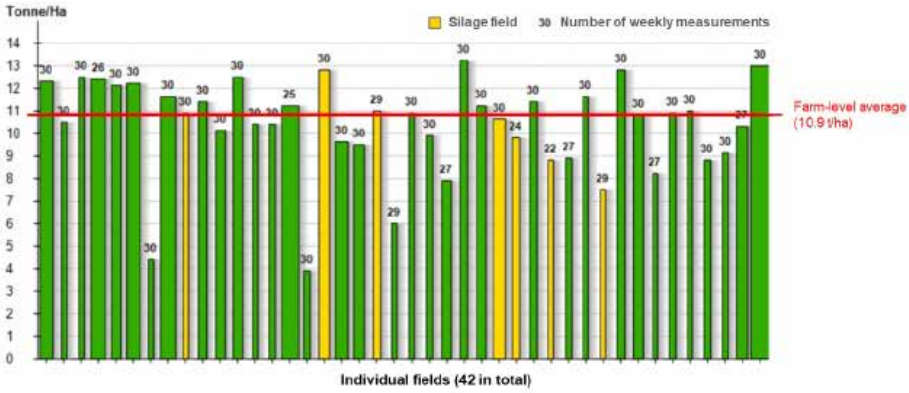


Figure 5 – An example of between-field yield difference observed on a GrassCheck Network farm during the 2022 grazing season (anonymised data).

Exciting new developments. GrassCheck is always evolving and a couple of new initiatives are launching this year. First, in response to the recent fertiliser price and also as part of our ongoing effort to minimise agriculture's impact on water quality, we have set up additional experimental plots that receive reduced amounts of nitrogen.

For the first time in the programme's history, some of these plots are sown with a grass/clover mix, with no synthetic nitrogen applied at all. Second, AgriSearch is funding a new 4-year PhD studentship to further improve the GrazeGro model, the computer simulator behind our weekly grass growth forecasts. A focus of the project will be to equip the model with additional capability for decision support to optimise grass yield, utilisation and quality, especially during challenging weather conditions and under climate change.

Resilient Swards for Sustainable Livestock Systems

Dr David Patterson, Livestock Production Sciences, AFBI

In Northern Ireland (NI), ruminant livestock production systems are largely grass-based, with 96% of all agricultural land area classified as grassland. Perennial ryegrass (PRG) (*Lolium perenne*) is the dominant species used when reseeding and has the potential to produce yields of 15 tDM/ha. Grazing utilisation rates of up to 91% are achievable, with herbage of high nutritional value.

However, ryegrass-only swards are reliant on artificial fertiliser inputs, with rates of 270kgN/ha/year required for a yield of 12-15tDM/ha. There are economic challenges and environmental concerns associated with this reliance on fertiliser, such as leaching and gaseous emissions. These swards do not enhance biodiversity and are less able to cope with weather extremes of drought and waterlogging.

With looming net zero carbon targets for the NI agriculture sector, alternative grassland approaches and mitigations need to be considered for sustainable grass-based farming systems of the future.

Sward resilience and diversity can be enhanced if swards have species from more than one functional group (grasses, legumes and herbs). At farm level, this could involve a transition from grass-only to grass/clover, or to grass/clover/herb swards.

Research shows that multispecies swards (MSS) can produce similar yields to ryegrass-only swards whilst receiving 45% less artificial nitrogen. In addition, herb species such as plantain and cocksfoot are characterised by their deep rooting system which assists in drought resistance and resource utilisation from deeper soil layers.

Economic impact of MSS

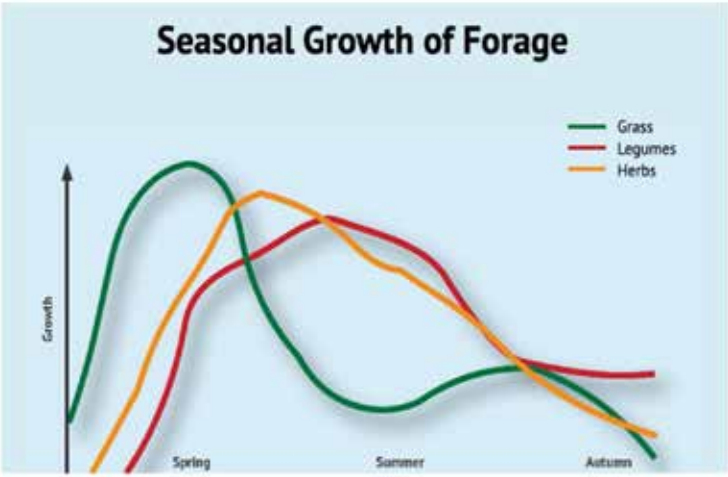
The economic sustainability of MSS for animal production will be determined by factors such as sward establishment costs, sward management, species persistency as well as

Increasing biodiversity

the impacts on livestock health and productivity. A key feature of MSS is its leguminous nature, where a sward containing 30% legume content will ensure the sward is self-sustaining for nitrogen, production costs are reduced and less affected by the volatility of fertiliser prices. An equal or higher level of animal performance can be expected from MSS in comparison to grass-only, such as earlier finishing of lambs. Grazing studies with beef cattle have shown similar or improved performance relative to grass/clover swards. Further savings could be made from a reduced requirement for anthelmintics when grazing MSS and potentially a reduced need for mineral supplementation (such as calcium, copper and selenium).

Future perspectives

There is evidence of many positives aspects of incorporating MSS in ruminant livestock systems. From a limited research base, MSS have the potential to increase sward diversity with similar yields to grass-only swards, at lower nitrogen rates, whilst supplying high quality feed for ruminants. These swards can contribute positively to rumen health, while improving biodiversity and mitigating environmental concerns.



However, some of the published research is conflicting, much is from the southern hemisphere and many are only short-term studies.

AFBI studies have shown that MSS are more challenging to establish and maintain than grass-only swards and there are issues with species persistency in the sward.

A comprehensive assessment of the impact of multi-species swards on animal performance, health, disease control, in addition to environmental impacts, soil quality, financial viability and overall suitability for the NI farming industry is required in order to meet the demands facing the agriculture industry.

Reducing emissions through improvements in grass quality

Dr Omar Carballo, Livestock Production Sciences, AFBI

Reducing the release of enteric methane emissions (CH_4) from livestock is a crucial part of our future strategy to achieve net-zero greenhouse gas emissions and combat climate change. Over the past 30 years AFBI's ruminant nutrition research programme at AFBI Hillsborough has been investigating how we can improve the efficient utilisation of energy and nitrogen, reduce enteric methane emissions and model relationships between nutrient input and output.

The consumption of feed by livestock is directly associated with their methane emissions as shown in Figure 1. However, the quality of the feed can significantly impact on methane emissions. Studies have demonstrated that increasing the quality of grazed grass can reduce the methane output from grazing animals.

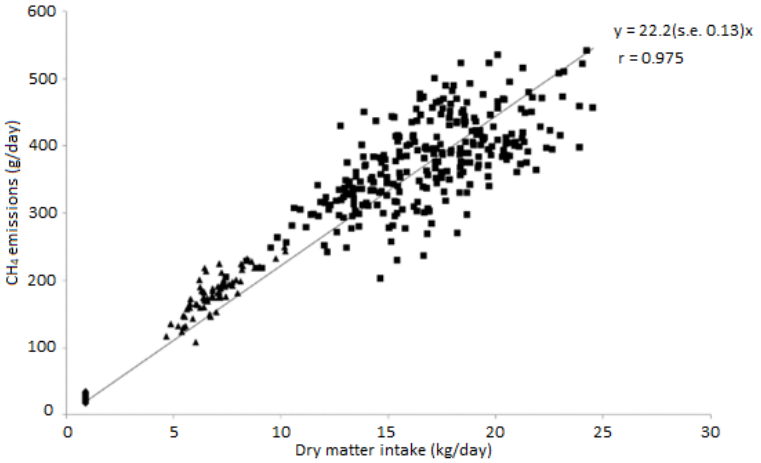


Figure 1. Observed dry matter intake and CH_4 emissions per day for sheep (♦; n = 288), beef cattle (▲; n = 71) and dairy cows (■; n = 284) included in the analysis (Adapted from Bell et al., 2016).

Many factors can influence the nutritional quality of grass consumed by livestock be that grazed or when ensiled such as grass variety, sward composition, management practice, maturity at harvest and fertiliser management.

Examples of grass quality factors known to affect enteric CH_4 output:

Fibre (NDF) content: Grasses with high NDF (neutral detergent fibre) content decrease dry matter intake due to the negative relationship between the NDF content of feeds and the rate at which they are digested. The ratio between digestible fractions (such as sugar) and non-digestible fractions (such as indigestible NDF) is also important.

Fat content: Recent research from New Zealand is indicating that new genetically engineered ryegrass cultivars with greater concentrations of fat in the leaf may potentially

result in higher gross energy grasses and up to 10-15% lower methane emissions for the same level of animal performance.

Digestibility (DOMD - digestible organic matter): AFBI research indicated that for every 1 unit increase in grass digestibility, methane emissions from a grazing dairy cow producing 8000kg of milk per year reduced by ~1.8% (Table 1).

Summary

Clearly improving the nutritional quality of grass consumed by ruminant livestock is an important part of our climate-change tool-kit moving forward. This tool-kit will include a range of elements from how we manage that grass and the land it is grown on through to breeding the varieties to reduce emissions and drive optimal animal performance.

Table 1. *Effects of grass quality (DOMD) on CH_4 emission in a cow with ad libitum grass intake and fixed concentrate input*

Grass DOMD (%)	70	71	72	73	74	75
Milk yield (kg/d)	25.0	25.4	25.8	26.2	26.6	27.0
CH_4/milk yield (g/kg)	16.4	16.1	15.8	15.5	15.3	15.0
CH_4 reduction (%)		1.8	3.6	5.4	7.0	8.7
CH_4 reduction (g/kg milk)		0.30	0.59	0.88	1.16	1.43
CH_4 reduction for 8000 kg milk (kg/y)		2.4	4.7	7.0	9.3	11.4


INNOVAR

InnoVar: Next generation variety testing for improved cropping on European farmland

EC H2020 Project 818144

Hazel Brown & Dr Lisa Black, Grassland and Plant Sciences, AFBI

Agriculture is increasingly being asked to meet the needs of an increasing population whilst at the same time reducing inputs and preventing harm to the environment.

To achieve this, the cultivation of the plants we use to fuel human and animal nutrition must maintain productivity in more sustainable growing conditions and be resilient and responsive to climate change.

New plant varieties produced by breeders must pass plant variety testing before they are eligible for national listing to enable them to be marketed and grown. These testing systems determine if plants are distinct from, and offer clear improvements in terms of performance to, varieties already commercially available, and have been developed over decades.

To improve efficiency in plant variety testing and introduce traits of sustainability, new innovative methods, incorporating new technologies, are essential. This is where InnoVar fits in.

InnoVar is focused on introducing efficiencies and innovations into plant variety testing. The project was developed and is coordinated by the team at AFBI Crossnacreevy Plant Testing Station, in collaboration with 21 partners from 10 countries.

Using wheat as a test crop, **InnoVar** will devise and demonstrate improved, efficient methods of:

- integrating new science into DUS and VCU testing processes,
- combining DUS and VCU characters, and
- incorporating variety information into decision-making on-farm.

InnoVar draws together expertise and knowledge from across crop science, phenomics, genomics, and machine learning to develop and deliver methods and tools to achieve greater efficiency in the DUS and VCU testing processes.

Crop science: InnoVar gathers data from a European-wide trial series covering core VCU, drought, organic, durum, and DUS trials. These trial locations have been divided into 5 agro-climatic zones.

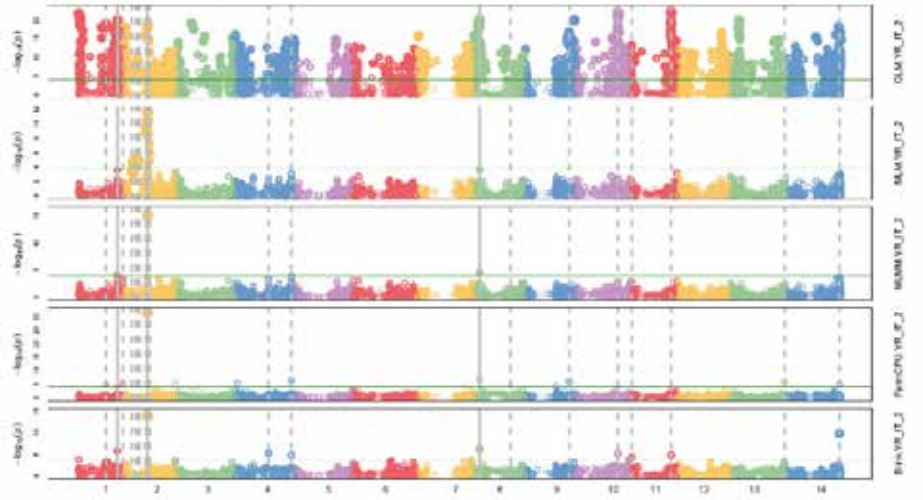
VCU trials have been hosted at 16 sites across Europe (see right) for three consecutive years.

A standardised VCU protocol based on those collected from partner countries was developed for the project.

These trials assess the impact of plant protection products, drought, and organic practice on varietal performance across the EU in a range of environments.

Phenotyping and phenomics: Phenomic data is generated from the InnoVar trials using drones. Multispectral sensors capture more effective plant health and management data than tools used in the past. They can pinpoint nutrient deficiencies, identify pest damage, optimise fertilisation and assess water quality. InnoVar is testing the efficacy of using state of the art technology to improve efficiency in measuring morphological plant traits.

Genomics: The genetic similarity of the InnoVar panel has been analysed using SNP markers. Existing and new genetic data for InnoVar varieties is combined with the phenotypic and phenomic data in genome-wide association studies to identify genomic loci and markers associated with DUS and VCU traits of interest, such as resistance to disease.



Preliminary GWAS analysis of the Global Durum Panel by InnoVar partners University of Bologna

Ultimately, the tools and models developed will enable assessors to allocate varieties into High Performance Low Risk (HPLR) categories based on their field performance under variable input regimes and their target market environmental conditions.

This HPLR categorisation is a novel branding that is being developed by InnoVar to promote understanding of 'fit-for purpose' varieties and their performance by farmers and growers. A farmers' survey distributed across Europe by partners found that end users would benefit from recommendations based on individual diseases and would also prefer to see the data involved in making the decision.

These new approaches, combined with conventional plant evaluation techniques, will deliver Next Generation Variety Testing – NGVT. The aim is to evaluate the potential to deliver harmonised variety testing across Europe so that average yields can approach potential yields using 'fit-for-purpose' regional varieties.

THIS PROJECT HAS RECEIVED FUNDING FROM THE **EUROPEAN UNION' HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME** UNDER GRANT AGREEMENT N. 818144

SUPER-G: First results from research into use of multi-species swards on farm

Jason Rankin, Agrisearch, Hillsborough

Ruminant livestock farmers in Northern Ireland (NI) are facing economic challenges due to rising input costs, as well as ever increasing environmental challenges to lower their greenhouse gas emissions and improve soil health and water quality.

Due to these challenges, there is a growing interest into the potential benefits of increasing plant diversity in swards (multi-species swards; (MSS)). The suggested benefits from incorporating a mix of grass, legume and herb species into grazing platforms includes improved soil health, reduced need for manufactured nitrogen fertiliser and improved drought tolerance.

Methodology

In 2019, AgriSearch and AFBI recruited 7 commercial farms in NI to trial MSS through the SUPER-G project, a Europe-wide Research Project into Developing SUstainable PERmanent Grassland systems and policies funded by Horizon Europe.

The project aims to develop sustainable permanent grassland systems and policies with farmers, citizens, and policymakers;

ensuring business viability, while supporting biodiversity and delivering several other ecosystem services.

The study was undertaken on seven commercial dairy, beef and sheep farms across Northern Ireland. A split field trial was used that involved 2 seed mixes, and the farmers sowed approximately 5 acres of each mix.

The first mix contained 80% perennial ryegrass (Glenarm, Ballintoy and AberGain), 11% white clover (crusader), 5% plantain (Tonic plantain) and 4% chicory (commander).

The second mix was a control and contained 89% perennial ryegrass (Glenarm, Ballintoy and AberGain) and 11% white clover (crusader).

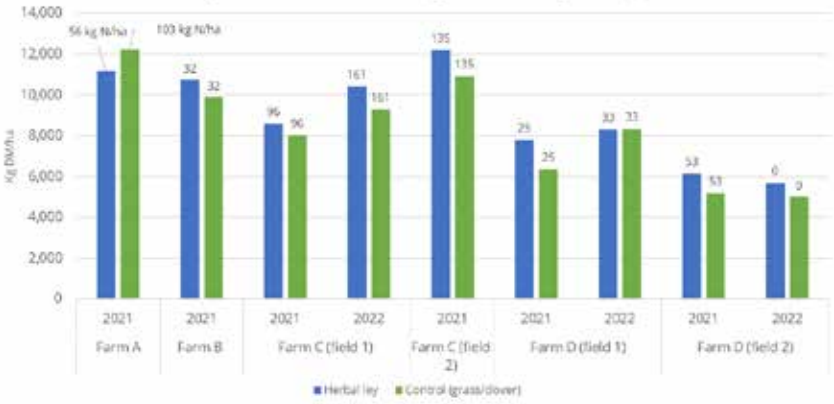
The swards were established during autumn 2019 and spring 2020, using one of three establishment methods which included full ploughing and cultivation, minimal cultivation and surface seeding (with and without burning off the existing sward). The farmers provided sward management information, including pre-and post-grazing sward covers and organic and artificial fertiliser application rates. In addition, visual botanical assessments, as well as herbage quality and mineral samples were taken three times per year (spring, summer and autumn). Soil samples were taken in autumn 2022 at sampling depths of 0-10cm and 0-30cm, and analysed by NRM laboratories (Bracknell, UK) for carbon and organic matter.

Results/Conclusions

Initial results from 2020-2022 have suggested that MSS can produce comparable yields to conventional perennial ryegrass (PRG) and white clover swards. Across the two years of data collection the MSS on average yielded 9 tonnes of DM/ha using an average of 66kg of nitrogen per ha.

The control swards on average yielded 8.4 T DM/Ha using an average of 71 kg N/ha. Therefore, the farmers observed that MSS can produce similar yields to grass/clover swards.

Figure 1: Utilised yield on individual farms (Kg DM/ha) and Kg n/Ha applied



Furthermore, when comparing the nutritional quality of MSS to PRG/white clover swards, this project found that the MSS had slightly lower dry matter levels, with dry matter of the multi-species samples averaging at 15.5% compared to 16.7% for the control samples. Herbage mineral analysis results showed that on average the MSS and control samples had similar crude protein (22.02% and 21.44% respectively) and water-soluble carbohydrate levels (19% and 18.7%, respectively). However, the MSS contained slightly higher levels of some minerals such as calcium and molybdenum, compared to the PRG/white clover swards.

This project has highlighted some of the potential benefits of MSS in NI. However, there is still considerable information needed about this type of sward, particularly around grazing management and herb persistency.

In this study, the addition of herbs to grazing swards had no adverse impact on production, however could have potential environmental benefits. Further research will be required to test different MSS on farms in Northern Ireland.

ACKNOWLEDGEMENTS

THE AUTHORS WOULD LIKE TO ACKNOWLEDGE THE SEVEN FARMERS THAT TOOK PART IN THIS PROJECT.

THIS PROJECT HAS RECEIVED FUNDING FROM THE **EUROPEAN UNION' HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME** UNDER GRANT AGREEMENT N. 774124

Trees in grasslands — Silvopasture at Loughgall

GrowIN and Irish Agroforestry Forum: Professor Jim McAdam

AFBI has a long history of involvement in agroforestry research. In the 1980s, there was increasing concern over the negative effects of grassland intensification — low biodiversity; habitat loss; eutrophication; soil degradation and impoverished landscapes.

One option to make grassland more sustainable was seen to be increasing tree cover and delivering a wide range of ecosystem services. In agroforestry systems, trees are combined with crops and/or animals on the same unit of land and there are significant ecological or economic interactions between the tree and the agricultural components. One variant of agroforestry is silvopasture, in which trees are grown in grazed pasture in a regular or varied pattern and which was seen as having particular relevance to Northern

Ireland, where farms were small and farmers were reluctant to take land out of grassland production.

In 1989, Loughgall was chosen to site a centrally-coordinated National Network Silvopastoral Experiment and considerable investment went into establishing a replicated trial comparing grassland (ryegrass-based), silvopastoral (trees at 400/ha and grazed) and woodland (trees at 2500/ha, ungrazed) systems. Detailed measurements were taken on performance and outputs of all the components of the system.

Sheep carrying capacity and grass production was not reduced in the silvopasture until trees were c. 12 years old (c. 8m height & 15cm diameter) and subsequently recovered after tree thinning. Individual sheep performance was unaffected by the tree presence. From an animal welfare perspective, the evidence of animals seeking shade and shelter can infer individual animal performance benefits and resilience to climate extremes. Silvopasture is a high welfare-friendly environment for stock: animals have a more varied

diet from tree fodder, and the system suits multi-species swards; animals have reduced incidence of respiratory diseases; and stock seek out shade and shelter.

Soil physical structure is improved and soil zonal exploitation by roots led to greater water infiltration and reduced run-off for flood mitigation and significantly more earthworms than in grassland-only systems. Improved soil porosity in silvopasture gradually increased the length of the grazing season up to about 3-4 months over grassland-only systems when trees were mature. The associated benefits of reduced ammonia emissions from animals outside, increased grassland utilisation, especially at either ends of the season, and animal health are a considerable benefit to stock farms. Carbon sequestration from the tree component of the system has been estimated at 2.4t/c/ha/yr.

Silvopastoral systems are grassland systems which are environmentally, economically and socially sustainable, and which have the potential to create resilience to predicted climate change impacts.

The results from this trial have had far-reaching benefits for promotion of silvopasture as a grass-based livestock system or a tree-based livestock production system to deliver high quality timber on the island of Ireland and further afield. The Loughgall silvopastoral site is now one of the longest running continually managed research sites in Europe.

Virtual fencing — a breakthrough technology for grazing management?

Dr Conor Holohan & Dr Francis Lively, Livestock Production Sciences, AFBI

Virtual fencing has the potential to transform the way we manage grazing livestock.

At AFBI, we are evaluating the potential of this new technology, with the research programme currently in its third year.

Above: Beef heifers strip-grazing (location of virtual fence illustrated by yellow line)
Left: Ewes fitted with virtual fence collars

How does it work?

Virtual fencing uses a combination of GPS technology and sensory cues to fence livestock within a desired area without the need for physical fences.

There are typically two main parts to the system: a virtual fence collar fitted on the animal's neck and a mobile app which is used to map out the GPS boundary (i.e., the virtual fence) around the grazing area. When the animal approaches the virtual fence an audio cue (beeping sound) alerts the animal to alter its direction away from the fence. This is followed by an electric pulse if the animal proceeds to pass beyond the virtual fence.

The principle is based on associative learning, whereby animals learn to respond to the audio cue and avoid the electric pulse. This learning typically takes place during an initial 1-2 week training period.

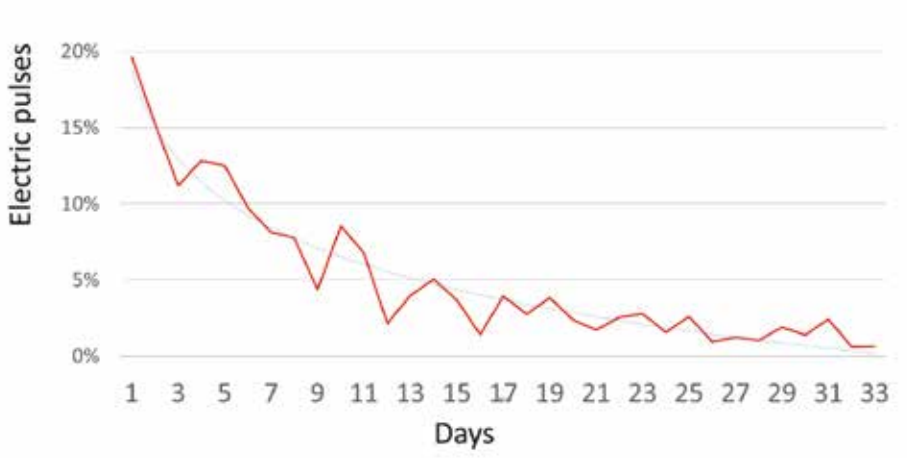


Figure 1. Rate of learning in virtually fenced beef cattle (percentage of virtual fence interactions which resulted in an electric pulse, between Day 1 and Day 33 of the study)

What are the potential benefits?

- Ability to introduce temporary fencing in areas where physical fencing may not be feasible (e.g., mountainous terrain or short-term rented land).
- Improved grassland management and utilisation through rotational grazing, strip grazing, and more regular movements.
- Flexible grazing management: Virtual fencing can be easily set up and altered at any time.
- Reduced labour associated with maintaining and moving conventional fencing.
- Enhanced monitoring of individual animals within a herd/flock.
- Exclude animals from landscape features such as streams, lakes and sensitive habitats.

Key findings to date

To date the AFBI research programme has studied virtual fencing in over 300 animals across beef, sheep and dairy grazing experiments.

Effectiveness **–** The technology successfully contained animals in a range of grazing systems, with varying stocking densities and levels of grass availability.

Animal welfare **–** There is a minimum requirement that livestock technologies such as virtual fencing either maintain or enhance animal welfare. At a basic level, an electric pulse has the potential to cause pain and distress to an animal, and so the research at AFBI places a major emphasis on finding out if virtual fencing is ethically acceptable.

Overall, animals rapidly learned to respond to the audio cue within the first 3-5 days of virtual fence training, with some individuals taking longer to learn than others. Initial findings show no extreme behavioural reactions to virtual fencing, and similar levels of faecal cortisol (stress hormone) in virtual fenced and electric fenced cattle.

Mobile network availability **–** Current virtual fencing systems typically rely on mobile network coverage for flow of information between the mobile app and the device fitted to the animal. This may be a limiting factor in certain areas at present.

Battery life **–** Virtual fence collars are typically fitted with a rechargeable battery unit, with some devices incorporating small solar panels to help maintain battery charge. Battery life depends greatly on the grazing method and pasture design used.

In larger pastures, batteries can last several months without being recharged, while this reduces in smaller pastures (as animals come in contact with virtual fences more often).

GPS accuracy **–** GPS technologies sometimes experience 'GPS drift', which in a virtual fencing context, is the difference between the actual location of the animal and the location recorded by the virtual fence collar. Factors affecting drift include proximity to buildings, heavy tree cover, steep slopes and hilly terrain (if the animal is in a valley the GPS receiver sees less of the sky and fewer satellites). We have not experienced any significant GPS drift issues during experiments at AFBI Hillsborough.

Conclusion

Research to date indicates that virtual fencing can be an effective and ethically acceptable technology for use with grazing livestock. Although the number of farms using virtual fencing in the UK and Ireland is relatively small at present, it could become commonplace in the coming years particularly as the technology is further refined and becomes more affordable.

WE ACKNOWLEDGE THE FUNDING OF DAERA E&I, HORIZON 2020 (SUPER-G), AND THE HEA NORTH-SOUTH RESEARCH INITIATIVE IN SUPPORTING THE ONGOING VIRTUAL FENCING RESEARCH.

Getting more lamb from grass

**Dr Aurélie Aubry and Dr Francis Lively,
Livestock Production Sciences Branch, AFBI**

Value of grass

Grazed grass is the cheapest feed source for beef and sheep farms in the UK and Ireland relative to silage and concentrate feeds. Previous research provided clear evidence of the benefits of rotational grazing compared to set stock systems. However, setting up rotational strategies can represent significant costs for farmers. This will be worth it because increasing grass utilisation by even just 1 t DM/ha can result in an increase in lamb output, representing an increase in profit estimated at more than £230 per ha per year. A key challenge is to determine the optimal number of paddocks to include within a given grazing system.

Comparing sheep grazing systems with 4 or 8 paddocks

As part of a recent project funded by DAERA and AgriSearch, a 4 and an 8 rotational paddock grazing system were compared using the same number of ewes and grassland area at AFBI Hillsborough. This study found that grass yields were higher from the 8 paddock system by 1 t DM/ha/year, with no significant effect on grass quality. However, lambs grazing the 4 paddock system had higher average daily gains from 6 weeks onwards, reaching slaughter 36 days earlier than those on the 8 paddock system. A similar study was carried out on 5 commercial lowland farms up to weaning and found a similar pattern: higher grass production and utilisation on the 8 paddock systems but higher lamb growth on the 4 paddock systems.

Left: Lambs grazing MSS at AFBI Loughgall in 2022.

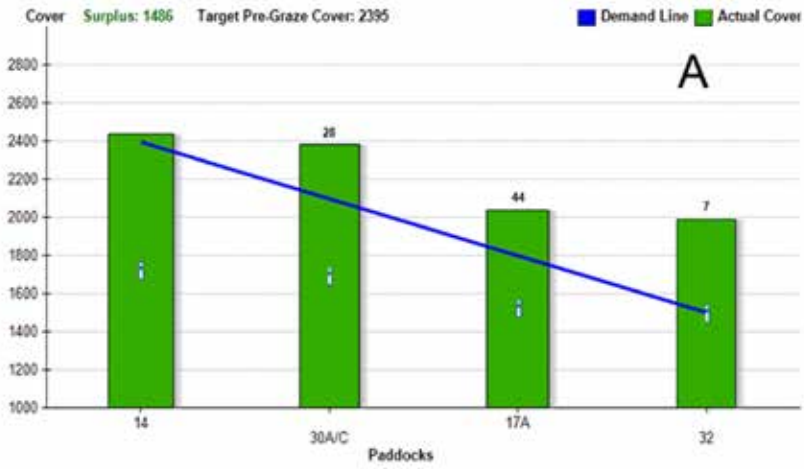
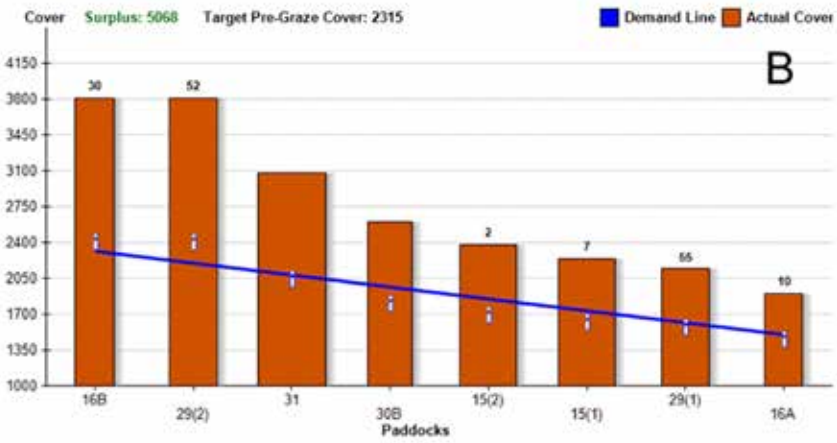


Figure 1. Example of grass covers (kg DM/ha) from a 4 paddock system (A) and a 8 paddock system in Spring.(B)

These results indicate that a greater number of paddocks offers opportunities for silage production or higher stocking rates but may result in an increase in days to slaughter. The ideal number of paddocks will therefore be different depending on flock size and slaughter targets.

Measuring grass to set more ambitious targets

Farmers involved in the study appreciated the flexibility that the 8 paddock system offered, by being able to take paddocks in or out to respond to grass shortages or excesses. Measuring weekly grass covers is crucial to inform these decisions, as it can provide a grass wedge such as those illustrated in Figure 1. Annual variation in paddock yields can also be used to identify those that need either reseeding or soil management intervention.



Integrating multi-species swards into grazing systems

In light of rising input costs such as fertilisers, we need grazing strategies that can produce more lamb or beef from grass with lower inputs. Rotational grazing is one solution, as well as the use of legumes and multispecies swards (MSS). Further research is ongoing at AFBI to better understand how these different options can be used together within rotational management systems (see photo, page 56).

Results so far indicated similar beef and sheep performance on MSS compared to grass/clover swards, reduced worm burden and greater soil biodiversity within earthworm populations.

Importantly, the additional resilience and biodiversity benefits that more efficient and diverse grazing systems provide will also help the sector to address rising environmental concerns.

Adult cranefly or Daddy Longlegs

Leatherjackets

Dr Archie K. Murchie, Dr Florentine Spaans, & Dr Stephen Jess, Grassland & Plant Sciences, AFBI and Jillian Hoy, Agrisearch, Hillsborough

Leatherjackets are so-called because of their tough leather-like skin. They are most noticeable in spring when fully grown.

Leatherjackets are the larvae of craneflies (also known as Daddy Longlegs), which belong to the fly family Tipulidae. The commonest species found in Northern Ireland pasture is *Tipula paludosa*. Leatherjackets damage agricultural grassland because the larvae feed on the roots and underground stems of grasses.

Adult craneflies emerge in late summer (August-September) to mate and lay their eggs in soil under grass. The subsequent larvae then feed and grow during the autumn, winter and spring, to pupate in the summer and emerge from the soil as adults.

For the main problem species, *T. paludosa*, there is only a single generation each year. Leatherjackets can be tremendously abundant in Northern Irish grassland.

The densities at which economic damage occurs to established leys is one million leatherjackets per hectare.

We typically sample leatherjackets using 10 cm diameter PVCu drainage pipes hammered into the soil and filled with a saturated salt solution. An average of eight leatherjackets per 10 pipes is equal to a million per ha. This equates to a loss of

Sampling leatherjackets using drainage pipes hammered into the soil and filled with saturated salt solution. Any leatherjackets within the pipe wriggle from the soil and float to the surface where they can be easily counted. Eight leatherjackets per 10 pipes indicates a leatherjacket problem

herbage equivalent to £155 per ha at current prices. Damage can be seen by bare patches, yellowing grass and holes in the turf from bird feeding.

Prior to 2016, leatherjackets were routinely controlled by the broad-spectrum organophosphate insecticide chlorpyrifos (trade name Dursban®). However, chlorpyrifos products were withdrawn in the EU in April 2016, with a few very limited exceptions, due to human-health issues, especially concerns that chlorpyrifos could affect the neurological development of the unborn child.

Yellowed grass and bird-feeding holes in turf indicate a severe leatherjacket problem

Since the withdrawal of chlorpyrifos, there are no recommended insecticides for use in agricultural grassland. Farmers have therefore been left with few options for leatherjacket control.

Under a European Innovation Partnership (EIP), AFBI is working with AgriSearch and a group of Fermanagh farmers to investigate how integrated pest management (IPM) principles can be used to mitigate against leatherjacket problems. IPM is a different approach compared to an insecticide application and involves multiple integrated steps to disadvantage the pest species.

In addition, IPM is not an instant fix, but is rather a multi-season approach, which seeks to reduce and maintain the leatherjacket populations at economically non-damaging levels; whilst at the same time protecting soil health, especially invertebrate biodiversity which would be killed by insecticide application. Much of the IPM framework is good agronomy, such as drainage, reseeding and liming of pastures. Break crops and multi-species swards can disrupt leatherjackets lifecycles. Tight grazing in late summer / early autumn can reduce egg laying sites. Application of herbicides could also help in this way by removing rushes as settling sites. The number of silage cuts and the timing of slurry applications may similarly impact on leatherjackets but has been little studied.

There are native predators and parasites of leatherjackets in the soil and these should be encouraged. For example, small parasitic wasps have been found to attack 44% of cranefly eggs in Northern Ireland. The intention is that although each step on its own may not control leatherjackets, cumulatively they could reduce the leatherjacket populations to non-damaging levels.

THE EUROPEAN INNOVATION PARTNERSHIP (EIP) SCHEME IS JOINTLY FUNDED BY THE EUROPEAN AGRICULTURAL FUND FOR RURAL DEVELOPMENT (EAFRD) AND THE DEPARTMENT OF AGRICULTURE, ENVIRONMENT AND RURAL AFFAIRS (DAERA).

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