TResearch

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DIGITAL DAIRY
Automation in industrial dairy production

GRASS GROWTH
Live data for accurate growth predictions

WASTE AWAY
A new approach to fresh food packaging

BACK IN TIME: Celebrating 50 years of Teagasc's Rural Economy and Development Programme p.18

Cream of the crop

Meet the researchers discovering the future of alternative growth media for mushrooms

Teagasc
Agriculture and Food Development Authority

Welcome

With a €521 million farm gate value, the horticulture sector in Ireland is spread across two key sub-sectors: horticulture food (€417 million) and amenity horticulture (€104 million).

In this issue we have a special focus on the work of Teagasc's Horticulture Development Department (HDD), a small but dedicated team who are driving and guiding the expansion and development of the horticulture sector in Ireland.

On p10 we meet the 'Beyond Peat' project team, who are working on identifying potential peat alternatives for Irish horticulture. Teagasc has been conducting mushroom research to support this important sector of Irish horticulture for over 50 years, which is one of the most efficient worldwide, producing top quality mushrooms for export. Helen Grogan and team explain how they are researching peat alternatives to make mushroom casing more sustainable into the future.

The HDD may be one of Teagasc's smaller departments, but as any good entomologist will tell you; small things can have a big effect. In an interview with Michael Gaffney on p24 he explains how studying insect pests and their invasive species is a crucial aspect of the preventative work involved in crop protection and how he is working to ensure successful crops for future growers, to mitigate problems of food security.

In our Look Ahead column, Dermot Callaghan, Head of HDD, examines some of the challenges and opportunities facing the horticulture sector (p34).

Articles from one of Ireland's foremost growers (Keelings, on p27), sustainable packaging (Leaf No Waste project, p22) and the Smart Apples project (p32) also feature.

Catriona Boyle
Editor, *TResearch* magazine, Teagasc

Agus luach ag geata na feirme de €521 mhilliún ag baint léi, tá earnáil na gairneoireachta in Éirinn leata thar dhá phríomh-fho-earnáil: bia gairneoireachta (€417 milliún) agus gairneoireacht taitneamhachta (€104 mhilliún).

San eagrán seo dírímid go speisialta ar obair Roinn Forbartha Gairneoireachta (HDD) Teagasc, foireann bheag dhíograiseach a bhfuil leathnú agus forbairt na hearnála gairneoireachta á spreagadh agus á dtreorú aici in Éirinn.

Ar leathanach 10 buailimid le foireann tionscadail 'Beyond Peat' atá ag obair ar roghanna féideartha eile in ionad móna a shainaithint do ghairneoireacht na hÉireann. Bhí Teagasc ag déanamh taighde ar mhuisiriúin chun tacú le hearnáil thábhachtach seo na gairneoireachta in Éirinn le níos mó ná 50 bliain anuas, agus is ceann de na hearnálacha is éifeachtaí í ar fud an domhain, ina dtáirgtear muisiriúin ardchaighdeáin le haghaidh onnmhairithe. Míníonn Helen Grogran agus an fhoireann conas atá siad ag déanamh taighde ar roghanna eile in ionad móna chun cásáil do mhuisiriúin a dhéanamh níos inbhuanaithe sa todhchaí.

B'fhéidir gur ceann de ranna níos lú Teagasc í HDD, ach mar a inseoidh aon fheithideolaí maith duit, d'fheadfadh nithe beaga tionchar mór a imirt. In agallamh le Michael Gaffney ar leathanach 24 míníonn sé an dóigh a bhfuil staidéar ar fheithidí lotnaide agus ar a speicis ionracha ina ghné ríthábhachtach den obair choisctheach a bhaineann le barra a chosaint agus an dóigh a bhfuil sé ag obair chun barra rathúla a chinntiú do shaothróirí amach anseo, d'fhonn fadhbanna bia a mhaolú.

Inár gcolún Look Ahead, déanann Dermot Callaghan, Ceann HDD, scrúdú ar chuid de na dúshláin agus de na deiseanna atá roimh earnáil na gairneoireachta (lch.34).

Tá ailt ann freisin ó cheann de shaothróirí is tábhachtaí na hÉireann (Keelings, ar lch. 27), faoi phacáistíocht inbhuanaithe (an tionscadal Leaf No Waste, lch. 22) agus faoin tionscadal Smart Apples (lch. 32).

Catriona Boyle
Eagarthóir, iris *TResearch*, Teagasc

TResearch is an official science publication of Teagasc. It aims to disseminate the results of the organisation's research to a broad audience. The opinions expressed in the magazine are, however, those of the authors and cannot be construed as reflecting Teagasc's views. The Editor reserves the right to edit all copy submitted to the publication.

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Main image shows Teagasc's Michael Gaffney, Helen Grogan, Eoghan Corbett and Donal Gernon in the Teagasc mushroom research centre.

Contents

Throughout TResearch, *we include icons alongside articles where there is a clear link to the urgent actions in our Climate Action Strategy. These actions are: Reduce Nitrogen Emissions, Reduce Methane Emissions, Increase Carbon Capture, Enhance Biodiversity, Increase Diversification, Enhance Adaptation, Circular Food System, and Supporting Policy.*

News

Grassland Peat Agriculture workshop

Pictured at the workshop which took place in Gurteen College are speakers from Teagasc, University College Dublin, University of Galway, Aarhus University, and the UK Centre for Ecology and Hydrology

The land-use sector in Ireland is a major source of greenhouse gas emissions that are projected to rise to 11.1 MT CO_2-eq by 2030. Grasslands on peat soils are estimated to cover 339,000 hectares (ha) and are estimated to account for emissions of up to 9 MT CO_2-eq per year. This estimate is highly uncertain and relies upon a number of assumptions regarding the areal extent, nutrient status, drainage status and the emission factor for agricultural peat soils. Each of these assumptions needs to be urgently refined to improve the emissions estimates and identify what farmers can do to reduce these emissions.

Speaking at a workshop organised by the new Teagasc Climate Centre and the ReWet project (Teagasc and University of Galway) at Gurteen College recently, with over 60 participants, Pat Tuohy, Teagasc, explained that the management of grassland peat soils at farm scale requires a range of measures to ensure appropriate land uses are promoted and carbon storage is optimised. Pat says: "Given that water table depth remains the critical parameter, which dictates the total emissions, there remains a lack of clarity around peatland hydrology at farm scale and its implications for future management."

Owen Fenton, Teagasc, adds: "On-going and future collaborative research projects that focus on improving the science, mapping and monitoring of Grassland Peat Agriculture within the Teagasc Climate Research Centre will help Ireland meet its climate targets and improve farming incomes through agri-environmental schemes and future carbon farming payments."

Supporting innovation and business engagement

Key Performance Indicators 2022

1 New opportunities

- **23** inventions/technologies disclosed to Engage@Teagasc
- **6** new patents filed

2 IP commercialisation activity

- **14** licences, options and assignments (LOAs) signed with industry – **6** of which are IP licences
- **3** new products/services to market
- LOA revenue **€833K**

3 Collaborative engagements with businesses

- **25** new collaboration agreements funded by industry signed – involving **36** different companies
- Teagasc winner of Knowledge Transfer Ireland (KTI) Award 2022 for Industry Engagement

4 Entrepreneurship and spin-out support

- **33** staff completed entrepreneurship or accelerator programmes (including Teagasc Catalysing Connections, UCC SPRINT Accelerator and EIT SeedBed Incubator)
- **4** pre-spin-out project ideas funded through Teagasc START Fund 2022

Scientific breakthrough in reducing methane emissions

A world-first scientific breakthrough that can enable the reduction of methane from the Irish cattle herd through animal genetics was recently announced by Minister for Agriculture, Food and the Marine, Charlie McConalogue TD and Minister of State with special responsibility for research and innovation, Martin Heydon TD.

This will be possible because of the publication of methane evaluations which will enable breeding programmes to reduce daily methane emissions in beef cattle. The research to underpin this is a result of a €3 million project 'GREENBREED', funded by the Department of Agriculture, Food and the Marine. The project has led to the publication of the world's first national genomic evaluations for methane emissions in Irish beef cattle.

Collaborative research, involving Teagasc, Southeast Technological University, Munster Technological University and ICBF, found:

- large differences in daily methane emissions between animals fed the same diet, with 11% of these differences being traced to genetic differences
- the 20% highest emitting animals genetically are expected to emit 30% more methane per day compared to the 20% lowest emitting animals.

The work indicates that breeding programmes to reduce methane emissions will be effective for selecting low-emitting livestock, especially when undertaken in tandem with the national genomic evaluations, such as the age at slaughter evaluations released in 2022.

Ministers Charlie McConalogue (left) and Martin Heydon (right) announced a world-first scientific breakthrough that can enable the reduction of methane through animal genetics. Pictured also are (middle l-r): Donagh Berry, Teagasc and Clodagh Ryan, ICBF

Diet-related diseases and personalised nutrition

The CoDiet project is a new Horizon Europe and UKRI-funded research project that will trial innovative diet-monitoring technologies to improve our understanding of the relationship between the food we eat and common non-communicable diseases (NCDs) such as heart disease, diabetes, obesity and cancer. Researchers will trial technologies such as wearable smart-cameras, and develop artificial intelligence tools to deliver personalised dietary advice.

According to the World Health Organisation, NCDs kill 41 million people each year. However, little is known about the dietary mechanisms that actually drive NCDs, and the current tools used to collect dietary information rely on self-reporting, which can be unreliable. There is also a lack of data relating to vulnerable groups, such as those from lower socioeconomic backgrounds, where NCDs are often over-represented.

At Teagasc, Food Bioscience Researchers Orla O'Sullivan and Paul Cotter are partners in the project, which is led by AZTI, Basque County, Spain. Using the facilities at Teagasc's DNA Sequencing Centre at Moorepark and the researchers' vast expertise in microbiome analysis and bioinformatics, they will focus on improving our understanding of the importance of individual variation in response to diet (and the risk of NCDs), as well as investigating NCD risk factors. This will give insight into the targeting of dietary NCD advice.

News in brief

Natural art

This image shows Luis Lopez-Sangil (Teagasc Soil Health Research Technologist, far right) talking in the Blackbird Cultur-Lab workshop about the diversity of soil colours and textures, and the science behind it, with artist Richard Malone (second from right), Karla Sánchez, workshop organiser (left) and Marta Onate, attendee, second from left.

London-based Wexford fashion designer and artist Richard Malone was invited to take part in a month-long research residency at the venue, which is a creative cultural laboratory based on a working farm in Foulksmills that is transitioning toward regenerative agriculture practices.

Richard developed a new body of work that included the study of natural dyes and clay along with collaborative dance movement.

Teagasc pig research

Over 170 pig producers and industry stakeholders attended a two-day research event (in Cavan and Cork). There was a viewing of the newest addition to the Teagasc Pig Research Facility, a state-of-the-art finisher building tailored to conduct low emissions and high welfare research trials.

Speaking at the event, Keelin O'Driscoll, Teagasc Researcher said: "The Teagasc Pig Department has a strong reputation both nationally and internationally in cutting-edge pig research. As well as showcasing our work, a main aim of the open days was to engage with our stakeholders so that going forward we can effectively target our programme to address their needs."

Award for Walsh scholar

Congratulations to Teagasc Walsh Scholar Elena Anedda, who won an oral presentation award at the ENVIRON conference held in ATU Letterkenny recently.

Elena is undertaking her PhD as part of the One Health European Joint Programme and is studying the impact of heavy metals on antimicrobial resistance in primary production. Her Teagasc supervisor is Kaye Burgess and the study is being done in collaboration with National University of Ireland Galway (NUIG) and Norwegian Veterinary Institute. Elena is pictured receiving her award from Liam McCarton, Environmental Sciences Association of Ireland Chairperson.

Circular Food System

Leader of the pack(aging)

An innovative approach to sustainable food packaging saw Teagasc's Shivani Pathania receive recognition at this year's UCC SPRINT Awards, with commercialisation for her concept next on the agenda.

At UCC's 2023 SPRINT Awards, all of the top accolades were awarded to female researchers. Among the winners was Teagasc Researcher Shivani Pathania. Shivani was accepted into UCC's SPRINT Accelerator programme last year, thanks to the close partnership between Teagasc and UCC technology transfer functions. She was the proud recipient of the 'Sustainability Award' with her Clean Green Packaging Technology, whereby establishment of a spin-out company is being considered as its commercialisation vehicle.

Shivani's current role in the Food Industry Development Department at Teagasc Food Research Centre, Ashtown, involves supporting the prepared consumer food (PCF) industry through the provision of technical and consultancy services, and contract research. It was during such PCF industry engagements that Shivani recognised the multiple challenges faced by small and medium-sized enterprises (SMEs) related to their packaging needs. More than 90% of food businesses in Ireland are SMEs, and they feel challenged to reduce food waste, and to improve operational efficiency and production automation.

As 68% of Irish SMEs are actively working towards reducing packaging use, this led Shivani to identify a gap in the market. With her concept for a novel sustainable packaging solution for small ready-to-eat food manufacturers, she secured internal Teagasc support to develop a first prototype.

Aligned with sustainability goals

Shivani's Clean Green Packaging Technology can provide an eco-friendly, sustainable packaging solution for gas-flushed ready-to-eat and ready-to-heat (RTE/RTH) products, suitable for SMEs. The semi-automatic machine features a novel nozzle design that can introduce modified atmosphere into the plastic pots, preserving and extending the shelf life of the food products, without the use of plastic film.

Teagasc Researcher Shivani Pathania with her SPRINT Award

> **The Clean Green Packaging Technology offers a solution that addresses the issue of both food waste and plastic waste.**

Shivani's innovation offers a solution that addresses the issue of both food waste and plastic waste. Not only is it in line with Teagasc's own climate action strategy pillar on circular food systems, but it further aligns with the UN Sustainable Development Goal to ensure responsible consumption and production patterns, as well as EU strategy on zero-landfill waste by 2025. All of this makes netting the Sustainability Award a truly deserving win.

Further to engagement with Engage@Teagasc, in 2022 Shivani secured funding through the Teagasc START Fund, which was set up to bring early-stage technologies closer to market as a basis for new companies. By using this to optimise the design and validate shelf life extension capabilities for a range of RTE products, the prototype is now closer to market, and the next step may be to seek commercialisation funding from Enterprise Ireland.

Photo courtesy of UCC Innovation

Connecting with entrepreneurs

With an interest in developing business knowledge and entrepreneurial skills, and securing further funding/investment for her spin out idea, Shivani was accepted into 2022 SPRINT, which UCC runs for its researchers to help potential and early stage spin-out companies overcome challenges they may encounter when starting businesses.

Shivani says: "As a participant of UCC SPRINT, I was delighted to receive this award, and really benefitted from participation in such an excellent programme and connecting with like-minded researchers.
I had the opportunity to connect with serial entrepreneurs as business mentors, learn from their invaluable experiences, draft business canvases, perfect my business pitch, and equip myself with the tools to navigate the uncertainties of the entrepreneurial journey."

Teagasc and Shivani are grateful to UCC for opening SPRINT to select Teagasc researchers since 2020. Shivani added: "Myriam Cronin, who runs the UCC SPRINT programme, demonstrates remarkable insight in understanding the unique journeys of participants and tailoring the modules to their specific requirements. I am so grateful to UCC and Myriam for this invaluable opportunity."

The entrepreneurial journey may have only started for Shivani but she is excited by the prospect of it. With an award won and investors already keen to engage, the future looks bright for Shivani and her Clean Green Packaging Technology. T

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Getting to know

Luis Lopez-Sangil

Equipped with a PhD in Soil Science, **Luis Lopez-Sangil** has swapped warmer Barcelona for wetter Wexford but maintains a sunny disposition through his work at Teagasc. Here, we find out more about his work as a Soil Health Research Technologist.

Hi Luis! Tell us a bit about where you're from.

I'm originally from Barcelona, but my family roots are from Lugo in Northwest Spain. So I see myself as a mix of Mediterranean and Atlantic heritage. I'm lucky to have lived in several countries (Spain, Sweden, UK, and now Ireland), trying to learn the best of each society.

What led you to Teagasc?

I graduated with a Biology BSc from the University of Barcelona, where I also did my PhD in Soil Science, with collaborations at Lund University and the University of Exeter. I held postdoctoral positions at the Open University and Lancaster University, before Brexit and the search for better work-life balance brought me to Teagasc Johnstown Castle.

What does your field of work look like?

I'm involved in a range of interdisciplinary research, from physical aspects of soil health to the nitty-gritty of soil biogeochemical cycles. I also survey soils by looking at their features and formation factors, which gives us valuable information about their vulnerabilities and functions. I also fly drones to capture aerial data!

What projects are you currently focused on?

I've just finished developing a novel technique at Teagasc to study how minerals protect soil organic matter, which will help us understand which soil types and land practices are better for sequestering carbon. I'm also coordinating the installation of new growth rooms in Johnstown Castle, and seeking to improve drone measurements for research projects.

How does Wexford compare to Barcelona?

I felt immediately at home when I landed in Wexford five years ago. Being a small town makes it easier to engage with people; I love how welcoming the community has been, and have happily settled here with my family. Although sometimes this "sunny" south-east corner of Ireland isn't that sunny! T

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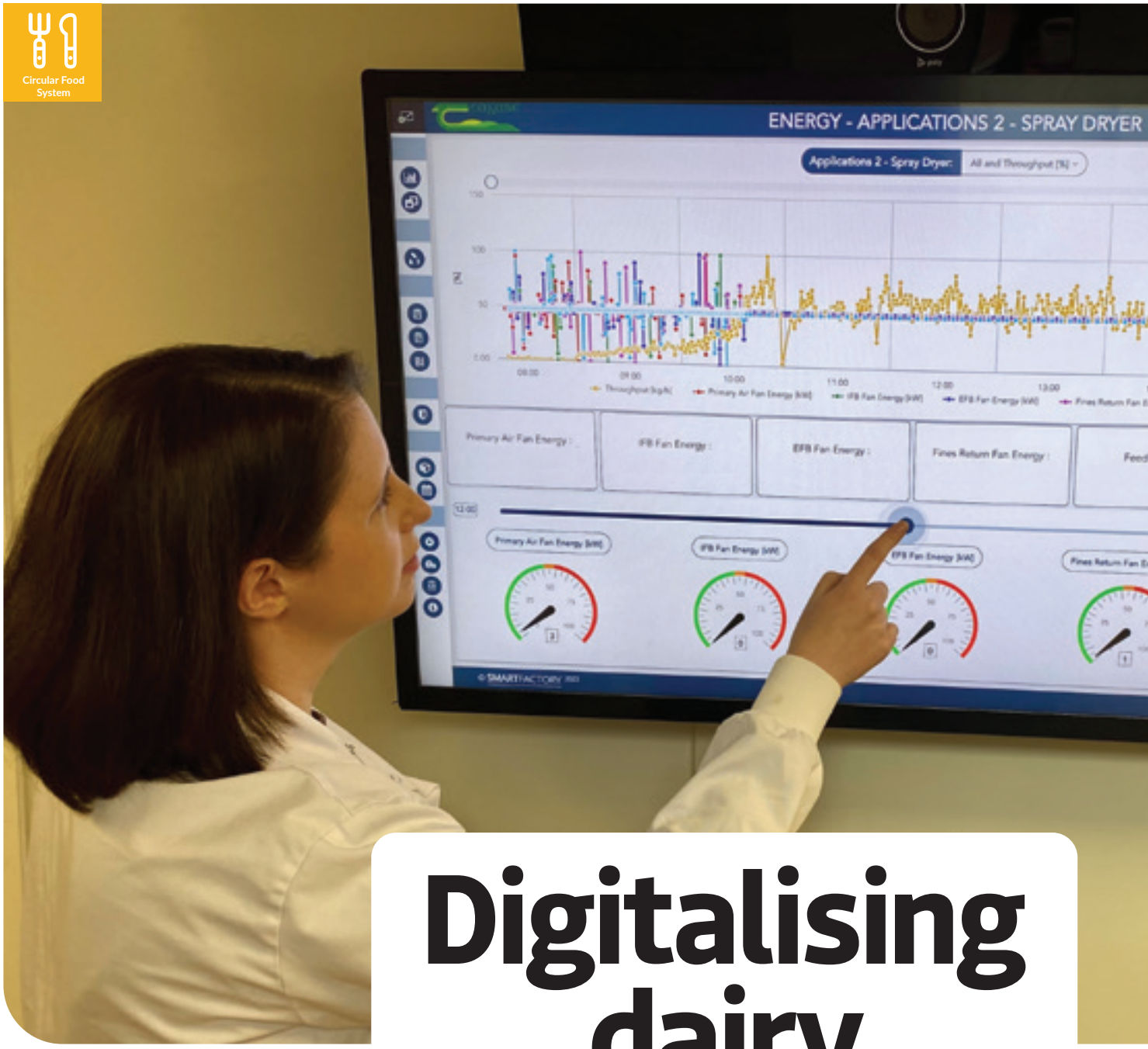
Circular Food System



Digitalising dairy

Researchers in the Food Chemistry and Technology department at Teagasc Moorepark are examining how the Industrial Internet of Things can make dairy processes more efficient and streamlined.

The Industrial Internet of Things (IIoT) aims to provide greater cohesion and communication between tech systems. At Teagasc Moorepark, researchers are examining how it can be used to aid the dairy industry.

In dairy production, IIoT sensors and devices can be embedded in milking machines to collect data on milk quality. Dairy processors can also use IIoT sensors and devices for process automation and optimisation, to monitor environmental parameters and product properties and to collect data on the equipment itself, for performance evaluation

There are several notable challenges facing industry implementation of IIoT. The complexity and scale of IIoT systems requires significant power consumption, and connecting their arrays of devices and sensors across different departments can be difficult to manage and orchestrate. Further to that, different devices may be operating on different protocols or communication standards, requiring effort to ensure effective system-wide communication and data transmission.

Additionally, businesses must ensure that they implement accurate security protocols and stay abreast of security measures to mitigate the risk of cyberattacks and data breaches.

Centralised, real-time data access

An IIoT platform has been successfully installed at Teagasc Moorepark pilot plant to enable real-time process monitoring and historical data access in one centralised location. This has been achieved through the use of existing unit operations, coupled with additional wireless sensors and gateways

Hanieh Amani

WAPS dashboard for energy monitoring of the spray dryer operations

	Internet of Things (IoT)	Industrial Internet of Things (IIoT)
What is it?	A system for connecting varying types of devices to shared networks – including, but not limited to, computing, mechanical and digital devices.	An extension of IoT, merging devices, software and networks for industrial sector applications (e.g. logistics and transport, health, agriculture, manufacturing).
What is it used for?	Allows devices to communicate and exchange data without the need for human interaction.	Supports real-time data gathering and remote monitoring of industrial processes.

that create a live representation of the processes. The following unit operations have been integrated into the platform: heat treatment, membrane filtration, evaporation, and spray drying.

The IIoT platform has been designed to perform a variety of data processing tasks, including real-time acquisition and aggregation, integration to a centralised location, analytics, and visualisation during pilot plant processing. The objective of this platform is to identify outliers and trends, to create a repository for real-time and historical data. In addition, process efficiencies can be identified by monitoring any variability that occurs in the process.

Data-driven decision-making

In addition to capturing these important process parameters, such as mass flow, feed pressure, steam-in pressure, temperature, process viscosity and powder moisture, the IIoT platform also calculates and visualises individual unit operation energy and water usage.

Moreover, the Work Area Performance System (WAPS) has been developed to support takt (a manufacturing term for required product processing time) and downtime analysis, digital workflows, energy monitoring, real-time visualisation, advanced analytics and reporting. It has been designed based on a standard architecture and meets the highest industrial networking and cybersecurity standards, including options for secure offsite remote connectivity.

The WAPS system uses both wired connectivity and wireless sensors to gather data from PLC-controlled (Programmable Logic Controller) machines and manual workstations. The data is then recorded as time-stamped events in the centralised location. WAPS is comprised of several modules and dashboards, each designed to provide specific functionality to users and offer a comprehensive overview of the pilot plant's performance, allowing researchers to make data-driven decisions during experiments.

Overall, implementation of IIoT in the dairy industry is advantageous as it allows real-time process monitoring and data analysis, which can lead to increased process efficiencies, enhanced productivity and improved safety for employees. It can also help reduce downtime and equipment failure. Furthermore, optimising the use of resources and minimising waste can result in overall cost savings. Teagasc's implementation of the IIoT and the WAPS dashboard system has enabled the pilot plant to collect, analyse and visualise critical data in real-time, thereby enhancing the plant's productivity and efficiency. T

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Re-Peat business

Beyond Peat is a five-year DAFM-funded research project aiming to identify potential peat alternatives for Irish horticulture. To highlight the work being done to meet that challenge, we spoke to the core Beyond Peat Mushroom team: Senior Research Officer Helen Grogan, Technologist Brian McGuinness, Specialist Advisor Donal Gernon, and Research Officer Eoghan Corbett.

Photography: John McElroy

Peatlands are natural reservoirs of carbon and biodiversity, the demise of which fuel climate change and environmental damage on a global scale. European governments are tackling the challenge to minimise carbon emissions and safeguard biodiversity through directives on climate, habitats, green energy and environmental sustainability. While most extracted peat in Ireland was used for electricity generation in power stations (which has now stopped), around 3% (2018) was used for commercial horticulture, including mushrooms, where a peat-based layer called 'casing' is essential for high-quality crops. Finding a replacement for peat is a major challenge, due to its excellent water-holding properties and consistency.

How did the Beyond Peat Mushroom team come about?

Helen: Teagasc have been conducting mushroom research to support this important sector of Irish horticulture for over 50 years, which is one of the most efficient worldwide, producing top quality mushrooms for export. We needed to address the sector's heavy reliance on peat to make mushroom casing more sustainable into the future.

Eoghan: This led to the Beyond Peat project being established in 2021. It aims to build a research platform for sustainable growing media in Ireland, to tackle uncertainty around the availability and supply of peat for the horticultural sector.

What are the team's main priorities?

Eoghan: To provide independent, evidence-based advice to growers to aid transitions away from peat use. A major aim is identifying and assessing the performance of peat-alternative materials derived from bio-renewable sources or as by-products of Irish industry and agri-food production. We also aim to utilise novel methods to transform these materials into usable

Beyond Peat Mushroom team members (l-r): Helen Grogan, Eoghan Corbett and Donal Gernon observe a small scale trial with novel peat-free casing blends

> **The Irish mushroom industry is one of the most efficient in the world, producing top quality mushrooms for export.**

growth media components and assess how they might be blended for best effect.

Donal: There are some key focus points for peat alternatives. Any raw materials used must be more environmentally sustainable than peat. Alternative blends should achieve similar yields and be of consistent quality compared to peat-based casing as the industry is a high-volume/low-margin business. Finally, alternative blends must be affordable in comparison to peat.

What is your approach to this research?

Helen: It's crucial that we follow a well-mapped experimental plan so that results are reliable and meaningful and so that they can be published in peer-reviewed journals and presented at conferences. We also participate in industry events and workshops to transfer knowledge in a meaningful way to end users.

Donal: As a specialist advisor, I regularly speak with growers to get a sense of what issues they're facing on the ground, which I incorporate into our research. Once we have a peat-free casing blend that we are satisfied with, we will conduct industry-scale trials in large modern growing facilities to see how it performs at a commercial level.

Eoghan: We're currently growing mushrooms with peat-free casing blends made up of various candidate materials. This experiment is designed to assess their effect on mushroom growth and to identify which characteristics of mushroom casing are achievably replicated and which require further refinement.

What are some of the key tools you used for this project?

Eoghan: Water availability and retention are critical aspects of a good casing, so we've invested in next-generation sensors that can be placed inside the casing layer during growth to measure water characteristics. These sensors help build up a picture of how water behaves in the casing layer during mushroom growth and development, allowing us to compare the attributes of novel peat-free blends with standard peat-based casing.

Brian: The Ashtown Mushroom research unit is a pilot scale mushroom growing facility, designed and built to our specific needs. Unlike a commercial facility, we've needed to develop equipment and methods to deliver crops on a small scale with minimal staff input, yet to commercial standards. We have designed a bespoke filling line which allows us to efficiently fill various containers with substrate. Once crops are completed, mushroom and compost waste is cooked out with steam to prevent pest and disease transmission, after which it is processed on-site using an aerobic digester to produce a composted product.

What makes this work so important in the context of Irish agriculture?

Helen: The Irish mushroom sector produces top quality mushrooms throughout the year. It is worth €130 million at farm gate and exports 80% of total production to the UK. It currently employs over 3,500 people in rural locations, so it makes an important contribution to rural economies.

Eoghan: There's an ever-increasing drive for more sustainable and circular agricultural practices. As the circular economy expands, this will increase competition for previously undervalued materials. By evaluating how best to make use of these resources now, the Beyond Peat project has an important role to play in highlighting what resources ▶

Brian McGuinness measures the colour and quality of mushrooms. Any peat alternative casing must result in high-quality white mushrooms. These mushrooms are not up to standard as they are blemished and bruised

will shape sustainable, economical and safe horticultural production into the future.

How does the Mushroom team contribute to Teagasc more broadly?

Helen: Mushroom research has been an integral part of Teagasc's activities for over 50 years, and underpinned the development of Ireland's mushroom industry. The team's outputs are appreciated by both the national and international mushroom community, which further boosts Teagasc's reputation.
Brian: The mushroom industry is Ireland's largest horticultural business, and our team have a long track record of providing support for the challenges unique to mushroom production. In our laboratories, we can provide disease diagnostic support to not only the mushroom industry but to other horticulture sectors. This allows Teagasc to be aware of issues currently affecting the industry, allowing us to make informed decisions when it comes to applied research support.

What does the future of your research look like?

Donal: In recent years, the mushroom industry has been investing in progressive, renewable technologies, which has greatly benefited the sector by reducing input costs. Mushroom picking automation is the next trend that will be introduced into the sector over the coming years as labour costs increase and availability of suitable staff decreases. In 2021 and 2022, I held webinars assessing the suitability of automation systems and their financial implications for Irish mushroom producers. This work will continue in the years ahead as we support the sector's transition toward automation.
Brian: In addition to the impending loss of peat as a mushroom casing ingredient, the sector faces pest and disease control challenges due to pesticide resistance and the loss of approved synthetic products. We're in a unique position to trial emerging biocontrol technologies against a wide range of mushroom crop diseases, and I would anticipate future work in this area to assess innovative disease control methods.

What are the principles you work to that you think make your team successful?

Helen: We're committed to high standards of scientific investigation and to our unbiased independent approach to finding solutions to problems facing the mushroom sector. We meet regularly to discuss issues of concern and approaches to work, and we all learn and benefit from each other, so the team is greater than the sum of its parts.
Brian: Despite being a small team, we have a wide range of skills from advisory, technical, academic and communications, which makes us adaptable and flexible in our approach to experimental work.

What are you proudest of as a member of the team?

Helen: Having led this team for many years now, I am particularly proud of our excellent track record in disease control research. It has also been very rewarding being involved in training the next generation of mushroom researchers.

Brian: How central we've been to the ongoing growth of the Horticultural Development Department since relocating to the Ashtown campus.

Donal: I'm proud to be part of a team who strive for solutions to real industry threats, and I'm hopeful the Beyond Peat project will have a huge impact for the sector.

Eoghan: Being part of a team which is tackling a real industry challenge, whilst at the same time helping to create a more sustainable model of food-production.

Supporting Policy

The social side of sustainability

Social sustainability is a measure of human welfare, with both internal dimensions, which relate to the individual, and external, which concern community-oriented issues around values and the demands of wider society.

There is increasing momentum worldwide to adopt an integrated approach to food systems. Sustainable food systems are profitable throughout, with a positive or neutral impact on the natural environment and broad-based benefits for society. To date, least attention has been given to the social dimension of sustainability, but it is now being increasingly recognised in policy. This is reflected in the more holistic objectives of the Common Agricultural Policy (CAP, 2023-27), the EU Farm to Fork strategy and the Irish Food Vision 2030. ▶

Covid-19 has had an impact on social contact among farmers, with more transactions via online marts and 10% of farmers only seeing someone outside their household once a week

Bo Scheeringa Photography /shutterstock.com

In meeting our sustainability goals, insights from social science can help us understand the social and institutional context to particular actions and behaviours, and the broader economic and political incentives. A suite of social sustainability indicators is being developed through the Teagasc National Farm Survey (NFS) using data collected on Irish farms. However, given its broad spectrum, the collection of some social data can be challenging, either due to the sensitive nature of the data itself or the intensive nature of its collection.

In addition to the demographic data reported on annually, a series of special surveys has been undertaken through the NFS in recent years. These have centred on issues such as generational renewal, farm safety, wellbeing, community engagement, rural services and digital connectivity. Some key findings from the 2021 survey are discussed below.

Health and wellbeing of farmers

Almost 40% of farmers reported experiencing stress relating to their farm business in the past five years. explains Senior Research Officer Emma Dillon.

"Across farm systems, the prevalence of stress was highest on dairy farms with more than one in two dairy farmers indicating that running their farm business was a source of stress," says Emma. "This compares to between one in four and one in three across other systems. All farmers reported a significant deterioration in their stress levels over recent years. Identified farm stressors include weather, workload and financial concerns."

On a more positive note, 78% of farmers surveyed reported having good or very good health. Post-Doctoral Research Mary Brennan says: "The figure was highest among tillage farmers and lowest among sheep farmers. However, the variation across farm systems is reflected in the fact that between a quarter and one-third of cattle and sheep farmers reported poor or fair health, compared to about one in ten dairy and tillage farmers, who tend to be younger, on average.

"It's also concerning that, of those reporting poor or fair health, almost half have no replacement labour. This seems to be an issue in some regions particularly where additional labour is in short supply."

40%

Percentage of farmers who reported experiencing business-related stress in the past five years. The percentage of dairy farmers (55%) who experienced stress is more than double that of tillage farmers (26%).

Increase in digital connectivity

A dramatic increase in smartphone usage among farmers is evident – rising sharply from 20% across farm systems in 2015 to 76% in 2021. Similarly, there has been a steady increase in internet usage among farm households over the last decade, with close to 90% having internet access in 2021 (almost universal usage on dairy farms).

Family labour is important on Irish farms with higher levels of female labour input evident on dairy and sheep farms

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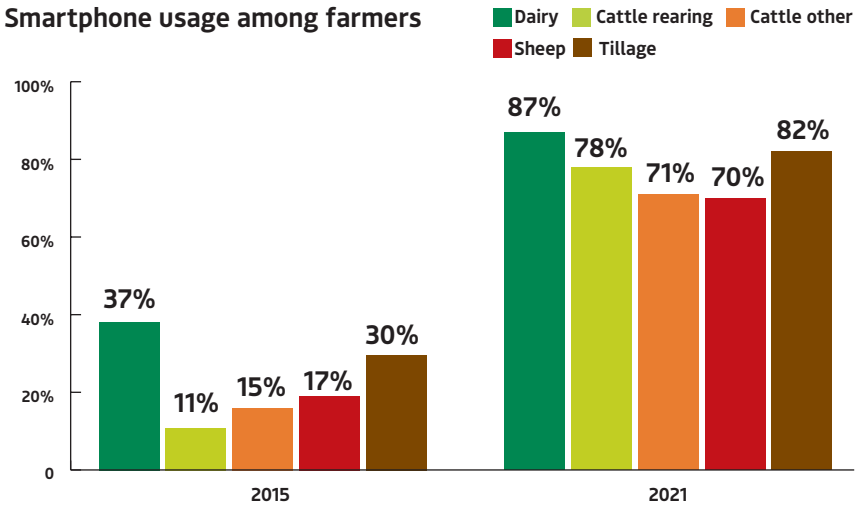
Smartphone usage among farmers



In terms of internet quality, 57% report good or very good internet access. However, the quality was reported to be poor or very poor on 15% of farm households across Ireland.

"The increase in digital engagement among farmers has been particularly evident since the onset of Covid-19," says Brian Moran, National Farm Survey Team Lead, "as demonstrated by farmer use of online livestock marts. According to the NFS, two-thirds of farmers watched marts online during the pandemic, with over half buying and selling in this way. More than four-fifths (83%) of those surveyed plan to continue doing so given the convenience for part-time farmers in particular."

The impact of Covid-19 is also evident in terms of the reduction in daily social contact among farmers. Rather starkly, the proportion of sheep farmers with daily

contact with people outside of their household dropped from almost three-quarters in 2018 to just over half in 2021, with a similar proportion reported for dairy and cattle farmers.

As a consequence, there has been an increase in the proportion of farmers with less social contact, with one in ten farmers only seeing someone from outside their household once a week.

Observations on age and gender

A core set of demographic data is collected through the NFS annually, and is reported upon in the annual and sustainability reports.

Data from the survey in 2021 reiterates the ageing nature of the Irish farm population, with the average farmer age standing at 58. Farm households are deemed to have a high age profile if the farmer is aged 60 or older with no members of the household aged below 45. Cattle and sheep farms were more likely to have a high age profile and be operated by farmers living alone.

In terms of labour input, hours worked and the greater labour intensity of dairying is reflected in longer hours worked on farm. When off-farm employment is factored in, the gap between dairy farms and other farm systems is reduced.

Taking gender into consideration, female labour input was reported on 54% of dairy farms; the next highest figure was on sheep farms, at 45%. Other farm systems reported lower proportions of female labour input, reflective of their generally part-time and more extensive nature.

54%

Female labour input on dairy farms – the highest proportion of all farm types. The lowest percentage was 28% for tillage farms.

Continued focus on social sustainability

"We need to further progress the routine collection of social data on Irish farms to better assess their social sustainability status," reflects Emma. "Work is ongoing in this regard. Food Vision 2030 focuses on the collection of data relating to issues such as generational renewal, gender balance, diversity, education and training, health and safety, mental health and wellbeing and broader rural development. These serve as a wish list for farm level social sustainability indicator design.

"The delivery of a more holistic assessment of farm level sustainability, with improved social metrics, will simplify the process of CAP monitoring and evaluation and facilitate more targeted support and ultimately help us achieve a wider range of sustainability goals." T

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Supporting Policy

A collaboration between Teagasc and the Agri-Food and Biosciences Institute is aiming to better understand viral-bacterial interaction in the poultry gut and its effect on food safety.

A delicate balance

The gut is home to a highly complex ecosystem comprising various microbiomes (microorganisms that live within a given environment, such as the human body or the digestive system), including bacterial, fungal, viral and bacteriophage, which are, to some extent, dependent upon each other and on the nutritional supply to the host.

Recent advancements in high throughput 'omics' technologies – which analyse and characterise the properties of microbiomes – have improved our understanding of the role of commensal and pathogenic bacteria in the immune system, but interactions with the virome is still unknown.

Researchers at Teagasc and the Agri-Food and Biosciences Institute (AFBI) in Northern Ireland are working together on a microbiome project to provide new insights into viral bacterial interaction in the poultry gut to determine potential dysbiosis, pathogen colonisation and its effect on broiler production.

Increase in harmful pathogens

Chicken meat continues to be one of the most consumed sources of protein worldwide, with demand expected to have increased significantly by the year 2050. With the ban of antibiotics as growth promoters in the European Union, enteric pathogens – microbes that can cause disease or infection – are becoming more frequently observed on broiler farms.

Strong pathogens such as *Campylobacter, Escherichia coli* and *Salmonella* can modify the chicken gut and cause intestinal and caecal dysbiosis – bacterial imbalance. Using advanced technology, we can better understand the interactions between the viruses and bacteria and therefore decrease the pathogen load in chickens, ensuring food safety.

The complex mechanism

Recent studies of gut microbes in humans and mammals have shown that viruses and bacteria interact to a much greater degree than was previously thought and in a variety of ways, both directly and indirectly, often enhancing pathogenesis.

Bacteria and viruses often occupy the same niches and the interactions are well characterised in humans – for example, influenza virus and streptococcus spp. It has been suggested that direct interactions largely favour virus pathogenicity while

Evidence-driven hypothesis

Guillain Barré syndrome is the most common cause of acute paralysis worldwide. The microorganisms mostly associated with Guillain Barré syndrome include *Campylobacter jejuni*, Zika virus and recently Coronavirus type-2.

There is evidence to support an auto-antibody mediated immune process that is triggered by molecular mimicry between structural components of peripheral nerves and microorganism interaction. Moreover, it has been reported that the initial primary infection by bacteria provides the foothold for other secondary pathogens. The pathogenicity-enhancing mechanism has also been demonstrated by reovirus and rotavirus, which are common enteric viruses in broiler chickens.

Research undertaken by the AFBI suggests that enteric viral infections and bacterial dysbacteriosis are underlying causes of observed growth issues in broilers. The Microbiome project between Teagasc and the the AFBI aims to provide a novel understanding of viral and bacterial interactions in the chicken gut, with a particular focus on their effect on *Campylobacter* proliferation and uneven flock growth in commercial chickens using advanced omics technology.

cottonbro studio/pexels.com

Research is helping Teagasc understand how pathogens in the chicken gut cause bacterial imbalance, which can affect food safety

indirect interactions promote bacterial activity/pathogenesis.

One mechanism of viral/bacterial interaction in the chicken gut is through the action of bacteriophages, which plays an important role in shaping the composition and function of the gut microbiome. For example, the addition of a bacteriophage cocktail to the drinking water of broiler chickens causes changes in the gut microbiome, including an increase in the abundance of *Lactobacillus* (good bacteria).

Another mechanism is through the activation of bacterial virulence genes. Viruses can trigger the expression of virulence genes in bacteria, leading to increased pathogenicity. This has been observed, for example with *Salmonella enterica*, where the presence of viruses caused the upregulation of virulence genes.

However, the interactions are not always easily understood and similar studies may report contradictory results.

It is also possible that the presence of different bacteriophages or viruses in the chicken gut may have different effects on colonisation with pathogens such as *Campylobacter*, and that the gut microbiome composition may also play a role in these interactions. T

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Celebrating REDP's impact on farming and policy

Teagasc's Rural Economy and Development Programme (REDP) strives to make an impact on the agri-food sector by bringing together several streams of work at different disciplinary, strategic and temporal scales. As part of its latest peer review process, the REDP team selected six case studies that realised the programme's objectives.

Over the past 50 years, the diverse range of research and knowledge transfer work from Teagasc's Rural Economy and Development Programme (REDP) has contributed to worthwhile outcomes for farmers, enterprises and policymakers. Six projects selected by the team as part of a peer review highlight how the ongoing and evolving relationships and interactions between REDP and its networks have the potential to achieve greater impact on the sector.

Each case study contributed to change along all three impact pathways: technology development and adoption; capacity development; and policy influence. The technology development and adoption pathway is perhaps the most familiar to most researchers. In the capacity building pathway, the process of carrying out research helps builds the capacity of actors in the agri-food system to innovate. For the policy influencing pathway, researchers generate insight and evidence that informs policy and contributes to policy change.

This suggests that the programme is not only developing and transferring research and technologies, but is also contributing to the ways in which this knowledge is made accessible and usable by end users. These pathways, outlined in Teagasc's Statement of Strategy, *Teagasc Together*, depict an overarching model of how Teagasc contributes to developmental impact in the agri-food sector.

CASE STUDY 1

Enhanced monitoring and evaluation of Irish agricultural performance

The National Farm Survey (NFS) was established in 1973 as a tool to assist in monitoring the economic performance of Irish farms and evaluating the impact of the Common Agricultural Policy in Ireland. It has developed in response to the expectations of society, policymakers and other stakeholders to now also assist in the monitoring and evaluation of social and environmental sustainability aspects of Irish farms.

The evolution of the NFS correctly anticipated a need to redefine farm data collection, monitoring and evaluation at EU level.

Key beneficiaries have been policymakers in Ireland, farmer representative organisations and civil society groups. Ireland is now one of the leaders among EU Member States in terms of the measurement of agricultural sustainability.

Teagasc researchers: Cathal Buckley, Emma Dillon, Trevor Donnellan, Kevin Hanrahan, John Lennon and Brian Moran

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CASE STUDY 2

FAPRI-Ireland models: support for evidence-based policymaking

From the early 1990s, the development of medium-term economic modelling and policy analysis capacity has strengthened evidence-based policymaking for the agri-food sector. Most directly, this capacity services the needs of policymakers in the Department of Agriculture, Food and the Marine (DAFM), the Environmental Protection Agency (EPA), the Climate Change Advisory Council (CCAC) and Department of the Environment, Climate and Communications (DECC).

This modelling capacity also informs other stakeholders, such as farmer unions (Irish Farmers' Association, Irish Creamery Milk Suppliers Association, Irish Cattle and Sheep Farmers' Association, Macra na Feirme), food industry representative bodies (lobby and business representative group Ibec, Dairy Industry Ireland, Meat Industry Ireland, Irish Co-operative Organisation Society) and civil society generally. Medium-term projections developed using the Food and Agriculture Policy Research Institute (FAPRI)-Ireland model have informed the development of successive rounds of agri-food sector policy processes: Agri-Vision 2015, Food Harvest 2020, Food Wise 2025 and Food Vision 2030.

Teagasc researchers: Trevor Donnellan, Kevin Hanrahan and Fiona Thorne

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CASE STUDY 3

Teagasc succession and inheritance Knowledge Transfer programme

Since around 2012, the Farm Management Knowledge Transfer (KT) Specialist department has been instrumental in equipping Teagasc KT advisors with the information and skills to allow them to be as effective as possible in facilitating conversations around succession. The department has co-ordinated annual information campaigns and 'Transferring the Family Farm' clinics for the farming community, which establish a regular contact point with over 1,200 farm family members considering succession.

Close collaboration with other local agencies, research projects, the development of resources for farm families and advisors, and the development and promotion of succession partnerships assist in generational renewal built capacity in the sector. The number of regular and specific purpose Succession Farm Partnerships registered annually continues to grow.

Teagasc researchers: Kevin Connolly, Anne Kinsella, Gordon Peppard and James McDonnell

CASE STUDY 4

Responsive and inclusive digital transformations on farms

Since 2017, Irish farm advisors and farmers are using responsively and responsibly researched and designed digital technologies and practices and are being supported to do so by technology development, capacity building and policy changes. These digital transformations arise from state-of-the-art REDP research, which contribute to multi-actor, inter-disciplinary research projects and programmes aimed at technology development and adoption.

Capacity is developed among a range of value chain and Agricultural Knowledge & Innovation Systems actors. One example is the development and use of digital extension toolboxes within the advisory service, focusing on grassland management, the prevention and management of Johne's disease; anti-microbial and anthelmintic use; farm safety; and time management. The research is also informing policy, particularly related to data governance and digitalisation of the Common Agricultural Policy, with one example being the AgriSnap App for farmers.

Teagasc researchers: Áine Regan, Áine Macken-Walsh, John Hyland, Réamonn Fealy and Maeve Henchion

Ground Picture/shutterstock.com

CASE STUDY 5

Contribution to informing and assessing national policies on land use and soils

Since 1998, the spatial analysis unit within REDP has developed a data and analysis infrastructure to inform the assessment of progress towards national environmental policy goals. The first national digital maps of soils, parent materials and habitats were produced.

National policies on land use and soils were informed and assessed thanks to the unit maintaining a strong scientific and technical track record in identifying knowledge and data gaps in the agri-environment area, and the development of industry-standard datasets to fill them. A National Land Cover and Land Use mapping programme has been created, and new Areas of Natural Constraint (ANC) regulations under Common Agricultural Policy have been developed.

The unit also informed and influenced draft EC regulations and subsequently went on to develop and produce the spatial database of environmental conditions on which the new ANC payments to 85,000 Irish farmers are based.

Teagasc researchers: **Stuart Green, Reamonn Fealy, David Meredith and Jesko Zimmerman**

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CASE STUDY 6

Contribution of Teagasc Rural Development to rural sustainability

From the late 2000s, in response to a reduction in staff, the loss of specific expertise and challenges from new policies, the Rural Development Department began to rethink how it engaged with farm families and rural dwellers. It did this in three primary ways: leveraging the reach of Teagasc communication channels (videos, webinars, webpages, factsheets, Options workshops and other events) to farm families to help them build capacity to develop appropriate diversification strategies; leveraging the support and services of rural agencies targeting farm families and rural dwellers; and high-level engagement in policy development.

The Department now facilitates the dissemination of information from Teagasc and from a wide range of rural actors to reach a client base of 45,000 farms on an ongoing basis.

Teagasc researchers: **Mary Ryan, Fintan Phelan, Wendy Conlon, Elaine Leavy, Kevin Connolly, Barry Caslin, Vanessa Keane, Joe Kelleher, Martin Bourke and Sean Keane**

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Circular Food System

No more PET peeves?

Recycled polyethylene terephthalate (rPET) is a sustainable packaging alternative to support the circular economy using recycled materials and minimising waste. The team behind the Leaf No Waste project at Teagasc Ashtown is currently investigating and trialling the use of novel rPET for fresh produce packaging using an automatic thermoformer and tray sealer.

The choice of packaging material plays an important role in maintaining quality, extending shelf life and ensuring consumer health and safety of fresh produce. Polyethylene terephthalate (PET) as a packaging material has consistently increased worldwide due to its excellent transparency, light weight, gas and water barrier properties, impact strength, and UV resistance. PET can be made from both fossil- and bio-based sources.

The heat-sealable properties of PET also facilitate technological advances for use in barrier solutions, hot-fill and thermoforming applications in a wide range of foods.

The global PET packaging market is projected to grow from $39.23 billion (€35.5 billion) in 2022 to $55.46 billion (€50.25 billion) by 2029, at a combined annual

John McElroy

Tigist T Shonte demonstrates the rPET packaging system at Teagasc Food Research Centre

growth rate of 5.1% in the forecast period 2022-2029. Bottled water and carbonated soft drinks are the dominant markets for PET packaging.

Aiming for increased circularity

PET plastics are widely produced and used, and more than half of them are disposed of without being recycled. Global and EU waste management rates showed that, in 2016, only 16% of polymers in flow were collected for recycling while 40% were sent to landfill and 25% were incinerated.

European countries have increased efforts to improve recycling rates. To meet EU Packaging Regulations (SI 322/2020), Ireland must now hit recycling targets of 65% of all packaging by 2025 and 70% by 2030.

Up to 80% of rPET food trays contain raw materials of recycled PET, reducing the polymer, oil raw material and energy used to manufacture a virgin PET tray, thereby promoting a circular economy and minimising plastic waste. Due to reduced material usage and high recycled content, the carbon footprint of rPET tray offerings are in excess of 85% lower than virgin mono PP food trays.

Virgin PET plastics can only be recycled for a limited number of times before becoming too degraded to be used again. This is because of a sharp reduction in the properties of the material due to deterioration of the thermo-oxidative and thermo-mechanical degradation of the chains, as well as hydrolytic scission.

A fresh approach to fresh produce

rPET and PET mono film have a number of key features that make them suitable for fresh produce packaging. They are lightweight with a high level of rigidity and an excellent barrier performance, suitable for Modified Atmosphere Packaging (MAP) to extend shelf life, and offer glass-like clarity for clear presentation of products ideally suited to fresh produce packaging (e.g. fruits and vegetables, poultry). Mono PET film is designed with 30% post-consumer recyclable materials, which greatly reduces carbon footprint as it produces the lowest greenhouse gas emissions, water usage and total energy usage of all plastics in manufacturing (including bio-based plastics).

70%

Ireland must recycle 70% of all packaging by 2030 to meet EU Packaging Regulations.

PET film is a strong, shred-resistant and lighter film with a thickness starting from 20 microns. PET film is a co-extruded polyester film with a layer of amorphous heat-sealable polyester film on one surface and plain polyester on the other, ideal for chilled applications where strong, permanent seals with good 'seal-through contamination' properties are required. It can be heat-sealed to itself or to rPET trays.

The Leaf No Waste project packaging team at Teagasc Ashtown is currently investigating and trialling the use of PET for fresh produce packaging using an automatic thermoformer packaging system based in the National Prepared Consumer Food Centre. The lightweight novel rPET plastic punnets are fully recyclable compared to PP (polypropylene), which is the most used material in Irish packaging. The use of thermoformed packaging materials can cut down on the warehousing cost of the trays currently used by the industry. PET monomaterials, if successfully used, can eliminate the use of Poly Vinyl Chloride (PVC) in fresh produce packaging.

The team is also assessing how these novel packaging formats impact product shelf life, while also looking at potential reductions in plastic use for packaged products and the overall cost implications of transitioning to these packaging formats. T

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Michael Gaffney, pictured in the glasshouse at Teagasc, Ashtown, amid the many rows of strawberry plants

Pest in class

Horticulture and Entomology Senior Research Officer Michael Gaffney is helping to lead a collaborative Teagasc project to automate pest control practices and tackle the ever-important issue of food security.

Photography: John McElroy

Horticulture may be one of Teagasc's smaller departments, but as any good entomologist will tell you; small things can have a big effect. Studying insect pests and other invasive species is a crucial aspect of the preventative work involved in crop protection and working to ensure successful crops for future growers, to mitigate problems of food security.

What does your career path at Teagasc look like?

I started out at Teagasc in Kinsealy, initially as an MSc student in 2002 in conjunction with UCD, which subsequently was converted into a PhD. In 2006 I took a research position at the University of Wales, Swansea, but my area of work was similar to what I had been doing at Teagasc, developing and deploying biological insecticides.

In 2007 I returned to Teagasc, working as a horticultural advisor, where I had responsibility for protected crops — meaning crops grown under glass or plastic, mostly in soilless growth media. I worked primarily as an advisor until 2013, when I transferred to a research officer position – I had been continually involved in research alongside the advisory work, but eventually switched to it full time. Partly, that's because horticulture is a very diverse area and the needs of the sector change, so we have to be flexible in our roles.

How did you originally get into entomology and horticulture?

I was a late convert to the field – I initially did biology and maths at Maynooth University, which at the time was a less typical route into horticulture. I had some lectures on biocontrol which touched on entomology, and it piqued my interest a bit. Then when I was looking for postgrad programmes, I found one on developing fungal biocontrol agents; at the time, the combination of entomology and fungi struck me as unusual, and seemed like it would be an interesting path to follow – and here we are!

How has this field of research changed over time?

One of the clearer shifts I've seen in crop protection, is the drive towards developing alternatives to synthetic pesticides. For example, the use of biological products such as entomopathogenic fungi and nematodes have been widely adopted in major crops such as mushrooms and soft fruit for managing pests – these are organisms that can infect and kill pests through cuticle penetration. While these approaches are most successful in soilless growth media in protected crops, there is potential, with further development, for them to be used effectively in soil-grown crops outdoors.

Therefore, there's growing acceptance of newer, perhaps less invasive, approaches to pest control, and increasing acceptance that these new approaches work differently from traditional pesticides and thus require different ways of thinking and different ways of actually evaluating their effectiveness.

Could you explain what Integrated Pest Management is?

Integrated Pest Management – IPM – is essentially a catch-all phrase to describe an approach to crop protection that involves the consideration of multiple control options. The term reflects thought and consideration of the pest, disease or weed lifecycle, its population size and the 'threshold' at which economic damage may occur in the crop and what management options may be available other than solely applying a pesticide.

It is about careful observation and information-based decision-making, so only the pesticides absolutely required are applied. This approach benefits all stakeholders including growers, although there is a need to increase, through research and development, more effective IPM strategies, particularly for outdoor crops.

A recent project you've been involved in for integrated pest management is the HALY.ID project – could you explain what it's about?

HALY.ID is a collaborative European research project that the Tyndall National ▶

Institute is working on in partnership with Teagasc. We are working together on the design and implementation of an automated pest monitoring system.

A key component of IPM is knowing when a pest is actually in your crop. Pest traps – either sticky traps or pheromone-based – are installed in many crops and then regularly collected for observation and identification. This process can be time-consuming and costly – sending staff to collect traps, observe and report, particularly from remote, hard-to-reach areas, and there is often a time delay from when the trap was deployed and when the information becomes available to the grower.

There's growing acceptance of newer approaches to pest control ... They require different ways of thinking.

So, the HALY.ID project arose from the question: can we automate this process? Not just automated imaging, but also automated identification of pests — in this case, *Halyomorpha halys*, or marmorated brown stink bug, from which the project takes its name.

The system developed takes a picture of the pest trap once every 24 hours and uses AI software to identify if the insect pest is present. It then communicates that finding to the grower. This helps reduce the time lag between trapping the insect and identification with the daily snapshot giving you a regular update, significantly reducing the amount of time staff would have to contribute to trap maintenance.

Another benefit of this system is how deployable it is; there's the one-off installation of it, it runs on a self-sustaining power source and then it just stays in place, monitoring.

We're currently in our first full season of monitoring in an apple orchard in Italy, but our preliminary data from last year was positive in terms of insect identification. The system needs another full season to validate results, and then hopefully it can be further developed to be able to identify a greater number of pests.

What are some of the future challenges in the field of pest management?

The big challenge coming is in relation to climate change – how it will affect crops directly, but also how it affects pest and beneficial insect lifecycles.

Pests such as aphids are vectors for many plant viruses; warmer, earlier springs would allow them to fly and spread earlier, impacting crops at more vulnerable development stages. In addition to this, due to national and European policy changes, we will have to integrate more alternative, non-pesticide-based crop protection strategies at a time of likely increasing pest pressure, which will be challenging.

From a horticultural perspective, reducing and eliminating peat as a growth media and moving to alternative materials will be a significant transition for the horticultural sector. Through the Beyond Peat project, we are testing and developing alternatives to peat in key horticultural crops and learning how we will need to alter our crop production protocols. One of our key objectives in this will be observing the changes in pest and disease epidemiology caused by the new production practices and the impact this will have on our IPM systems. Given how relatively rapidly we will need to transition away from peat, this is a very significant challenge for growers, researchers and advisors.

Michael Gaffney and Research Officer Helen Grogan inspect mushroom crops at the Mushroom Research Centre, Teagasc, Ashtown

Up close and personal

What's your favourite animal?
The vine weevil; they're the most elegant little insect. They're a very rudimentary pest but have a huge capacity to reproduce and resist pesticides, and they are a problem every single year. They are massively ordinary, but massively effective in their ordinariness!

If you hadn't ended up in research, what other job would you have wanted to give a go?
I always wanted to be a chef but was convinced by my parents to do science as a backup – so I never got round to the chef-ing!

What are you most proud of professionally?
I really like the opportunity to work in different scientific disciplines of relevance to horticulture, such as Integrated Pest Management, growth media and food safety and to be able to do that as part of international projects. I think it helps to promote the research we are doing, but also helps us to work collaboratively to try and solve some of the big challenges we are facing in the production of fruit and vegetable crops – challenges that, given the complexity and range of horticultural production systems, we would not be able to address on our own.

The more the berrier

At the forefront of Irish fruit production for nearly a century, Keelings remains committed to providing locally grown produce while facing the challenges of today.

Words by: Pat Farrell, Procurement Specialist at Keelings

Located in North County Dublin, Keelings is a 100% Irish owned, third generation family business, with a story stretching back to 1926. Since the beginning, there has been a focus on research and development, to produce the best quality produce. From the 1920s to the late 1960s, rhubarb was a key crop on the farm. In the 1930s, Keelings began growing more fruits and salads and supplying them to the local Dublin markets. The business first planted strawberries in 1937, with Bramleys following in 1949. Today, Keelings farm 1,214ha across Ireland, Costa Rica and Brazil.

Specialising in soft fruits

On the Irish farms, we now specialise in the production of soft and top fruit across 182ha. Strawberries are the main crop, with approximately 200 million berries produced each year from both heated and cold structures. This allows us to supply the market with Irish strawberries from March until November. Keelings are one of a few Irish farms growing and supplying raspberries, blackberries and blueberries to the major retailers, with the season running from May until October.

In relation to top fruit, our primary focus is on both dessert and culinary (Bramley apples) with a smaller area of pear production. Specialised storage allows us to supply Irish apples throughout the year. We have recently expanded our dessert apple production and will be working closely with Teagasc on its newly established research programme in this area.

In 2021, Keelings launched its new purpose, Better Food Better World. Our Better Food strategic priority strives to improve the quality, taste and freshness of our produce, which will encourage more people to enjoy fresh produce and consume their seven a day. This is achieved by significant investment in research and development, to deliver new growing techniques, technologies and varieties.

Seeking sustainable strategies

Since Keelings launched the 'Better World' strategic priority, considerable emphasis has been placed on improving the sustainability and environmental aspects of the farms; we currently have 82 honeybee hives in situ and aim to increase this to 100 by 2025. In addition, we have implemented no-mow policies and wildlife-friendly farm margins. We are a member of the All-Ireland Pollinator Plan 2021-2025.

The use of Integrated Pest Management (IPM) practices is routine, with prevention and the use of biocontrols being the initial focus when dealing with pest and disease issues. On the energy front, we are reducing our dependency on conventional fuels with the planned introduction of renewable technologies.

With the trend in healthy eating on the rise, the market demand remains robust for fresh produce. There is considerable scope for expansion in the supply and consumption of Irish raspberry, blackberry, blueberry and apple production, within a favourable policy environment.

Keelings remains committed to supplying locally grown produce to the consumer. Keelings' vision is to inspire more people to enjoy fresh produce leading to healthier, happier more productive lives. T

Keelings

Adaptation

Is the grass always greener?

The Moorepark St Gilles Grass Growth Model, or MoSt GG for short, enables farmers to access detailed data to more accurately predict grass growth and adequately prepare for periods of poor growth.

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Modelling of grass growth predictions across the country was initiated in response to the climatic conditions seen in 2018; cold weather in the spring and drought conditions in the summer resulted in poor grass growth, causing difficulties for many ruminant Irish livestock farms.

At that time, farmers wanted an accurate tool that would help to predict grass growth over the coming weeks to aid decision-making processes at farm level. Thus was born the Moorepark St Gilles Grass Growth (MoSt GG) model, which was used initially on three experimental farms to forecast grass growth for the upcoming weeks, thereby enabling farmers, advisors, and the government to prepare for the significant forage crisis that was then expected in the spring of 2018.

Unfortunately the weather challenges of 2018 didn't stop with the cold spring. Indeed, the summer of 2018 was characterised by water deficits and high temperatures, bringing more challenges to Irish grassland farmers and generating more interest in the model and its future grass growth predictions.

The regional differences in weather conditions in the summer of 2018 highlighted the need to expand the programme, which resulted in 30 commercial farms having their grass growth predicted by the end of 2018.

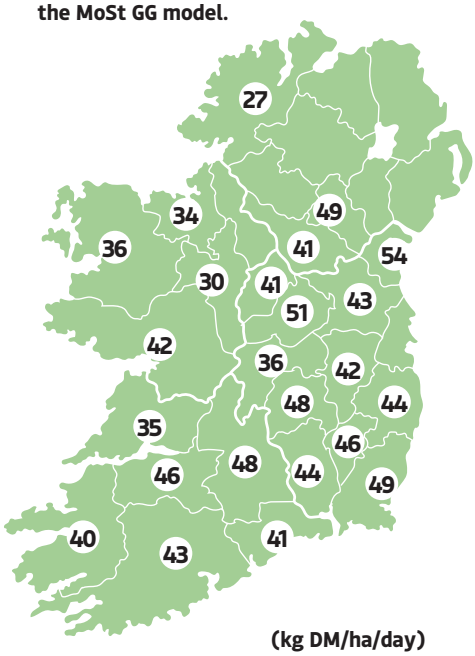
Providing live data to farmers

PastureBase Ireland (PBI) provides the backbone for the grass growth predictions. PBI farm-specific parameters are used to help populate the model, some of which include: paddocks area, grazing and cutting dates, number of grazing animals and their supplementation, and nitrogen fertilisation (chemical and organic) levels and application dates.

Briefly, the MoSt GG model predicts daily grass growth on grass-only swards (expressed as kg DM/ha; DM refers to the dry matter content of the grass and provides information on the nutritive value of the grass) depending on individual farm weather conditions, soil type, grazing animal type and management decisions. Farmer decisions that impact grass growth within the model, such as nitrogen (N) fertiliser application, as well as the pre- and post-grazing sward heights or the pre- and post-cutting heights, are also used to help improve the accuracy of the grass growth prediction. An added tool of the MoSt GG model is the ability to recreate the nitrogen flow both in the soil and in the plant to predict the N content of the grass, as well as the N leaching at the paddock level. Historical and forecast weather data — provided by Met Éireann — are also used in the model to predict grass growth. Grass growth predictions are conducted at the paddock level and are then averaged across the entire farm with live

Grass growth predictions

An example of grass growth prediction for the upcoming week based on the MoSt GG model.



(kg DM/ha/day)

Farmer decisions that impact grass growth are used to help improve the accuracy of the grass growth prediction

data available and provided to farmers.

From its inception, the MoSt GG model prediction has grown, and there are currently 84 farms involved in the project. Grass growth predictions are sent weekly to all the participant farmers, but are also available to Teagasc advisors alongside other information such as predicted rainfall and predicted soil temperature for the coming week, aimed at helping to advise farmers. The grass growth predictions are also freely available to the public weekly through the *Grass10* newsletter and on the PBI website. Since August 2020, the grass growth predictions have also been presented each Sunday by Met Éireann on RTÉ 1 during the farmer forecast.

Planning for paddock-specific performance

While the grass growth predictions are currently shown in the form of a precise number, each farm is different. This is why the trend of the grass growth prediction (increasing or decreasing compared to the previous week) is more important than the actual number. A specific farm could be consistently growing less than the prediction but understanding the overall trend and direction of the predictions supports management decision-making.

The incorporation of the MoSt GG model directly into PBI commenced in 2023 and will allow any farmer entering information inside PBI (at least 25 covers a year, N fertiliser application entered weekly) to avail of their own grass growth prediction based on the specific weather on their farm and their management practices.

In time, this will allow individual paddock predictions and recommendations around specific fertiliser application rates for each individual paddock of the farm to be generated. This will be based on historic performance from that individual paddock and therefore will allow precision grassland advice to be provided on a paddock-by-paddock basis. T

During the Moorepark open day on 4 July 2023, the grass growth prediction team will be present and grass growth predictions will be provided and presented. There will be opportunities for farmers to interact with grass growth prediction models.

FUNDING

Funding from Dairy Research Ireland is gratefully acknowledged.

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Reduce Methane Emissions

Bullish behaviour

The sexed semen lab at Teagasc Moorepark is helping to increase the availability of sex-sorted semen from large teams of dairy bulls of a high genetic index. Sexed semen allows greater reliability when predetermining calf sex, which can help bolster the Irish beef and dairy sectors.

The use of sex-sorted semen in dairy production allows predetermination of calf sex with ~90% reliability. At present, the only commercially available method of predetermining offspring sex is by manipulating the relative abundance of viable X- and Y-chromosome bearing sperm.

Recent developments regarding the availability and uptake of sex-sorted semen in Ireland have been remarkable. For example, there was no sex-sorted semen produced in Ireland for the 2021 breeding season, and availability was limited to a combination of a small number of Irish bulls that were moved to a sex-sorting lab in another country (e.g. Cogent in the UK) and imports of non-Irish bulls from other countries (e.g. UK, New Zealand).

In November 2021, Sexing Technologies established a lab at Teagasc Moorepark with the primary objective of stimulating greater availability of sex-sorted semen from large teams of dairy bulls of a high genetic index based on the national breeding index (i.e. Economic Breeding Index, EBI). The sex-sorting service was available to all artificial insemination (AI) companies operating in Ireland.

For the 2022 breeding season, the lab at Moorepark produced 85,000 straws for artificial insemination during a five-month period. For the 2023 season, Sexing Technologies started sorting at Moorepark in September 2022, and opened a second lab at the National Cattle Breeding Centre in November that same year. The combined output of the two labs for the 2023 breeding season was approximately 230,000 straws. There continues to be additional imports of sex-sorted semen from other countries (mainly UK and New Zealand), meaning that approximately 300,000 straws of sex-sorted semen were available for use in the 2023 breeding season.

The usage of sex-sorted semen must be carefully considered, as overall pregnancy per AI (P/AI) is less for inseminations with sex-sorted semen compared with conventional semen. For example, controlled studies using both sexed and conventional semen to inseminate lactating dairy cows in seasonal-calving herds after detected oestrus or timed AI both reported that, on average, P/AI was ~10% less for sexed semen. Reasons for a deterioration in P/AI following AI with sex-sorted semen include fewer sperm per straw (four million in SS straws vs. 15 million in conventional), damage to sperm during the sorting process and shorter fertile lifespan in the female reproductive tract.

On a positive note, our recent studies reported that a subset of herds achieved P/AI with sex-sorted semen equivalent to P/AI with conventional semen. Still, other herds had poor P/AI with sexed semen. This highlights that it is possible to achieve excellent reproductive performance using sexed semen, but that there is a risk of having a marked deterioration in fertility performance.

As sperm cells within the straw have already been exposed to potentially damaging steps during the sorting process, it is likely that sex-sorted semen straws are more susceptible to any errors during the insemination procedure (e.g. thawing temperature, thawing time, cold shock, time from thaw to completion of insemination). When sex-sorted semen was used fresh (i.e. without cryopreservation), field data generated in New Zealand indicated non-return rates that were comparable with conventional semen. Hence, freeze-thawing is potentially a large source of fertility loss, and needs to be implemented with strict adherence to protocols.

The keys to the successful use of sexed semen are consideration of sire and dam choice, timing of AI, and straw handling on the day of AI. It is likely the difference in P/AI between conventional semen and sex-sorted semen will continue to shrink as technologies for creating sex-biased semen improve, fostering greater usage of sexed semen.

Enthusiasm for using sex-sorted semen has arisen for several reasons:

- **Large teams of high Economic Breeding Index (EBI) bulls are 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 sex-sorted 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**
- **It facilitates a marked increase in the use of high Dairy-Beef Index semen to generate all non-replacement beef-cross calves, which could account for over 70% of the total calf crop. These beef-cross calves are more saleable compared with male dairy calves.**

Come meet Stephen and the reproduction team at the Moorepark Open day on 4 July where the most up to date research will be presented as well as information for farmers on how to select the best cows for sexed semen.

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Adaptation

Diversification

Ripe for the picking

Seeking to bolster the market for Irish apples, a new screening project will develop in-depth blueprints of customer preferences, allowing growers to focus on producing the most desirable varieties.

The market is ripe for the development of Ireland's dessert apple sector. Across the globe, demand is increasing for apples and apple-derived products. The Irish domestic retail market alone is valued at €131 million; despite a suitable growing climate, the majority of this is imported. Against this, consumer perception of Irish-grown apples is improving, in line with increasingly positive views towards healthier eating and plant-based nutrition alongside the environmental upside of more heavily plant-based diets.

In light of this, the Smart Apples project represents a fundamental step in developing the apple sector in Ireland. The proposed Teagasc research programme will need to be built on sound decisions regarding not only which varieties are suitable for the Irish climate, but also consumer and market acceptance.

Building a blueprint for consumer preference

Different apple varieties produced in Ireland, as well as a range of new genotypes being established at Teagasc Oak Park, will be evaluated to characterise their physicochemical parameters (e.g. flesh firmness, acidity, soluble solids, size, weight, colour and shape). The same varieties will undergo comprehensive sensory testing, taking into account appearance, flavour, taste and texture attributes, using a combination of descriptive profiling and consumer evaluation techniques. Consumers' explicit food-related emotions to the apples will also be measured, resulting in a detailed blueprint characterising the relationship between the apples, their sensory attributes and consumer liking.

Underpinning the development of apples with consumer-based sensory and emotional information is a key requirement for successful product development, and this holistic approach will provide new scientific outputs for the apple sector in Ireland. Consumers will be asked to score apple samples based on taste and acceptability (e.g. sourness, sweetness, bitterness) and will also be asked to indicate how differences in these attributes would affect their willingness to choose a particular apple variety. This will be done using a nine-point Likert hedonic scale, as well as five-point JAR scales for attribute-specific questions (see box, right).

Supporting Teagasc objectives

Understanding the physicochemical qualities of different apple varieties in Ireland and consumers' sensory preferences of these fruits are, together with future evaluation of agronomic behaviour, important tools for selecting apple varieties with high market potential in Ireland.

Fruit Research Officer Alberto Ramos Luz says: "The results of this research will serve as guidance for the implementation of new market-led orchard planting, as well as a

Jules_Kitano / stock.adobe.com

Sensory evaluation scales

The nine-point hedonic scale asks participants to rank product attributes according to preference, using a nine-point scale ranging from 'like extremely' to 'dislike extremely'.

The five-point JAR (just about right) scale is used to measure appropriate levels of a given product attribute. The scale ranges from 'too much' at one end to 'too little' at another end, with the middle point of the scale being 'just about right'.

variety selection tool for future research on different forms of management to obtain maximum yield efficiency and fruit quality.

"This makes it possible to recommend a more efficient technological package than those practised today in Ireland, making apple production more attractive to Irish farmers, with greater profitability and with an offer of higher quality fruits to consumers."

This directly impacts economic, environmental and social issues, which are Teagasc strategic objectives, supporting rural development, mitigating gaseous emissions, adaptation to climate change, a more biodiverse agriculture and promoting human health and nutrition, and above all supporting viable farming, promoting the production of fruits to replace imports. Apples will be the pilot initiative in this context.

Growing for consumers

By the end of the project in 2027, it will be possible to use faster and cheaper methods to characterise the sensory profile of apples, as well as to develop an indicator based on the correlation of physicochemical characteristics, sensory profile and Irish consumer preference as a tool for selecting apple varieties.

Growers looking to diversify their production will have a better chance of succeeding in apple production and Irish apple growers will be able to improve profitability using the knowledge of consumer preference as one of the factors in choosing which varieties to produce. The project will also help mitigate the risk factor of planting orchards, as it affords growers the opportunity to focus on apple varieties that have wide market acceptance. T

FUNDING

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Strawberry trials at Teagasc, Ashtown

Innovation drivers in horticulture

Dermot Callaghan, Head of the Horticulture Department, examines some of the challenges and opportunities facing the horticulture sector.

With a €521 million farm gate value, the horticulture sector is spread across two key sub-sectors: horticulture food (€417 million) and amenity horticulture (€104 million). The sector is diverse and fragmented, making it challenging to provide research and advisory services.

Most Irish horticulture produce is consumed in the domestic market with only two sectors having significant export trade: mushrooms and amenity horticulture. Horticulture is the fourth largest sector after dairy, beef and pigs in terms of gross output value.

The operating environment for Irish horticulture has changed significantly in recent decades. There has been consolidation in grower numbers but the value and volume of the sector has remained relatively static.

Brexit, Covid and the Russian invasion of Ukraine have negatively affected input prices, labour availability and supply chains, but there are positive drivers: an emphasis on healthy eating, more sustainable supply chains, and the importance of flora in our built environment.

A policy for sustainability

The Department of Agriculture, Food and the Marine (DAFM) set the wider policy agenda for Ireland's horticulture sector. The key policy document Food Vision 2030 directly requires stakeholders to identify areas for research "*in order to enable innovation, technology adoption, strategic development and alternative growing media*".

It's imperative to set specific environmental targets for the sector. Lifecycle and environmental footprint analysis is required to provide metrics and an evidence base for sustainability claims and mitigation strategies.

New targets to reduce the environmental impact of agricultural activities help highlight possibilities for diversification and alternatives for land-use, further providing opportunities for horticulture food and plant production. Horticulture is one of the most carbon-efficient sectors; expansion could contribute towards achieving carbon neutrality by 2050.

Teagasc is developing an apple research orchard for the development of the eating apple sector in Ireland, looking to elucidate variety suitability in the Irish climate, alongside consumer and market acceptance of these varieties.

Finding alternatives

Given current trends, which are likely to intensify over time, such as increased demand for plant-based foods, there's opportunity to expand the horticulture sector. Utilising horticultural outputs in consumer foods has accelerated, and is likely to continue as the research environment focuses on new product development and waste valorisation.

Research on peat alternatives for horticultural growing media has attracted international attention and is expected to be a key focus for research across Ireland and elsewhere in the coming decade. Teagasc is currently conducting research to find peat alternatives through DAFM-funded project Beyond Peat. Peat alternatives will need to match quality and consistency and be able to achieve equitable yields, while remaining affordable and available.

Technology adoption will continue to be a key trend for the sector, with a need to apply technical solutions to emerging problems in the horticultural business model, targeting inputs such as labour efficiency. There will be continued investment by growers and producers in leading-edge technology, such as increased automation and precision engineering. T

John McElroy

Events: my take-home message

Teagasc's researchers attend many events throughout the year, sharing the findings from their research with national and international audiences. Here, we capture the take-home messages – key pieces of information that our researchers want people to remember – from recent events.

Soil biodiversity

Event: 3rd Global Soil Biodiversity conference, Dublin, and associated 'Farming for Soil Health' field day, Johnstown Castle
Date: 13 to 16 March 2023

Co-hosted by University College Dublin and Teagasc, in association with the Global Soil Biodiversity Initiative, this conference brought together the world's leading experts in soil biodiversity science, with over 650 people in attendance from more than 120 countries.

Fiona Brennan, Soil Microbiologist in Teagasc's Environment, Soils and Land Use Department, Johnstown Castle, says: "There has been recent intensification of international efforts to safeguard soil health and increase understanding of the importance of soil biodiversity in addressing food security and climate regulation

Kerry Ryan and Natalie Oram at the Farming for Soil Health field day

challenges. A key message from the conference was the need for the scientific community to work closely with policy makers to ensure policy is underpinned by soil biodiversity science."

Associated with the conference was a field day held in Johnstown Castle, Wexford, called 'Farming for Soil Health: Building resilient agricultural systems from the ground up'. Fiona says: "With more than 350 attendees the take home messages from the event were that good soil health is critical for productive and resilient agricultural systems, that farmers should take steps to safeguard and manage soil health, and that a range of tools are available to help farmers monitor and enhance their soil health."

Global wheat improvement

Event: G20 Meeting of Agricultural Chief Scientists, Varanasi, India
Date: 17 to 19 April 2023

The presentation of the Wheat Initiative's work given by John Spink, Head of the Teagasc Crops, Environment and Land Use Programme at the G20 intergovernmental forum set a major focus on the importance of cooperation and coordination in research to address the challenges threatening global food security.

John explains: "The Wheat Initiative provides an excellent example of the value of collaborative research. A key objective has been to enhance sustainable wheat production under increased climate stress, and access to the best and safest technologies in breeding, agronomy, plant nutrition and protection against pathogens and pests. These factors are essential and have to be implemented through a strong science-based framework."

John outlined the programmes of the initiative, including the Alliance for Wheat Adaption to Heat and Drought (AHEAD) and the Wheat Initiative Crop Health Alliance (Watch-A), the 10+ Wheat Genomes Project, the International Wheat Genome Sequencing Consortium (IWGSC), as well as the International Wheat Yield Partnership (IWYP).

The conclusion was that the Wheat Initiative is a vital organisation that coordinates wheat research worldwide. However, it is the only G20 crop improvement initiative (although crop improvement and crop diversity is critical to face the challenges posed by the climate crisis). The initiative supports three of the UN's Sustainable Development Goals (SDGs): Zero Hunger, Responsible Consumption and Production, and Partnerships for the Goals.

John Spink, Teresa Saavedra and Frank Ordon with Smita Sirohi, Joint Secretary (G-20), Ministry of Agriculture & Farmers Welfare

Save the date

Moorepark23 – Securing A Sustainable Future

Date: 4 July 2023
Location: Moorepark, Co. Cork

The dairy industry has gone through a transformation since milk quota removal was first discussed at EU level. Since then, fat and protein output has increased by over 90% nationally within Ireland's traditional grass-based systems. The changes have occurred against a backdrop of an economic crisis, a pandemic and a war in Europe.

Future development of the dairy industry will require a close alignment with EU and national policy objectives. The challenges of reducing carbon emissions, improving animal welfare, water and air quality and enhancing biodiversity outcomes, while generating financially-rewarding career opportunities, are most urgent. Moorepark23 will focus on all of these issues, identifying the technologies and pathways for the industry to go about addressing them.

Don't miss out on Teagasc's upcoming events! Visit our website to see what we have planned: www.teagasc.ie

Dotty dots on trees

Plants exist in close association with microbes, both on the surface (epiphytes) and inside (endophytes). These microbes are also known as the second genome of plants that help fight against biotic and abiotic stressors.

The ElmAsh project will explore microbiomes of different ash genotypes to identify and grow culturable microbes that could be used as bioagents in combating ash dieback disease and other threats. This image shows some of the fungal epiphytes that grew on the surface of a fallen tree into these beautiful mushroom-like structures, which are also providing an essential ecosystem service by decomposing a dead tree into organic matter.

Photo and description by:
Dheeraj Rathore,
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Tree Improvement
Teagasc Project: ElmAsh